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ESTIMATES OF ANNUAL BIRTHS AND OF THE GENERAL FERTILITY RATES IN JAPAN, 1890—1920

—Derived by Projecting the Census Population of 1920 Backwards—

MASAAKI YASUKAWA

PREFACE

ONE OF THE MAJOR defects in the Japanese demographic data is the lack of an annual series of births before 1920 when the first census was taken (the census date, October 1, 1920).

The ideal situation for estimating the births in any of the previous years, aside from working with registration figures, would be one in which an accurate census age distribution and a cohort life table which covers the years between the time of birth and the time of enumeration are available.

In order to estimate the number of births by the inverse survivorship method, the cohort life table has been made on the basis of "Reformation of Japanese Pre-census Life Tables" by Mr. Koichi Matsuura.

Calculations involved in estimating the number of births have been made for the two sexes separately. Therefore, in order to test the consistency of the estimates, the sex ratios at birth for the period 1890–1920 were also calculated. With the exception of the rather low values of the sex ratios in 1898 and 1899 the series is mostly consistent. This anomaly disappeared when these cohorts were obtained from the 1925 census age distribution. This suggests that the deficit in male births in 1898 and 1899 as calculated from the 1920 census age distribution may be due to the fact that the population aged 21 and 22 in 1920 was of military age.

Having estimated the number of births during the period 1890–1920, it is possible to estimate the general fertility rate if only we have estimates of the number of females aged 15–44 during the same period. The latter was obtained by projecting backwards by 5-years the 1920 census population by age by means of the ${}_5L_x$ values derived mostly from the reformed life tables. The estimates for the intervening years were then obtained by simple interpolation.

This essay is the combination of two previous works: (1) The research originally made at the Office of Population Research, Princeton University, at the suggestion of Professor Ansley J. Coale, director of the Office, where the writer served as a Population Council Fellow for the year, 1960–61, and (2) Subsequent continuous work. I express my thanks to Professor Coale for his kind guidance.

1. PROBLEM

Population and economy interact, in other words, population and economy stimulate each other in their ever changing courses of development. Judging from what has happened in the past with some advanced countries, we seem quite justified in stating that an economic progress causes population growth. Of the demographic theory which supports the concomitance of economic development and population growth, study, succeeding in establishing the so called demographic change pattern, has been made by such scholars as W. S. Thompson, F. W. Notestein, C. P. Blacker, A. Landry and some others.[1] This pattern is an empirical law known as "demographic transition." Here its general phases will be explained by citing H. Leibenstein's simple diagram[2] which is based on Blacker's classification.

Blacker classifies the demographic evolution into the following five stages: the high stationary (HS), the early expanding (EE), the late expanding (LE), the low stationary (LS) and the diminishing (D) as shown in Figure 1·1.

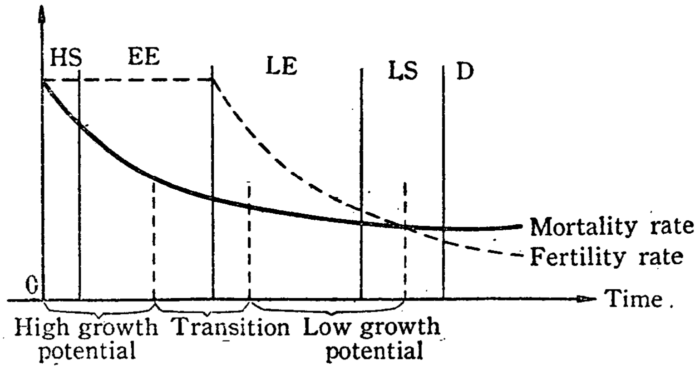

FIGURE 1·1

The fertility and mortality rates at HS are in balance at a high level. Here the population is in a stationary state making no in-

[1] Thompson, W. S., Plenty of People, 1948, Chap. 6.

Notestein, F. W., "The Population of the World in the Year 2000," *Journal of the American Statistical Association*, Sept. 1950, pp. 335-45.

Blacker, "Stages in Population Growth," *Eugenics Review*, 1947; United Nations, The Determinants and Consequences of Population Trends, 1953, p. 44.

Landry, A., La Révolution Démographique, 1934, pp. 44-55.

[2] Leibenstein, H., Economic Backwardness and Economic Growth, 1957, p. 156.

crease. At EE where, given the necessary stimulus for economic development and supposing the take-off into self-sustained growth to be begun, then, so long as the take-off is begun, the population tends to increase and soon reaches its maximum growth rate, with the mortality beginning to decline and the fertility still remaining at a high level as before. At LE where if the economic development should still be sustained, the mortality approaches its possible lowest level, and the fertility also rapidly follows in its wake, although it always lags behind the former in this downward trend, resulting in a slackening of population increase which will soon bring both population and economy to a standstill. At LS this condition reaches its lowest extremity and rushes into the D stage, where the fertility and the mortality interchange their positions, causing a positive decline of population.

Thompson and Notestein abridged these five stages into three as is represented at the base of Figure 1·1. They put the first stage and the first part of the second stage of Blacker's together and designated the countries in this state as high growth potential countries and those in the other extremity as low growth potential countries. The countries between these two extremities are in the transitional state. The fertility in the first of this treble stage classification is in no way controlled, and it is fairly controlled in the last. In the intermediary stage between the two fertility is in transition. Considered in terms of this classification, it is possible to mark the countries of the world into some sort of demographic types.[3]

However, this evolutionary explanation of demographic process, which is based on evidence from advanced countries, encounters some difficulty when it comes to be applied to the actual conditions of the various countries of the world. Take, for example, mortality. The decrease of mortality is generally attributed to the heightened productivity of labor owing to technological progress and improvements in medical science and sanitation, in spite of diverse historical conditions. So, generally speaking, any economic development brings about a rapid decrease in mortality.

However, the decreasing mortality as we find it in less developed countries is rather the result of the spread of knowledge of medicine and sanitation as imported from other countries; these countries have not come through the same developmental process of society as the advanced countries have. A. J. Coale and E. M. Hoover state: "Substantial economic improvement may be a sufficient condition for

[3] Leibenstein, H., ibid., p. 156.

a decline in mortality, but it is not today a necessary condition."[4]

Of a change in fertility, H. Leibenstein critically says: "It is of interest to note that this view of the relationship between fertility decline and economic development cannot be deduced entirely on the basis of historical evidence. The reason for this is that although fertility decline may be a necessary condition, it is certainly not a sufficient condition for economic growth. Sustained development may depend on the onset of fertility decline, but sustained fertility decline depends in turn on sustained development. Therefore, in the usual case either both occur or neither occurs."[5]

M. Tachi also made a model pattern, Figure 1·2, by combining

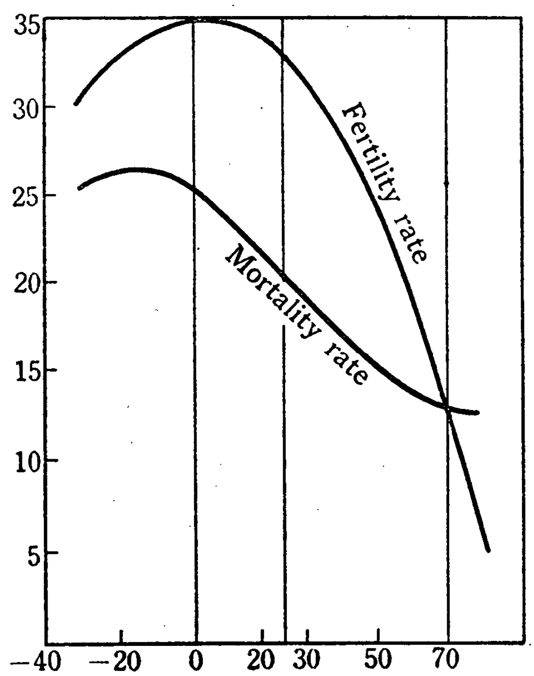

FIGURE 1·2

the mortality rates and the fertility rates of England and Wales, Sweden, France, Italy and Germany over 150 years before 1938, with the turningpoint of the decline in fertility rates of these countries as the pivot of investigation.[6] The Figure indicates that both fertility and mortality rates are high in the early stage of economic development. In this stage, however, we find some discrepancies

[4] Coale, A. J. and Hoover, E. M., Population Growth and Economic Development in Low-Income Countries, 1958, p. 14.

[5] Leibenstein, H., op. cit., p. 168.

[6] Tachi, Minoru "The Population of Japan after World War II" in *Population Problems of Japan* edited by the Population Problems Research Council, Mainichi Newspapers, 1950, p. 9. (in Japanese)

in the trends of fertility and mortality rates from the showings of the model pattern made by European and American demographers, although they are on the same track Figure 1·2, with reference to other periods of economic development.

M. Tachi states: "These discrepancies are due to the gradually accomplished improvement in statistical technique, not the result of the substancial rise in fertility."[7] In other words, "they are mainly due to the improvement in the registration of births and deaths."[8]

Suppose there exists no "statistical deficiency" as a factor in the movement of fertility as was claimed by M. Tachi in the case above. Still it seems not impossible for fertility to rise in the early stage of socio-economic development on account of the socio-economic conditions as well as the demographic conditions which may have existed before the beginning of such a stage, even though mortality may not be on the increase at the time.

Having finished the discussion of the important points in connection with over subject, and admitting that the demographic movement of Japan is just as much the outcome of the influence of the economic development since the middle part of the Meiji Era (1890's) as was the case with some advanced countries, the writer comes to the conclusion that the increase in the population of Japan was essentially due to the decline in mortality and not to the increase in fertility. Y. Morita has already published a similar view on this point. It is the writer's intention and the aim of this work to offer another additional analysis of the matter as seen from an angle differing from Y. Morita's.[9]

2. A METHOD TO ESTIMATE BIRTHS

Many deficiencies were found in the annual registration series of births prior to 1920 when the first census was taken. Quite independent of the officially registered number of births, a basically different system of calculation was contrived as a method to estimate births as is explained below:

The basic aspects of statics and dynamics of population structure are represented by the cubic Figure 1·3, the three dimensions of which are x (age), L_0 (population in age 0) and t (time). Confining our observation to the female population only, we have their distribution at

[7] *Population Encyclopedia*, 1957, p. 260. (in Japanese)

[8] Tachi, M., op. cit., p. 10.

[9] Morita, Yuzo, *An Analysis of Population Growth*, 1944, Chapter 8. (in Japanese), and "An Estimation on the Actual Birth-and Death-Rates in the Early Meiji Period of Japan," *Population Studies*, London, Vol. XVII, No. 2, November 1963.

1890 (t_0) represented by the plane (t_0, $L_0(0)_0$, ω_0), and that at 1920 (t_1) represented by the plane (t_1, $L_0(1)$, ω_1). In other words, these two planes describe the age distributions respectively at two different times in the course of passing years. So, the number of births, $L_0(0)$, at t_0 (the population at age 0) becomes L_{30} (the population at age 30) after 30 years, in other words, the population at age 30 in 1920 is the same group of people that were born in 1890. A demographic term "cohort" signifies this "simultaneous birth group."

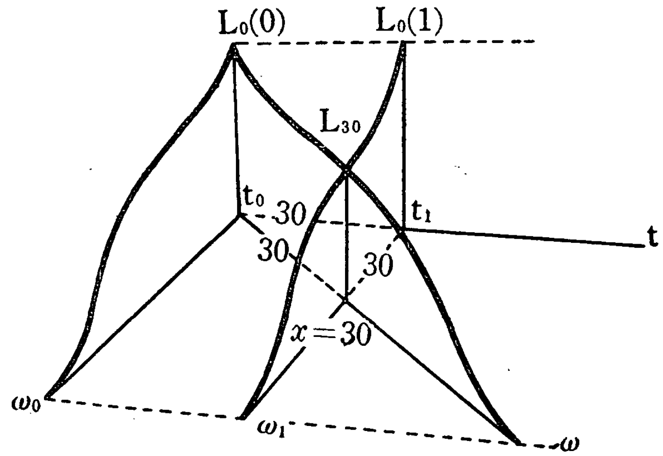

FIGURE 1·3

Thus the plane (t_0, $L_0(0)$, ω) represents the age distributions of the cohort depicting the life journey of the birth group that came into being in 1890 (t_0). The age distributions at each age level are represented by a curve, indicating the diminution of the survivors with aging or, to put it differently, the increase of deaths with the passage of time. So, given the population at age 30 in 1920 and the cohort curve of the survivors, it is possible to compute inversely the births in 1890.

The best way to check the yearly births that were inversely calculated by the method above, is to look into the sex ratios at birth, for generally the sex ratios at birth are fairly steady.

With the above explained principle as the basis of our study, we now proceed to our practical step: the preparation of an exact census age distribution and a cohort life table. As a pre-requisite for this step, here are presented four official life tables:

the 1st Life Table (1891–1898)
the 2nd Life Table (1899–1903)
the 3rd Life Table (1909–1913)
the 4th Life Table (1921–1925).

Looking over these tables, we find that these was a considerable underregistration of deaths in the first three tables, that is, prior to 1920. We decided, therefore, to use K. Matsuura's "reformed life tables."[10] Finding, however, that K. Matsuura adopted the mortality rates for the ages 5–50 as they were presented in the official life tables, we also used them excepting those at the age 0, considering the accuracy of the calculating process of mortality rates at each age level. With reference to the ages below 5 (the ages above 50 are not the concern of our study), a multiplier was sought to link the official tables and K. Matsuura's reformed life tables so as to facilitate recalculation. Then the required cohort life tables, 1891–1920, have been made from the official life tables as presented below:

Cohort Life Table	Related Period	Corresponding Official Life Table
(A)	1891—1898	1st
(B)	1898—1902	2nd
(C)	1902—1908	Avr. of 1st & 2nd
(D)	1908—1913	3rd
(E)	1913—1920	Avr. of 3rd & 4th.

With the cohort life tables obtained, it is now possible to estimate by the formula below the number of births for the year from October 1, 1889 to October 1, 1890.

$$B_{1890} = ({}_1P_{30})_{1920} \times \left(\frac{{}_1L_{23}}{{}_1L_{30}}\right)_E \times \left(\frac{{}_1L_{18}}{{}_1L_{23}}\right)_D \times \left(\frac{{}_1L_{12}}{{}_1L_{18}}\right)_C \times \left(\frac{{}_1L_{8}}{{}_1L_{12}}\right)_B \times \left(\frac{l_1}{{}_1L_{8}}\right)_A \times \left(\frac{1}{p_0}\right)_{1890}$$

<u>Formulas to Estimate Yearly Births 1890–1920</u>

E	D	C	B	A
1913–20	1908–13	1902–08	1898–1902	1891–1898

$$B_{1890} = ({}_1P_{30})_{1920} \times \left(\frac{{}_1L_{23}}{{}_1L_{30}}\right)_E \times \left(\frac{{}_1L_{18}}{{}_1L_{23}}\right)_D \times \left(\frac{{}_1L_{12}}{{}_1L_{18}}\right)_C \times \left(\frac{{}_1L_{8}}{{}_1L_{12}}\right)_B \times \left(\frac{l_1}{{}_1L_{8}}\right)_A \times \left(\frac{1}{p_0}\right)_{1890}$$

$$B_{1891} = ({}_1P_{29})_{1920} \times \left(\frac{{}_1L_{22}}{{}_1L_{29}}\right)_E \times \left(\frac{{}_1L_{17}}{{}_1L_{22}}\right)_D \times \left(\frac{{}_1L_{11}}{{}_1L_{17}}\right)_C \times \left(\frac{{}_1L_{7}}{{}_1L_{11}}\right)_B \times \left(\frac{l_1}{{}_1L_{7}}\right)_A \times \left(\frac{1}{p_0}\right)_{1891}$$

....

[10] Matsuura, K., "Reformation of Japanese Pre-census Life Tables," Kyushu J. Med. Sci. 9., 1958, pp. 70–85.

	E	D	C	B	A
	1913–20	1908–13	1902–08	1898–1902	1891–1898

$$B_{1900} = ({}_1P_{20})_{1920} \times \left(\frac{{}_1L_{13}}{{}_1L_{20}}\right)_E \times \left(\frac{{}_1L_{8}}{{}_1L_{13}}\right)_D \times \left(\frac{{}_1L_{2}}{{}_1L_{8}}\right)_C \times \left(\frac{l_1}{{}_1L_{2}}\right)_B \times \left(\frac{1}{p_0}\right)_{1900}$$

$$B_{1901} = ({}_1P_{19})_{1920} \times \left(\frac{{}_1L_{12}}{{}_1L_{19}}\right)_E \times \left(\frac{{}_1L_{7}}{{}_1L_{12}}\right)_D \times \left(\frac{{}_1L_{1}}{{}_1L_{7}}\right)_C \times \left(\frac{l_1}{{}_1L_{1}}\right)_B \times \left(\frac{1}{p_0}\right)_{1901}$$

$$B_{1902} = ({}_1P_{18})_{1920} \times \left(\frac{{}_1L_{11}}{{}_1L_{18}}\right)_E \times \left(\frac{{}_1L_{6}}{{}_1L_{11}}\right)_D \times \left(\frac{l_1}{{}_1L_{6}}\right)_C \times \left(\frac{1}{p_0}\right)_{1902}$$

....

$$B_{1918} = ({}_1P_{2})_{1920} \times \left(\frac{l_1}{{}_1L_{2}}\right)_E \times \left(\frac{1}{p_0}\right)_{1918}$$

$$B_{1919} = ({}_1P_{1})_{1920} \times \left(\frac{l_1}{{}_1L_{1}}\right)_E \times \left(\frac{1}{p_0}\right)_{1919}$$

$$B_{1920} = ({}_1P_{0})_{1920} \times \left(\frac{l_0}{{}_1L_{0}}\right)_E$$

where:

B_{1890} is the births during October 1, 1889 to October 1, 1890

$({}_1P_{30})_{1920}$ is the population age 30 in 1920

$(1/p_0)_{1890}$ is the inverse survivorship ratio for births occurring in 1890

All other factors represent life table inverse survivorship ratio,

$$L_x = .5l_x + .5l_{x+1} \text{ [where, } L_0 = .3l_0 + .7l_1,\ L_1 = .4l_1 + .6l_2]$$

and where:

p_0 is probability of surviving from age 0 to 1

$$p_0 = \left(\frac{l_1}{l_0}\right), \qquad p_0 = [1 - {}_1q_0]$$

${}_1q_0$ is infant mortality in a life table.

Then, the infant mortality rates, ${}_1q_0$, were obtained by combining mortality rates at age 0 of the reformed life tables and those of the official life tables. More concretely put, they were obtained as follows: first, the ratios between the series of 5-yearly moving average of the official infant mortality rates and the actual values were obtained, and then they were multiplied by Matsuura's trend value $({}_1q_0)'_t$.

where:

$({}_1q_0)_t$ is the official infant mortality at t.

$({}_1q_0)'_t$ is the trend value of mortality rate age 0, (Matsuura's calculation) at t.

Then the probability of surviving age 0 is estimated by the formula below:

$$({}_1p_0)_t = 1 - \kappa \cdot ({}_1q_0)'_t \qquad \left[\text{where, } \kappa = ({}_1q_0)_t \Big/ \frac{1}{5} \cdot \sum_{t-2}^{t+2} ({}_1q_0)_t\right]$$

3. THE CALCULATING PROCESS OF BIRTHS

Table 1·1 (male) and Table 1·2 (female) show the births that were estimated by the previously explained formula, with the 1920 Census population $({}_1P_a)_{1920}$, 5 cohort life tables (A, B, C, D, E) and the yearly inverse probability of surviving age 0, $(1/p_0)_t$. The calculating process of $({}_1p_0)_t$ is presented in Table 1.3 (male) and Table 1·4 (females). The estimated infant mortality rates are shown in Figure 1·4. In

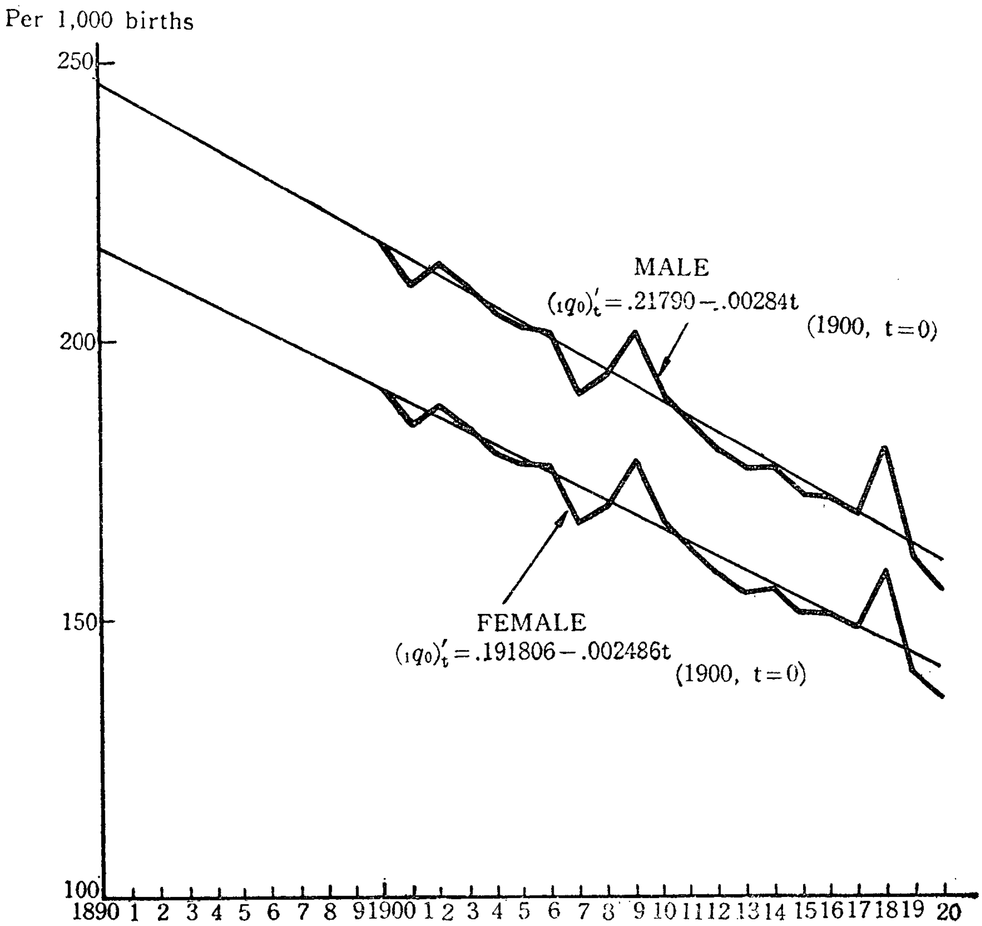

FIGURE 1·4. Estimated Infant Mortality

TABLE 1·1

ESTIMATED ANNUAL BIRTHS FROM THE 1920 CENSUS POPULATION, 1890—1920. (MALE)

	$({}_1P_a)$ 1920	$\left(\frac{{}_1L_{a-7}}{{}_1L_a}\right)_E$	$\left(\frac{{}_1L_{b-5}}{{}_1L_b}\right)_D$	$\left(\frac{{}_1L_{c-6}}{{}_1L_c}\right)$	$\left(\frac{{}_1L_{d-4}}{{}_1L_d}\right)_B$	$\left(\frac{l_1}{{}_1L_{d-4}}\right)_A$	$\left(\frac{1}{p_0}\right)_t$	Est. Births (I)
B(1890) =	376,298 ×	1.0627 ×	1.0450 ×	1.0307 ×	1.0139 ×	1.1468 ×	1.3268	= 664,476
B(1891) =	356,110	1.0645	1.0431	1.0267	1.0152	1.1400	1.3222	= 621,230
B(1892) =	394,576	1.0662	1.0402	1.0237	1.0173	1.1320	1.3169	= 679,370
B(1893) =	394,788	1.0679	1.0365	1.0218	1.0208	1.1219	1.3120	= 670,899
B(1894) =	414,570	1.0691	1.0323	1.0210	1.0266	1.1085	1.3071	= 694,854
B(1895) =	435,036	1.0696	1.0281	1.0215	1.0367	1.0897	1.3023	= 718,937
B(1896) =	437,874	1.0688	1.0240	1.0233	1.0538	1.0625	1.2975	= 712,431
B(1897) =	444,738	1.0666	1.0207	1.0268	1.0766	1.0276	1.2927	= 710,994
B(1898) =	461,097	1.0628	1.0183	1.0330	1.0904		1.2880	= 723,972
B(1899) =	451,400	1.0576	1.0170	1.0433	1.0750		1.2833	= 698,797
B(1900) =	504,665	1.0514	1.0168	1.0610	1.0519		1.2786	= 769,895
B(1901) =	540,206	1.0447	1.0177	1.0877	1.0226		1.2670	= 809,398
B(1902) =	551,297	1.0382	1.0196	1.1090			1.2725	= 823,543
B(1903) =	560,403	1.0326	1.0228	1.1018			1.2658	= 825,451
B(1904) =	541,472	1.0284	1.0283	1.0917			1.2587	= 786,835
B(1905) =	547,194	1.0259	1.0375	1.0772			1.2548	= 787,236
B(1906) =	542,715	1.0252	1.0533	1.0552			1.2520	= 774,233
B(1907) =	611,024	1.0261	1.0802	1.0249			1.2371	= 858,695
B(1908) =	132,892	1.0291	1.1026				1.2419	= 891,849
B(1909) =	652,451	1.0350	1.0930				1.2534	= 925,121
B(1910) =	647,588	1.0453	1.0793				1.2364	= 903,319
B(1911) =	666,528	1.0635	1.0586				1.2289	= 922,157
B(1912) =	695,972	1.0937	1.0272				1 2206	= 954,374
B(1913) =	699,656	1.1202					1.2132	= 950,852
B(1914) =	710,539	1.1146					1.2157	= 962,794
B(1915) =	692,744	1.1077					1.2087	= 927,500
B(1916) =	710,398	1.0980					1.2084	= 942,573
B(1917) =	699,956	1.0837					1.2048	= 913,891
B(1918) =	696,348	1.0617					1.2214	= 902,997
B(1919) =	699,325	1.0286					1.1928	= 858,012
B(1920) =	944,552	1.1273						=1,064,793
		E ·	D ·	C ·	B ·	A ·	$\left(\frac{1}{p_0}\right)$	

where b = a − 7 c = b − 5 d = c − 6

TABLE 1·2

ESTIMATED ANNUAL BIRTHS FROM THE 1920 CENSUS POPULATION, 1890—1920. (FEMALE)

	$({}_1P_a)$ 1920	$\left(\frac{{}_1L_{a-7}}{{}_1L_a}\right)_E$	$\left(\frac{{}_1L_{b-5}}{{}_1L_b}\right)_D$	$\left(\frac{{}_1L_{c-6}}{{}_1L_c}\right)_C$	$\left(\frac{{}_1L_{d-4}}{{}_1L_d}\right)_B$	$\left(\frac{l_1}{{}_1L_{d-4}}\right)_A$	$\left(\frac{1}{p_0}\right)_t$	Est. Births (J)
B(1890) =	360,749 ×	1.0770 ×	1.0551 ×	1.0428 ×	1.0159 ×	1.1393 ×	1.2766 =	631,626
B(1891) =	344,438	1.0782	1.0541	1.0378	1.0164	1.1329	1.2726 =	595,325
B(1892) =	378,403	1.0796	1.0522	1.0332	1.0180	1.1253	1.2685 =	645,367
B(1893) =	377,847	1.0808	1.0493	1.0296	1.0213	1.1156	1.2646 =	635,688
B(1894) =	397,327	1.0818	1.0454	1.0271	1.0273	1.1025	1.2606 =	658,935
B(1895) =	416,191	1.0822	1.0409	1.0260	1.0378	1.0843	1.2567 =	680,222
B(1896) =	427,718	1.0819	1.0361	1.0265	1.0551	1.0584	1.2527 =	688,488
B(1897) =	434,397	1.0806	1.0314	1.0292	1.0773	1.0256	1.2488 =	687,519
B(1898) =	473,159	1.0779	1.0272	1.0350	1.0902		1.2450 =	735,963
B(1899) =	460,955	1.0737	1.0241	1.0451	1.0743		1.2411 =	706,336
B(1900) =	494,726	1.0681	1.0221	1.0626	1.0510		1.2373 =	746,307
B(1901) =	524,268	1.0613	1.0216	1.0889	1.0221		1.2278 =	776,750
B(1902) =	539,048	1.0541	1.0225	1.1096			1.2323 =	794,429
B(1903) =	545,265	1.0470	1.0252	1.1020			1.2268 =	791,257
B(1904) =	526,333	1.0408	1.0303	1.0916			1.2209 =	752,204
B(1905) =	533,459	1.0358	1.0391	1.0768			1.2178 =	752,915
B(1906) =	525,475	1.0326	1.0547	1.0546			1.2154 =	733,533
B(1907) =	597,303	1.0317	1.0812	1.0245			1.2031 =	821,237
B(1908) =	616,988	1.0334	1.1028				1.2071 =	848,760
B(1909) =	636,364	1.0386	1.0929				1.2166 =	878,784
B(1910) =	634,672	1.0487	1.0792				1.2026 =	863,822
B(1911) =	652,979	1.0666	1.0583				1.1964 =	881,832
B(1912) =	681,165	1.0964	1.0269				1.1894 =	912,173
B(1913) =	681,852	1.1221					1.1832 =	905,273
B(1914) =	692,745	1.1161					1.1854 =	916,519
B(1915) =	679,547	1.1086					1.1795 =	888,572
B(1916) =	696,898	1.0983					1.1793 =	902,640
B(1917) =	690,824	1.0834					1.1762 =	880,314
B(1918) =	690,678	1.0611					1.1903 =	872,345
B(1919) =	692,891	1.0281					1.1662 =	830,755
B(1920) =	932,043	1.1125					=	1,036,898
		E ·	D ·	C ·	B ·	A ·	$\left(\frac{1}{p_0}\right)$	

where b = a − 7 c = b − 5 d = c − 6

TABLE 1·3

ESTIMATES OF $({}_1p_0)_t$ VALUES, FROM q_0 VALUES FOR THE REFORMED LIFE TABLES AND OFFICIAL INFANT MORTALITY RATES, 1890-1920. (MALE)

Year t	$k = \frac{5({}_1q_0)_t}{\sum_{t-2}^{t+1} ({}_1q_0)_t}$ (1)	$({}_1q_0)'_t$ (2)	Adjusted Infant Mortality Rate (1) · (2)	$({}_1p_0)_t$ [=1−(1)·(2)]
1890	1.000	.24630	.24630	.75370
91	〃	.24346	.24346	.75634
92	〃	.24062	.24062	.75938
93	〃	.23778	.23778	.76222
94	〃	.23494	.23494	.76506
1895	〃	.23210	.23210	.76790
96	〃	.22926	.22926	.77074
97	〃	.22642	.22642	.77358
98	〃	.22358	.22358	.77642
99	〃	.22074	.22074	.77926
1900	〃	.21790	.21790	.78210
01	.980	.21506	.21076	.78924
02	1.009	.21222	.21413	.78587
03	1.003	.20938	.21001	.78999
04	.995	.20654	.20551	.79449
1905	.997	.20370	.20309	.79691
06	1.002	.20086	.20126	.79874
07	.968	.19802	.19168	.80832
08	.998	.19518	.19479	.80521
09	1.051	.19234	.20215	.79785
1910	1.009	.18950	.19121	.80879
11	.998	.18666	.18629	.81371
12	.983	.18382	.18070	.81930
13	.971	.18098	.17573	.82427
14	.996	.17814	.17743	.82257
1915	.985	.17530	.17267	.82733
16	1.000	.17246	.17246	.82754
17	1.002	.16962	.16996	.83004
18	1.087	.16678	.18129	.81871
19	.986	.16394	.16164	.83836
1920	.963	.16110	.15514	.84486

Column 1, Calculated from the official infant mortality rates in Table 3·5.
Column 2, $({}_1q_0)'_t = .21790 - .00284\,t$ (1900, $t = 0$)
[Computed from q_0 of the reformed life tables.]

TABLE 1·4

ESTIMATES OF $({}_1p_0)_t$ VALUES, FROM q_0 VALUES FOR THE REFORMED LIFE TABLES AND OFFICIAL INFANT MORTALITY RATES, 1890–1920. (FEMALE)

Year t	$k = \frac{5({}_1q_0)_t}{\sum_{t-2}^{t+2}({}_1q_0)_t}$ (1)	$({}_1q_0)'_t$ (2)	Adjusted Infant Mortality Rate (1)·(2)	$({}_1p_0)_t$ [=1−(1)·(2)]
1890	1.000	.21667	.21667	.78333
91	〃	.21418	.21418	.78582
92	〃	.21169	.21169	.78831
93	〃	.20921	.20921	.79079
94	〃	.20672	.20672	.79328
1895	〃	.20424	.20424	.79576
96	〃	.20175	.20175	.79825
97	〃	.19926	.19926	.80074
98	〃	.19678	.19678	.80322
99	〃	.19429	.19429	.80571
1900	〃	.19181	.19181	.80819
01	.980	.18932	.18553	.81447
02	1.009	.18683	.18851	.81149
03	1.003	.18435	.18490	.81510
04	.995	.18186	.18095	.81905
1905	.997	.17938	.17884	.82116
06	1.002	.17689	.17724	.82276
07	.968	.17440	.16882	.83118
08	.998	.17192	.17158	.82842
09	1.051	.16943	.17807	.82193
1910	1.009	.16695	.16845	.83155
11	.998	.16446	.16413	.83587
12	.983	.16197	.15922	.84078
13	.971	.15949	.15486	.84514
14	.996	.15700	.15637	.84363
1915	.985	.15452	.15220	.84780
16	1.000	.15203	.15203	.84797
17	1.002	.14954	.14984	.85016
18	1.087	.14706	.15985	.84015
19	.986	.14457	.14255	.85745
1920	.963	.14209	.13683	.86317

Column 1, Calculated from the official infant mortality rates in Tables 3·5.
Column 2, $({}_1q_0)'_t = .191806 - .002486\,t$ (1900, $t = 0$)
[Calculated from q_0 of the reformed life tables.]

estimating the cases under 5 years of age, the modification by multiplies, which effectively links the official life tables and the reformed life tables was necessary.

The formulas for multiplies are presented below:

The Multiplies Linking Official Life Tables and the Reformed Life Tables (age 1~5)

1890 ⋮ 1893	$\left(\frac{l_1}{l_5}\right)_{A(R)} \Big/ \left(\frac{l_1}{l_5}\right)_A$
1894	$\left[\left(\frac{{}_1L_4}{l_5}\right)_{B(R)} \Big/ \left(\frac{{}_1L_4}{l_5}\right)_B\right] \cdot \left[\left(\frac{l_1}{{}_1L_4}\right)_{A(R)} \Big/ \left(\frac{l_1}{{}_1L_4}\right)_A\right]$
....	
1901	$\left[\left(\frac{{}_1L_1}{l_5}\right)_{C(R)} \Big/ \left(\frac{{}_1L_1}{l_5}\right)_C\right] \cdot \left[\left(\frac{l_1}{{}_1L_1}\right)_{B(R)} \Big/ \left(\frac{l_1}{{}_1L_1}\right)_B\right]$
1902 1903	$\left(\frac{l_1}{l_5}\right)_{C(R)} \Big/ \left(\frac{l_1}{l_5}\right)_C$
1904	$\left[\left(\frac{{}_1L_4}{l_5}\right)_{D(R)} \Big/ \left(\frac{{}_1L_4}{l_5}\right)_D\right] \cdot \left[\left(\frac{l_1}{{}_1L_4}\right)_{C(R)} \Big/ \left(\frac{l_1}{{}_1L_4}\right)_C\right]$
1905	$\left[\left(\frac{{}_1L_3}{l_5}\right)_{D(R)} \Big/ \left(\frac{{}_1L_3}{l_5}\right)_D\right] \cdot \left[\left(\frac{l_1}{{}_1L_3}\right)_{C(R)} \Big/ \left(\frac{l_1}{{}_1L_3}\right)_C\right]$
....	
1918	$\left(\frac{l_1}{{}_1L_2}\right)_{E(R)} \Big/ \left(\frac{l_1}{{}_1L_2}\right)_E$
1919	$\left(\frac{l_1}{{}_1L_1}\right)_{E(R)} \Big/ \left(\frac{l_1}{{}_1L_1}\right)_E$
1920	$\left(\frac{l_0}{{}_1L_0}\right)_{E(R)} \Big/ \left(\frac{l_0}{{}_1L_0}\right)_E$

[(R) refers to Reformed Life Table].

Their resultant values are presented in Table 2·1. So, the estimated final results as presented in (K) and (Q) of Table 2·2 are the products respectively of (I) (J) of Tables 1·1 and 1·2 and the multipliers (G) (H) of Table 2·1: (K) = (I)·(G) and (Q) = (J)·(H). To check these estimated results by the sex ratio at birth, refer to Table 2·2.

Studying the sex ratios at birth in this Table, we find those in 1898 and 1899 were less than 100, and the years preceding and following these years also show low values.

This comes from the fact that 1920, the year of the basic population for this study, was about the time when the population reached 21 or 22 years of age. In other words, the males about this time

TABLE 2·1

MULTIPLIERS BY SEX FOR REFITTING THE ESTIMATED BIRTHS, 1890-1920

Year	Male (G)	Female (H)	Year	Male (G)	Female (H)
1980	1.0388	1.0246	1905	1.0203	1.0214
91	1.0388	1.0246	06	1.0206	1.0220
92	1.0388	1.0246	07	1.0181	1.0195
93	1.0338	1.0246	08	1.0143	1.0157
94	1.0223	1.0256	09	1.0119	1.0131
1895	1.0236	1.0282	1910	1.0084	1.0087
96	1.0209	1.0270	11	1.0083	1.0079
97	1.0243	1.0281	12	1.0070	1.0072
98	1.0268	1.0288	13	1.0046	1.0051
99	1.0266	1.0284	14	1.0046	1.0051
1900	1.0270	1.0289	1915	1.0046	1.0051
01	1.0244	1.0265	16	1.0025	1.0027
02	1.0205	1.0225	17	.9996	.9996
03	1.0205	1.0225	18	1.0005	1.0003
04	1.0204	1.0220	19	1.0011	1.0007
			1920	1.0127	1.0101

were at military age. Some of them were in service abroad, and this reduced births about 1920, the 1st census year. It was essential, therefore, to check and supplement this statistical drawback. This necessity was, in accordance with the estimation formula presented before, to be met by checking the obtained estimated results in conjunction with the cohorts for the 1925 census population (the 2nd census) and for the years, 1920-1925. First, the cohorts for the years, 1920-1925, were made from the 4th official life table (1921-1925), and computed (M) (N) (Tables 3·1 and 3·2) by combining them with the previously mentioned official tables. Further, the products, (S) and (T), obtained by multiplying (M) (N) with the previously presented multipliers, and their sex ratios at birth were sought. They are presented in Table 3·3.

This Table shows 1898 and 1899, and the years immediately before and after these years having steady sex ratios around 105. It is interesting to note that the sex ratios, 1903-5, estimated from the people who were of military age in 1925, were smaller than those estimated from the 1920 census.

It seems appropriate that we adopt, from these two kinds of estimated results, the yearly number of births, both male and female,

TABLE 2·2

REFITTED BIRTHS AND THE SEX RATIO COMPUTED FROM THE 1920 CENSUS POPULATION, 1890-1920

Age in 1920	Year	Estimated Male Births (K) = (I)·(G)	Estimated Female Births (Q) = (J)·(H)	Sex Ratio
30	1890	690,258	647,164	106.7
29	91	645,334	609,970	105.8
28	92	705,730	661,243	106.7
27	93	696,930	651,326	107.0
26	94	710,349	675,804	105.1
25	1895	735,904	699,404	105.2
24	96	727,321	707,077	102.9
23	97	728,271	706,838	103.0
22	98	743,374	757,159	98.2
21	99	717,385	726,396	98.8
20	1900	790,682	767,875	103.0
19	01	829,147	797,334	104.0
18	02	840,426	812,304	103.5
17	03	842,373	809,060	104.1
16	04	802,886	768,752	104.4
15	1905	803,217	769,027	104.4
14	06	790,182	749,671	105.4
13	07	874,237	837,251	104.4
12	08	904,602	862,086	104.9
11	09	936,130	890,296	105.1
10	1910	910,907	871,337	104.5
9	11	929,811	888,798	104.6
8	12	961,055	918,741	104.6
7	13	955,226	909,890	105.0
6	14	967,223	921,193	105.0
5	1915	931,767	893,104	104.3
4	16	944,929	905,077	104 4
3	17	913,525	879,962	103.8
2	18	903,448	872,607	103.5
1	19	858,956	831,337	103.3
0	1920	1,078,316	1,047,371	103.0

TABLE 3·1

ESTIMATES OF BIRTHS FROM THE 1925 CENSUS POPULATION 1890—1920. (MALE)

Age in 1925	$({}_1P_{a+5})_{1925}$		$\left(\frac{{}_1L_a}{{}_1L_{a+5}}\right)$		$\frac{E.B.*}{({}_1P_a)_{1920}}$		Estimated Births	Year of Birth
(a + 5)			[1920—25 L.T.]		$\left[=E\cdot D\cdot C\cdot B\cdot A\left(\frac{1}{p_0}\right)\right]$		(M)	
35	364,269	×	1.0427	×	1.7658	=	670,691	1890
34	342,781		1.0424		1.7445	=	623,336	91
33	380,942		1.0425		1.7218	=	683,782	92
32	377,039		1.0429		1.6994	=	668,228	93
31	395,616		1.0436		1.6761	=	692,003	94
30	415,297		1.0448		1.6526	=	717,066	1895
29	421,859		1.0463		1.6270	=	718,143	96
28	431,547		1.0480		1.5987	=	723,030	97
27	459,219		1.0498		1.5701	=	756,926	98
26	449,831		1.0514		1.5481	=	732,177	99
25	479,526		1.0529		1.5256	=	770,265	1900
24	508,530		1.0540		1.4983	=	803,075	01
23	515,339		1.0546		1.4958	=	811,846	02
22	514,323		1.0540		1.4730	=	798,507	03
21	498,870		1.0518		1.4531	=	762,458	04
20	519,085		1.0477		1.4387	=	782,430	1905
19	517,171		1.0419		1.4266	=	768,709	06
18	587,050		1.0350		1.4053	=	853,856	07
17	607,544		1.0284		1.4092	=	880,465	08
16	635,207		1.0229		1.4179	=	921,285	09
15	632,445		1.0191		1.3949	=	899,048	1910
14	651,919		1.0171		1.3835	=	917,353	11
13	686,823		1.0167		1.3713	=	957,569	12
12	694,200		1.0176		1.3590	=	960,022	13
11	698,851		1.0195		1.3550	=	965,409	14
10	676,325		1.0227		1.3389	=	926,088	1915
9	688,302		1.0283		1.3268	=	939,084	16
8	674,815		1.0386		1.3056	=	915,047	17
7	665,110		1.0568		1.2968	=	911,505	18
6	655,459		1.0872		1.2269	=	874,307	19
5	805,751		1.1128		1.1836	=	1,061,263**	1920

* E.B.: the births estimated from the 1920 census population.

$$** \quad ({}_1P_5)_{1925} \times \left(\frac{l_1}{{}_1L_5}\right)_F \times \left(\frac{1}{p_0}\right)_{1920} = 805,751 \times \frac{83,796}{75,301} \times \frac{1}{.84486} = 1,061,263$$

TABLE 3·2

ESTIMATES OF BIRTHS FROM THE 1925 CENSUS POPULATION, 1890—1920. (FEMALE)

Age in 1925	$({}_1P_{a+5})_{1925}$		$\left(\frac{{}_1L_a}{{}_1L_{a+5}}\right)_F$		$\frac{\text{F.B.*}}{({}_1P_a)_{1920}}$		Estimated Births	Year of Births
(a + 5)	[1920—25 L.T.]				$\left[=\text{E·D·C·B·A}\left(\frac{1}{p_0}\right)\right]$		(N)	
35	343,525	×	1.0542	×	1.7509	=	634,078	1890
34	324,235		1.0541		1.7284	=	590,726	91
33	360,022		1.0541		1.7055	=	647,236	92
32	354,071		1.0544		1.6824	=	628,094	93
31	367,777		1.0549		1.6584	=	643,406	94
30	388,314		1.0555		1.6344	=	669,883	1895
29	402,986		1.0564		1.6097	=	685,272	96
28	405,246		1.0575		1.5827	=	678,263	97
27	437,606		1.0588		1.5554	=	720,674	98
26	427,382		1.0601		1.5323	=	694,236	99
25	461,805		1.0612		1.5085	=	739,266	1900
24	485,371		1.0620		1.4816	=	763,711	01
23	499,614		1.0622		1.4738	=	782,131	02
22	506,536		1.0617		1.4511	=	780,386	03
21	485,635		1.0602		1.4291	=	735,801	04
20	506,535		1.0575		1.4114	=	756,032	1905
19	491,157		1.0534		1.3959	=	722,218	06
18	568,317		1.0476		1.3749	=	818,573	07
17	591,664		1.0409		1.3757	=	847,243	08
16	624,557		1.0340		1.3809	=	891,774	09
15	619,409		1.0279		1.3611	=	866,600	1910
14	638,412		1.0234		1.3505	=	882,351	11
13	671.923		1.0208		1.3391	=	918,487	12
12	674,500		1.0204		1.3277	=	913,803	13
11	677,636		1.0216		1.3230	=	915,877	14
10	659,848		1.0247		1.3076	=	884,129	1915
9	671,914		1.0307		1.2952	=	896,980	16
8	661,532		1.0417		1.2743	=	878,143	17
7	657,864		1.0602		1.2630	=	880,901	18
6	647,460		1.0900		1.1990	=	846,171	19
5	792,998		1.1144		1.1585	=	1,023,786**	1920

* E.B.: Births estimated from the 1920 census population.

$$** \quad ({}_1P_5)_{1925} \times \left(\frac{l_1}{{}_1L_5}\right)_F \times \left(\frac{1}{p_0}\right)_{1920} = 792{,}998 \times \frac{85{,}600}{76{,}811} \times \frac{1}{.86317} = 1{,}023{,}786$$

TABLE 3·3

REFITTED BIRTHS AND THE SEX RATIO COMPUTED FROM THE 1925 CENSUS POPULATION, 1890—1920

Age in 1925	Year	Estimated Male Births (S) = (M)·(G)	Estimated Female Births (T) = (N)·(H)	Sex Ratio
35	1890	696,714	649,676	107.2
34	91	647,521	605,258	107.0
33	92	710,313	663,158	107.1
32	93	694,155	643,545	107.9
31	94	707,435	659,877	107.2
30	1895	733,989	688,774	106.6
29	96	733,152	703,774	104.2
28	97	740,600	697,322	106.2
27	98	777,212	741,429	104.8
26	99	751,652	713,952	105.3
25	1900	791,062	760,631	104.0
24	01	822,670	783,949	104.9
23	02	828.489	799,729	103.6
22	03	814,876	797,945	102.1
21	04	778,012	751,989	103.5
20	1905	798,313	772,211	103.4
19	06	784,544	738,107	106.3
18	07	869,311	834,535	104.2
17	08	893,056	860,545	103.8
16	09	932,248	903,456	103.2
15	1910	906,600	874,139	103.7
14	11	924,967	889,322	104.0
13	12	964,272	925,100	104.2
12	13	964,438	918,463	105.0
11	14	969,850	920,548	105.4
10	1915	930,348	888,638	104.7
9	16	941,432	899,402	104.7
8	17	914,681	877,792	104.2
7	18	911,961	881,165	103.5
6	19	875,269	846,763	103.4
5	1920	1,074,741	1,034,126	103.9

TABLE 3·4

FINAL ESTIMATED BIRTHS AND THE SEX RATIOS, 1890—1920.

Year	Male	Female	Sex Ratio	Year	Male	Female	Sex Ratio
1890	696,714	649,676	107.2	1905	803,217	772,211	104.0
91	647,521	609,970	106.2	06	790,182	749,671	105.4
92	710,313	663,158	107.1	07	874,237	837,251	104.4
93	696,930	651,326	107.0	08	904,602	862,086	104.9
94	710,349	675,804	105.1	09	936,130	903,456	103.6
1895	735,904	699,404	105.2	1910	910,907	874,139	104.2
96	733,152	707,077	103.7	11	929,811	889,322	104.6
97	740,600	706,838	104.8	12	964,272	925,100	104.2
98	777,212	757,159	102.6	13	964,438	918,463	105.0
99	751,652	726,396	103.5	14	969,850	921,193	105.3
1900	791,062	767,875	103.0	1915	931,767	893,104	104.3
01	829,147	797,334	104.0	16	944,929	905,077	104.4
02	840,426	812,304	103.5	17	914,681	879,962	103.9
03	842,373	809,060	104.1	18	911,961	881,165	103.5
04	802,886	768,752	104.4	19	875,269	846,763	103.4
				1920	1,078,316	1,047,371	103.0

which exhibit higher estimated values. They are presented in Table 3·4, together with their sex ratios. Also, for convenience of comparison and reference, the official births and the sex ratios derived from them, together with the infant mortality rates that were used as original material are presented in Table 3·5. Among the sex ratios at birth, the one for 1906 and those around that year show an unusual value, for the year 1906 falls on the "Hi-no-e U-ma."[11]

4. ESTIMATES OF THE GENERAL FERTILITY RATES

With the births obtained by the above process for the 30 years from 1890 to 1920, we now proceed to seek the birth rates for these years, by dividing the number of births by population, and looking at their trend in the period under consideration. Of course, it was easy to obtain the birth rates for Japan proper by official statistics. Our study, however, is primarily based on the assumption that the demographic data of Japan before 1920 is defective, and that we should resort to the estimates we calculated from the 1920 census and the life tables, instead of depending on the official data on

[11] See Appendix.

TABLE 3·5

ANNUAL BIRTHS AND INFANT MORTALITY RATES FOR JAPAN, 1894—1920.
(OFFICIAL FIGURES)

Year	Infant Mortality	Births (Total)	Births (Male)	Births (Female)	Sex Ratio
1894	.....	1,208,983	620,844	588,139	105.6
1895	.....	1,246,427	638,895	607,532	105.2
96	.....	1,282,178	651,468	630,710	103.3
97	.....	1,334,125	683,941	650,184	105.2
98	.....	1,369,638	696,137	673,501	103.4
99	153.8	1,386,981	713,442	673,539	105.9
1900	155.0	1,420,534	727,916	692,618	105.1
01	149.9	1,501,591	769,494	732,097	105.1
02	154.0	1,510,835	773,296	737,539	104.8
03	152.4	1,483,816	763,806	726,010	105.2
04	151.9	1,440,371	738,230	702,141	105.1
1905	151.7	1,452,770	735,948	716,822	102.7
06	153.6	1,394,295	726,155	668,140	108.7
07	151.3	1,614,472	818,114	796,358	102.7
			(2,280,217)	(2,181,320)	(104.5)
08	158.0	1,662,815	850,209	812,606	104.6
09	167.3	1,693,850	863,855	829,995	104.1
1910	161.2	1,712,857	872,779	840,078	103.9
11	158.4	1,747,803	891,049	856,754	104.0
12	154.2	1,737,674	886,449	851,225	104.1
13	152.1	1,757,441	897,824	859,617	104.4
14	158.5	1,808,402	925,855	882,547	104.9
1915	160.4	1,799,326	918,296	881,030	104.2
16	170.3	1,804,822	921,347	883,475	104.3
17	173.2	1,812,413	924,953	887,460	104.2
18	189.0	1,791,992	914,685	877,307	104.3
19	171.0	1,778,685	910,400	868,285	104.9
1920	165.7	2,025,564	1,035,134	990,430	104.5
21	168.3				
22	166.4				

population.

So, because total populations required as denominations in calculating birth rates could not be obtained from the existing defective material, we decided, therefore, to estimate the women, ages 15–44, and use the quotients of the number of births divided by these numbers, as the general fertility rates. For estimating the women's ages 15-44, the 1920 census and its cohort life table were also used. The reason why the re-estimate on the basis of the 1920 census was not

Related Periods of Cohort Life Tables	Reformed Life Tables
1890—1895	1st Life Table (1891—98)..........(A)
1895—1900	Avr. of 1st and 2nd Life Tables
1900—1905	2nd Life Table (1899—1903) ....(B)
1905—1910	Avr. of 2nd and 3rd Life Tables
1910—1915	3rd Life Table (1909—13) ....(D)
1915—1920	Avr. of 3rd and 4th Life Tables
4th Life Table (1921—25) (Official Life Table).........(F)	

TABLE 4·1

$_5L_x$ OF COHORT LIFE TABLES

$_5L_x$ VALUES FOR ESTIMATING THE NUMBER OF WOMEN AGED 15—44. COPIED FROM THE REFORMED LIFE TABLES AND THE 1921—1925 OFFICIAL LIFE TABLE.

$l_0 = 10,000$

Age x	$(_5L_x)_F$ [1921—1925]	Sum of F & D	$(_5L_x)_D$ [1909—13]	Sum of D & B	$(_5L_x)_B$ [1899—1903]	Sum of B & A	$(_5L_x)_A$ [1891—98]
15—19	35,704	70,483	34,779	68,321	33,542	65,978	32,436
20—24	33,661	66,705	33,044	65,097	32,053	63,140	31,087
25—29	31,790	63,142	31,352	61,837	30,485	60,085	29,600
30—34	30,144	59,973	29,829	58,817	28,988	57,112	28,124
35—39	28,563	56,908	28,345	55,828	27,483	54,107	26,624
40—44	26,996	53,880	26,884	52,860	25,976	51,086	25,110
45—49	25,489	50,944	25,455	49,960	24,505	48,119	23,614
50—54	23,813	47,595	23,782	46,573	22,791	44,677	21,886
55—59	21,745	43,402	21,657	42,291	20,634		
60—64	19,084	38,122	19,038	37,062	18,024		
65—69	15,684	31,364	15,680				
70—74	11,569	23,132	11,563				
		$2(_5L_x)$ [1915—20]	$(_5L_x)$ [1910—15]	$2(_5L_x)$ [1905—10]	(L_{5x}) [1900—05]	$2(_5L_x)$ [1895-1900]	$(_5L_x)$ [1890—95]

made is that looking at the final results of the estimated female births, we found them practically the same values as derived from the 1920 census. The next step was to make the required cohort

TABLE 4·2

$\left(\frac{{}_5L_x}{{}_5L_{x+5}}\right)$ FROM THE CENSUS POPULATION, AGED 15—74, AND EACH COHORT LIFE TABLE

Age x	$({}_5P_x)$ 1920	$\left(\frac{{}_5L_x}{{}_5L_{x+5}}\right)$ [1915—20]	$\left(\frac{{}_5L_x}{{}_5L_{x+5}}\right)$ [1910—15]	$\left(\frac{{}_5L_x}{{}_5L_{x+5}}\right)$ [1905—10]	$\left(\frac{{}_5L_x}{{}_5L_{x+5}}\right)$ [1900—05]	$\left(\frac{{}_5L_x}{{}_5L_{x+5}}\right)$ [1895—1900]	$\left(\frac{{}_5L_x}{{}_5L_{x+5}}\right)$ [1890—95]
70—74	497,015						
65—69	697,943	1.3559					
60—64	852,598	1.2155	1 2142				
55—59	927,720	1.1385	1.1376	1.1411			
50—54	1,112,174	1.0966	1.0981	1.1013	1.1045		
45—49	1,317,606	1 0704	1.0703	1.0727	1.0752	1.0770	
40—44	1,602,802	1.0576	1.0561	1.0580	1.0600	1.0617	1.0634
35—39	1,701,921	1.0562	1.0543	1.0561	1.0580	1.0591	1 0603
30—34	1,774,534	1.0539	1.0524	1.0535	1.0548	1.0555	1.0563
25—29	1,914,206	1.0528	1.0511	1.0513	1.0516	1.0521	1 0525
20—24	2,290,955	1.0564	1.0540	1.0527	1.0514	1.0508	1 0502
15—19	2,668,373	1.0566	1.0525	1.0495	1.0465	1.0449	1.0434

TABLE 4·3

WOMEN 15—44, ESTIMATED FROM THE 1920 CENSUS POPULATION (1890—1915)

Age	1920	1915	1910	1905	1900	1895	1890
70—74	497,015						
65—69	697,943	673,903					
60—64	852,598	848,350	818,253				
55—59	927,720	970,683	965,083	933,708			
50—54	1,112,174	1,017,338	1,065,907	1,062,846	1,031,280		
45—49	1,317,606	1,190,471	1,088,857	1,143,398	1,142,772	1,110,689	
40—44	1,602,802	1,393,500	1,257,256	1,152,011	1,212,002	1,213,281	1,181,107
35—39	1,701,921	1,692,879	1,469,167	1,327,788	1,218,828	1,283,631	1,286,442
30—34	1,774,534	1,793,655	1,781,586	1,547,767	1,400,551	1,286,473	1,355,899
25—29	1,914,206	1,868,229	1,885,311	1,872,981	1,627,632	1,473,520	1,354,013
20—24	2,290,955	2,022,167	1,969,113	1,984,667	1,969,252	1,710,316	1,547,491
15—19	2,668,373	2,420,623	2,128,331	2,066,584	2,076,954	2,057,671	1,784,544
Women 15—44	11,952,791	11,191,053	10,490,764	9,951,798	9,505,219	9,024,892	8,509,496

TABLE 4·4

GENERAL FERTILITY RATES, 1890—1920

Year	Estimated Total Births	Women 15—44	General Fertility Rate
1890	1,346,390	8,509,496	158.2
91	1,257,491	8,612,575	146.0
92	1,373,471	8,715,654	157.6
93	1,348,256	8,818,734	152.9
94	1,386,153	8,921,813	155.4
1895	1,435,308	9,024,892	159.0
96	1,440,229	9,120,957	157.9
97	1,447,438	9,217,023	157.0
98	1,534,371	9,313,088	164.8
99	1,478,048	9,409,154	157.1
1900	1,558,937	4,505,219	164 0
01	1,626,481	9,594,535	169 5
02	1,652,730	9,683,851	170.7
03	1,651,433	9,773,166	169 0
04	1,571,638	9,862,482	159.4
1905	1,575,428	9,951,798	158 3
06	1,539,853	10,059,591	153.1
07	1,711,488	10,167,384	168.3
08	1,766,688	10,275,178	171.9
09	1,839,586	10,382,971	177.2
1910	1,785,046	10,490,764	170.2
11	1,819,133	10,630,822	171.1
12	1,889,372	10,770,880	175.4
13	1,882,901	10,910,937	172 6
14	1,891,043	11,050,995	171.1
1915	1,824,871	11,191,053	163.1
16	1,850,006	11,343,401	163.1
17	1,794,643	11,495,748	156.1
18	1,793,126	11,648,096	153.9
19	1,722,032	11,800,443	145.9
1920	2,125,687	11,952,791	177.8

life tables using the example presented before as a pattern. The reformed life tables, however, were remodelled in 5 year age gradation (refer to the upper Table on page 55), with the exception of the 4th life table which is the official life table.

Table 4·1 shows ${}_5L_x$ value for each cohort life table. In Table 4·2 $({}_5P_x)_{1920}$, indicates the number of women, aged 15–74, in 5 year age gradation, and $({}_5L_x/{}_5L_{x+5})$ indicates the inverse survivorship ratios in 5 year age gradation. Because of the fact that the women, ages 70–74, in 1920 were in the age limits, 40–44, in 1890, that is, 30 years before, it is also possible to compute by Table 4·3 the number of women, aged 15–44, in each 5 years period from 1890 through 1920. The number of women in each year was obtained by simple interpolation. The general fertility rates as shown in Table 4·4 were computed by obtaining the total estimated births as presented in Table 3·4.

5. INFLUENZA EPIDEMIC CONSIDERED[12]

In the thirty year period under investigation are included two years 1918 and 1920 when influenza was virulent. These two years, however, are not included in the life tables—the 3rd life table, 1909–13 and the 4th iife table, 1921–25—that were used as the basis of our study.

It was, therefore, necessary for us to contrive a special method which would take the influenza epidemic into consideration as we were to use the age distribution of the 1920 census as the basis of our study. What we should do was to make a proper model life table since no such table was available in Japan and no official population statistics prior to 1920 were to be used by us. The tables of this sort both on developed countries and under-developed countries had been published by the United Nations.[13] It was impossible for us to use them either, for the age specific mortality rates for Japan are very different from those of other countries. The only thing we could do was to make a model life table especially suited for our purpose. This work is now being done in my research office. After all we had no other way but to use the official statistics on mortality with an analysis of its causes.

In Table 5·1 are presented the official number of influenza deaths which occurred in 1918 and 1920. They are illustrated by Figures 2·1 and 2·2. These statistics are in 5 year age gradation. They were

[12] This work was made in 1962 with the aid from the Keio Study Promotion Fund.

[13] United Nations; "Methods for Population Projections by Sex and Age," 1956. and "Age and Sex Patterns of Mortality, Model life tables for under-developed countries," 1955.

TABLE 5·1

INFLUENZA DEATHS IN 1918 AND 1920 (OFFICIAL FIGURES)

Age	Influenza Deaths 1918		Influenza Deaths 1920	
	Male	Female	Male	Female
0	3,375	3,103	5,041	4,276
1	1,672	1,853	3,056	3,019
2	1,459	1,734	1,620	1,907
3	1,286	1,541	1,259	1,542
4	1,092	1,451	991	1,327
	(8,884)	(9,682)	(11,967)	(12,071)
5—10	2,440	3,628	2,273	3,305
10—15	968	1,420	999	1,709
15—20	1,807	2,104	3,412	4,401
20—25	2,748	3,048	4,909	6,360
25—30	2,611	3,003	5,273	6,485
30—35	2,624	2,447	5,553	5,355
35—40	2,393	1,895	4,297	3,400
40—45	1,961	1,378	3,435	2,530
45—50	1,438	875	2,464	1,498
50—55	1,295	824	2,161	1,572
55—60	899	600	1,586	1,252
60—65	1,113	940	3,194	2,569
65—70	1,183	1,087		
70—75	1,105	1,112	1,761	1,908
75—80	660	724		
80—85	239	360	247	431
85—90	104	174		
90—95	11	28	16	27
95+	4	6		
Unknown	1	1	3	—
Total	34,488	35,336	53,555	54,873

Statistics on Causes of Deaths, Japanese Empire

Influenza Deaths by 5 Year Age Gradation

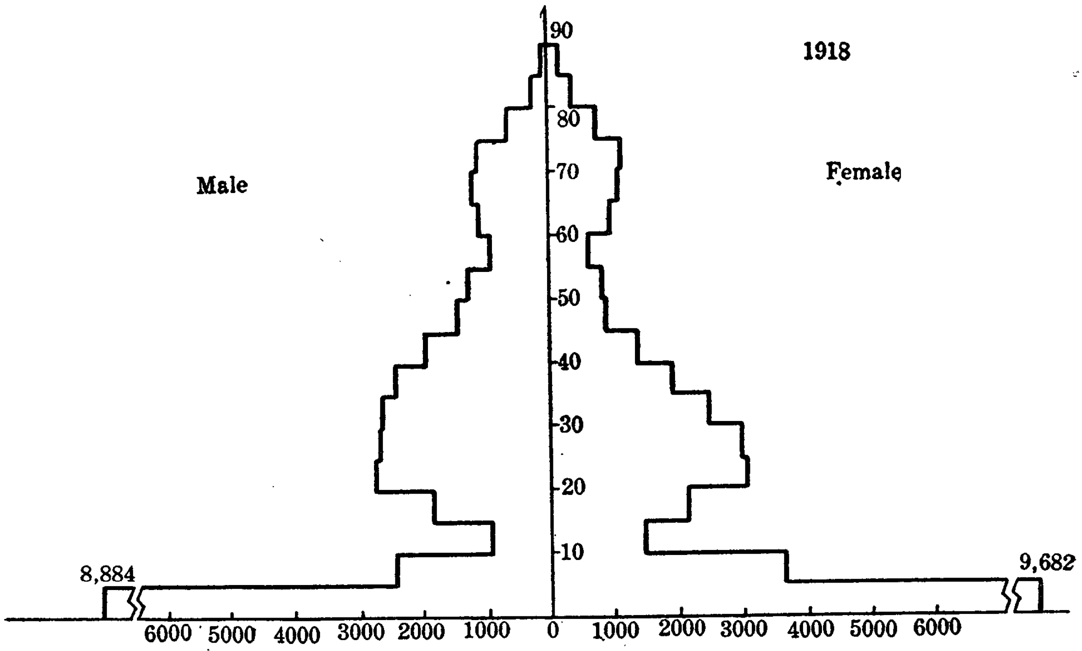

FIGURE 2·1

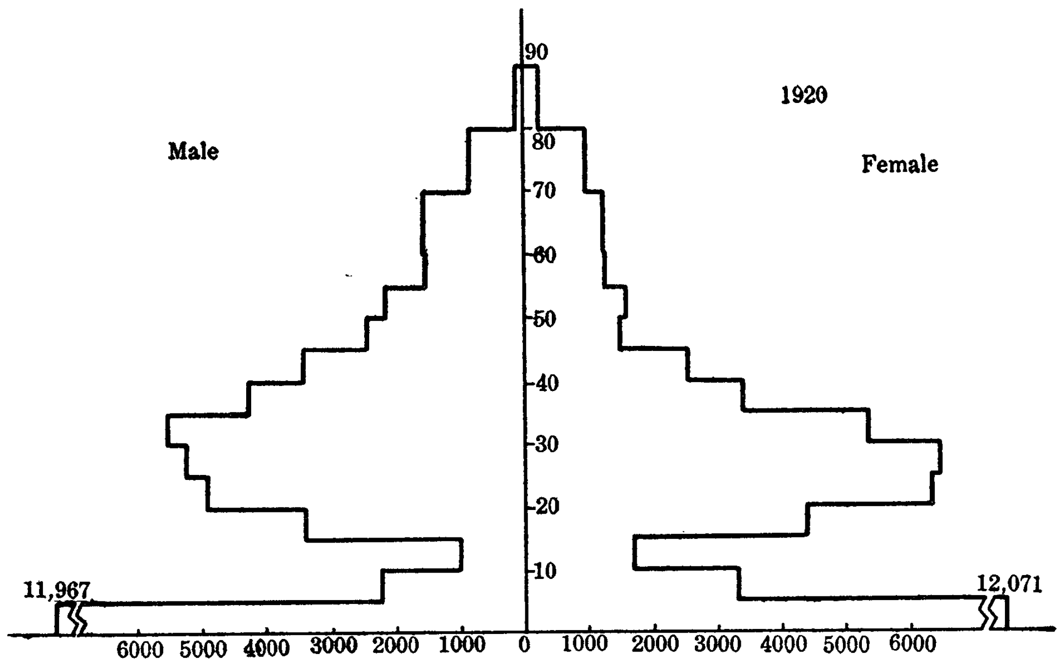

FIGURE 2·2

TABLE 5·2

SUPPOSED SURVIVORS IN 1920, ESTIMATED FROM INFLUENZA DEATHS IN 1918 AND 1920 (MALE)

Age 1918 $x-2$	Age 1920 x	Influenza Deaths 1918 D_{x-2} (1)	L_x/L_{x-2} (2)	(3) (1) × (2)	Influenza Deaths 1920 D_x (4)	(5) (3) + (4)	Year
28	30	523	.9839	514	1,088	1,602	1890
27	29	522	.9836	514	1,077	1,591	91
26	28	528	.9832	519	1,066	1,585	92
25	27	533	.9827	524	1,055	1,579	93
24	26	539	.9820	529	1,040	1,569	94
23	25	544	.9814	534	1,026	1,560	1895
22	24	550	.9810	539	1,011	1,550	96
21	23	512	.9806	502	996	1,498	97
20	22	474	.9804	465	982	1,447	98
19	21	437	.9806	429	922	1,351	99
18	20	399	.9812	392	862	1,254	1900
17	19	361	.9823	355	802	1,157	01
16	18	328	.9842	323	742	1,065	02
15	17	294	.9865	290	682	972	03
14	16	261	.9890	258	586	844	04
13	15	227	.9912	225	489	714	1905
12	14	194	.9927	192	393	585	06
11	13	253	.9936	251	296	547	07
10	12	311	.9938	309	200	509	08
9	11	370	.9935	369	251	620	09
8	10	429	.9930	426	302	728	1910
7	9	488	.9922	484	353	837	11
6	8	609	.9908	603	404	1,007	12
5	7	768	.9889	780	456	1,216	13
4	6	1,092	.9851	1,076	563	1,639	14
3	5	1,286	.9783	1,258	723	1,981	1915
2	4	1,459	.9669	1,411	911	2,402	16
1	3	1,672	.9491	1,587	1,259	2,846	17
0	2	3,375	.8905	3,005	1,620	4,625	18
	1				3,056	3,056	19
	0				5,041	5,041	1920

TABLE 5·3

BIRTHS ESTIMATED FROM INFLUENZA DEATHS (MALE)

Age	Year	Supposed Survivors in 1920 (5)	[E·D·C·B·A ·1/p_0] (6)	(7) (5) × (6)	Multipliers (8)	Births Estimated from Influenza Deaths (9) (7) × (8)
30	1890	1,602	1.7658	2,829	1.0388	2,939
29	91	1,591	1.7445	2,775	1.0388	2,883
28	92	1,585	1.7218	2,729	1.0388	2,835
27	93	1,579	1.6994	2,683	1.0388	2,787
26	94	1,569	1.6761	2,630	1.0223	2,689
25	1895	1,560	1.6526	2,578	1.0236	2,639
24	96	1,550	1.6270	2,522	1.0209	2,575
23	97	1,498	1.5987	2,395	1.0243	2,453
22	98	1,447	1.5701	2,272	1.0268	2,327
21	99	1,351	1.5481	2,091	1.0266	2,147
20	1900	1,254	1.5256	1,913	1.0270	1,965
19	01	1,157	1.4983	1,734	1.0244	1,781
18	02	1,065	1.4958	1,593	1.0205	1,637
17	03	972	1.4730	1,432	1.0205	1,461
16	04	844	1.4531	1,226	1.0204	1,263
15	1905	714	1.4387	1,027	1.0203	1,048
14	06	585	1.4266	835	1.0206	852
13	07	547	1.4053	769	1.0181	783
12	08	509	1.4092	717	1.0143	727
11	09	620	1.4179	879	1.0119	889
10	1910	728	1.3949	1,015	1.0084	1,024
9	11	837	1.3835	1,158	1.0083	1,168
8	12	1,007	1.3713	1,381	1.0070	1,391
7	13	1,216	1.3590	1,653	1.0046	1,661
6	14	1,639	1.3550	2,221	1.0046	2,231
5	1915	1,981	1.3389	2,652	1.0046	2,661
4	16	2,402	1.3260	3,187	1.0025	3,195
3	17	2,846	1.3056	3,716	.9996	3,715
2	18	4,625	1.2968	5,998	1.0005	6,001
1	19	3,056	1.2269	3,749	1.0011	3,753
0	1920	5,041	1.1273	5,683	1.0127	5,755

TABLE 5·4

SUPPOSED SURVIVORS IN 1920, ESTIMATED FROM INFLUENZA DEATHS IN 1918 AND 1920 (FEMALE)

Age 1918 $x-2$	Age 1920 x	Influenza Deaths in 1918 D_{x-2} (1)	L_x/L_{x-2} (2)	(3) (1) × (2)	Influenza Deaths in 1920 D_x (4)	(5) (3) + (4)	Year
28	30	578	.9800	567	1,161	1,728	1890
27	29	601	.9795	588	1,207	1,795	91
26	28	602	.9793	590	1,252	1,842	92
25	27	604	.9790	592	1,297	1,889	93
24	26	606	.9786	593	1,299	1,892	94
23	25	608	.9782	595	1,287	1,882	1895
22	24	610	.9777	596	1,282	1,878	96
21	23	572	.9774	559	1,277	1,836	97
20	22	534	.9772	522	1,272	1,794	98
19	21	496	.9773	485	1,194	1,679	99
18	20	459	.9777	448	1,115	1,563	1900
17	19	421	.9785	412	1,037	1,449	01
16	18	393	.9797	385	959	1,344	02
15	17	366	.9814	359	880	1,239	03
14	16	339	.9836	333	773	1,106	04
13	15	311	.9862	307	665	972	1905
12	14	284	.9887	281	557	838	06
11	13	372	.9907	369	450	819	07
10	12	461	.9918	457	342	799	08
9	11	549	.9922	545	406	951	09
8	10	637	.9921	632	470	1,102	1910
7	9	726	.9914	719	533	1,252	11
6	8	871	.9901	862	597	1,459	12
5	7	1,034	.9880	1,021	661	1,682	13
4	6	1,451	.9840	1,428	794	2,222	14
3	5	1,541	.9773	1,506	970	2,476	1915
2	4	1,734	.9662	1,675	1,327	3,002	16
1	3	1,853	.9490	1,759	1,542	3,301	17
0	2	3,103	.8969	2,783	1,907	4,690	18
	1				3,019	3,019	19
	0				4,276	4,276	1920

TABLE 5·5

BIRTHS ESTIMATED FROM INFLUENZA DEATHS (FEMALE)

Age	Year	Supposed Survivors in 1920 (5)	[E·D·C·B·A ·1/P_0] (6)	(7) (5) × (6)	Multipliers (8)	Births Estimated from Influenza Deaths (9) (7) × (8)
30	1890	1,728	1.7509	3,026	1.0246	3,100
29	91	1,795	1.7284	3,102	1.0246	3,178
28	92	1,842	1.7055	3,142	1.0246	3,219
27	93	1,889	1.6824	3,178	1.0246	3,256
26	94	1,892	1.6584	3,138	1.0256	3,218
25	1895	1,882	1.6344	3,076	1.0282	3,163
24	96	1,878	1.6097	3,023	1.0270	3,105
23	97	1,836	1.5827	2,906	1.0281	2,988
22	98	1,794	1.5554	2,790	1.0288	2,870
21	99	1,679	1.5323	2,573	1.0284	2,646
20	1900	1,563	1.5085	2,358	1.0289	2,426
19	01	1,449	1.4816	2,147	1.0265	2,204
18	02	1,344	1.4738	1,981	1.0225	2,026
17	03	1,239	1.4511	1,798	1.0225	1,838
16	04	1,106	1.4291	1,581	1.0220	1,616
15	1905	972	1.4114	1,372	1.0214	1,401
14	06	838	1.3959	1,170	1.0220	1,196
13	07	819	1.3749	1,126	1.0195	1,148
12	08	799	1.3757	1,099	1.0157	1,116
11	09	951	1.3809	1,313	1.0131	1,330
10	1910	1,102	1.3611	1,500	1.0087	1,513
9	11	1,252	1.3505	1,691	1.0079	1,704
8	12	1,459	1.3391	1,954	1.0072	1,968
7	13	1,682	1.3277	2,233	1.0051	2,244
6	14	2,222	1.3230	2,940	1.0051	2,955
5	1915	2,476	1,3076	3,238	1.0051	3,255
4	16	3,002	1.2952	3,888	1.0027	3,898
3	17	3,301	1.2743	4,206	.9996	4,204
2	18	4,690	1.2630	5,923	1.0003	5,925
1	19	3,019	1.1990	3,620	1.0007	3,623
0	1920	4,276	1.1125	4,757	1.0101	4,805

remodeled by the 5 year age moving average method into one of each age specification. In Table 5·2 is presented the result of the computation process described below:

D_{x-2}, the number of influenza deaths by age in 1918, was multiplied by (L_x/L_{x-2}), the survivorship ratio for the two years, 1918 and 1920, to obtain the possible number of surviving people on the assumption that those influenza deaths had not occurred. To this the number of influenza deaths by age in 1920, D_x, was added the following: $D_{x-2_{1918}} \times (L_x/L_{x-2}) + D_{x_{1920}}$. With this as the basis for our calculation, we obtained, by the same method as described in Section 3, the number of births during the 30 years from 1890 to 1920; they are

Births Estimated From Influenza Deaths

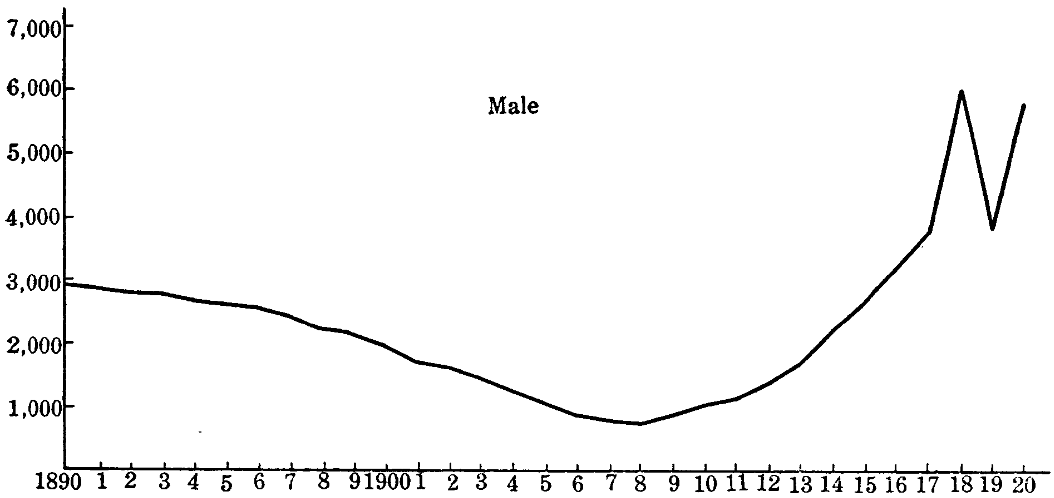

FIGURE 2·3

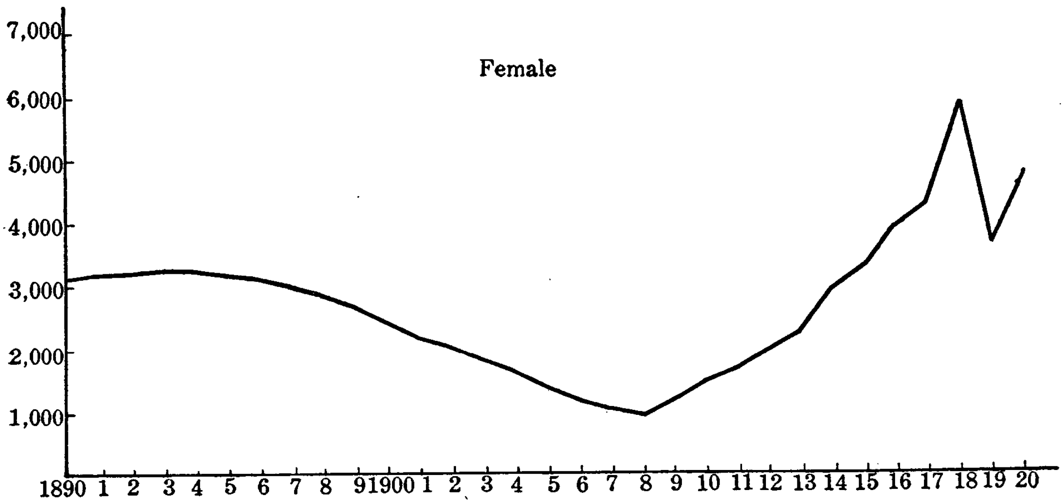

FIGURE 2·4

TABLE 5·6

ESTIMATED BIRTHS AND GENERAL FERTILITY RATES (INCLUSIVE OF INFLUENZA CASES), 1890–1920

Year	Births (Male) (1)	Births (Female) (2)	Total Births (3) (1) + (2)	Women (Ages 15-44) (4)	General Fertility Rate (5) = (3)/(4)	Sex Ratio (1)/(2)
1890	699,654	652,776	1,352,430	8,531,019	158.5	107.2
91	650,404	613,148	1,263,552	8,634,061	146.3	106.1
92	713,147	666,376	1,379,523	8,737,104	157.9	107.0
93	699,717	654,582	1,354,299	8,840,147	153.2	106.9
94	713,038	679,022	1,392,060	8,943,190	155.7	105.0
1895	738,543	702,567	1,441,110	9,046,232	159.3	105.1
96	735,726	710,182	1,445,908	9,142,741	158.1	103.6
97	743,052	709,826	1,452,878	9,239,252	157.3	104.7
98	779,544	760,029	1,539,573	9,335,761	164.9	102.6
99	753,796	729,042	1,482,838	9,432,272	157.2	103.4
1900	792,860	770,301	1,563,161	9,528,781	164.0	102.9
01	830,928	799,538	1,630,466	9,619,150	169.5	103.9
02	842,063	814,330	1,656,393	9,709,518	170.6	103.4
03	843,834	810,898	1,654,732	9,799,886	168.9	104.1
04	804,149	770,373	1,574,522	9,890,254	159.2	104.4
1905	804,265	773,612	1,577,877	9,980,623	158.1	104.0
06	791,034	750,867	1,541,901	10,089,738	152.8	105.3
07	875,020	838,399	1,713,419	10,198,853	168.0	104.4
08	905,329	863,202	1,768,531	10,307,969	171.6	104.9
09	937,019	904,785	1,841,804	10,417,084	176.8	103.6
1910	911,931	875,652	1,787,583	10,526,199	169.8	104.1
11	930,979	891,028	1,822,007	10,667,247	170.8	104.5
12	965,663	927,069	1,892,732	10,808,295	175.1	104.2
13	966,097	920,708	1,886,805	10,949,343	172.3	104.9
14	972,080	923,503	1,895,583	11,090,391	170.9	105.3
1915	934,428	924,448	1,857,461	11,231,439	165.4	101.1
16	948,124	903,296	1,851,420	11,384,049	162.6	105.0
17	918,394	909,281	1,827,675	11,536,657	158.4	101.0
18	917,950	887,081	1,805,031	11,689,267	154.4	103.5
19	879,023	876,230	1,755,253	11,841,875	148.2	100.3
1920	1,084,071	1,052,176	2,136,247	11,994,485	178.1	103.0

shown in Table 5·3. Similarly obtained results for females are presented in Tables 5·4 and 5·5. They are illustrated by Figures 2·3 and 2·4.

To estimate the general fertility rates, the same method as above was used for the women 15–44 years. With the application of the cohort life tables presented in Section 4, the estimates were made. These result, being added to the number of women in Table 4·4, are presented in Table 5·6(4), and the general fertility rates derived from them are presented in Table 5·6(5).

The final number of births calculated from the two census populations, 1920 and 1925, are presented in Tables 2·2 and 3·3. To these births were added the probable births estimated from influenza epidemic in 1918 and 1920, the results are shown by Figures 2·5 and 2·6. Also, the general fertility rates, including influenza cases, are shown by Figure 3·1.

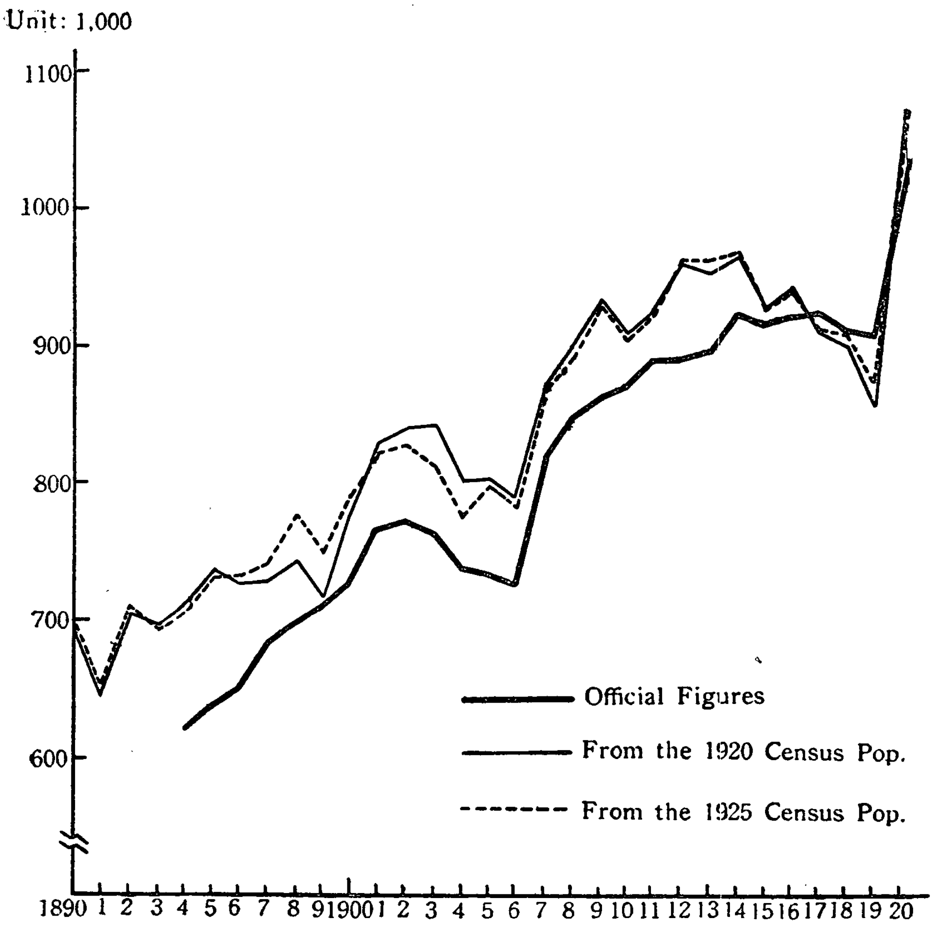

FIGURE 2·5
Estimated Births (Male), 1890–1920 (inclusive of influenza cases)

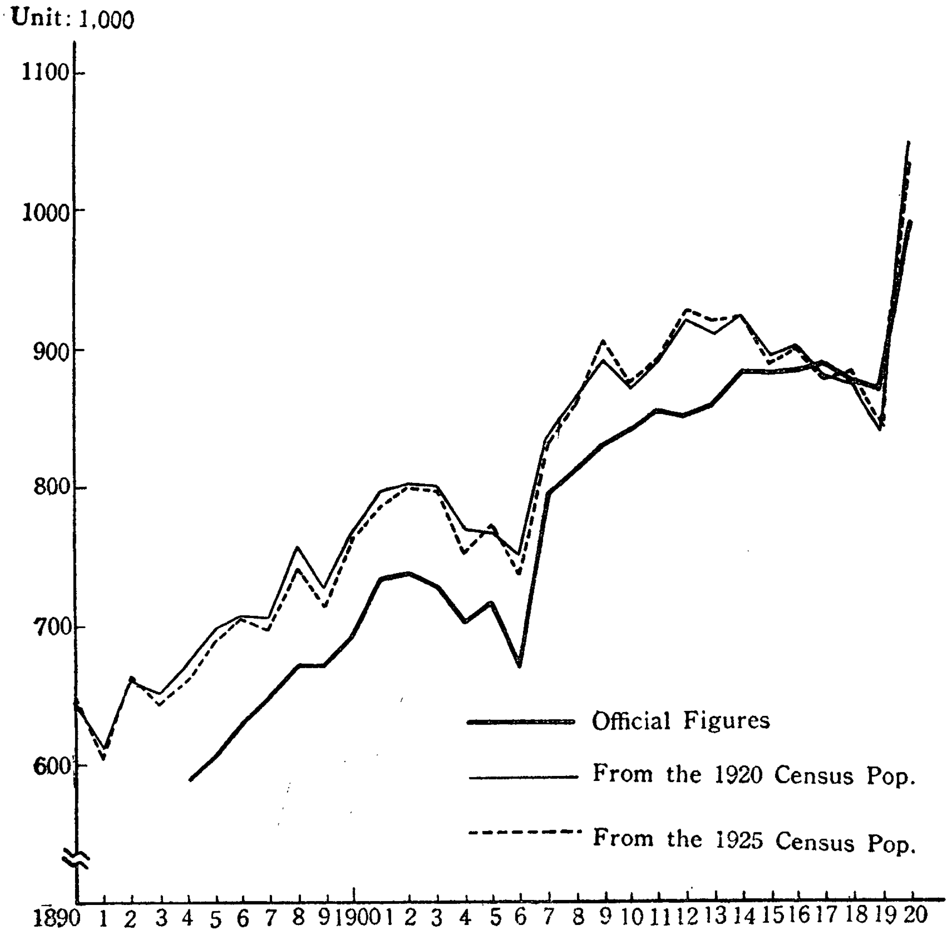

FIGURE 2·6

Estimated Births (Female), 1890–1920 (inclusive of influenza cases)

6. REFLECTIONS

The births ranging over the period from the middle part of the Meiji Era (Meiji Era: 1868–1912) to 1920, the 9th year of the Taisho Era (the Taisho Era is from 1912 through 1926) are shown in Figures 2·5 and 2·6. The estimated births are much larger than the official ones. It is interesting to note that these estimated births are in parallel to the official figures in trend, although they show distinctive difference from the latter in rising level.

In making these estimates, we used K. Matsuura's Life Tables and took a declining tendency of mortality rates for granted. So, these estimates, if considered in terms of the "demographic transition" pattern—an empirical law based on the evidence from West European countries—cannot be of use to prove the concomitance of economic development and a declining tendency of mortality rates. In other words, there is no way of ascertaining from this data, if the popu-

FIGURE 3·1
General Fertility Rate 1890–1920 (inclusive of influenza cases)

lation increase under our consideration was due to the decline of mortality rates. The point, therefore, which we should clarify now is if the fertility rates maintained a certain level or tended to decline, while we grant K. Matsuura's assumption that the continuous decline of mortality rates has actually happened.

Looking over the estimated general fertility rates, we find—roughly speaking, even if not in a smooth curve—that they tended to rise for the 20 years from 1890 to 1910 and began to decline in the decade from 1910 to 1920. This movement of general fertility rates, however, cannot be said equally true of the birth rates tendency unless it is examined in relation to the change in the age structure in the period under consideration. It seems we are permitted to admit this movement of general fertility rates to have happened to some extent with the birth rates too, as we can hardly perceive any sudden change in the age structure during the period.

With the completion of the general survey of the subject, it seems we should admit that the population increase of Japan was due to the decline of mortality effected through the economic development since the Meiji Era, but at the same time we cannot but consider that this population increase of Japan, different from the case of developed countries, was also due to the peculiar conditions of the country caused by the increase in the birth rates.

We must be aware that the Tokugawa period (1603-1867), when the population remained stationary at 30,000,000 mark, had social conditions that were very different from those that existed in the developed countries before the advent of modern economic life. Stating this as I do, I am in no way trying to answer the oft-discussed, enigmatic question: "What was the cause of the rapid economic growth of Japan since the Meiji Era.?" For from it I rather carefully refrain from making any remark on the subject.

The problem of migration was not taken up in this work. This omission was made not because we were afraid of complicating the resultant estimates, but because of the small number of emmigrants going out from Japan was so small that we could safely dismiss the matter in this sort of statistical work.

APPENDIX

IMPACT OF THE SUPERSTITION ATTACHED TO THE "HI-NO-E U-MA" YEAR ON THE SEX RATIO AT BIRTH IN 1906

Japan has been under the influence of Chinese culture for well over 1000 years. It is but natural, therefore, that the Japanese people should adopt the Chinese calendar in their day-to-day life. This calendar is evolved from various combinations of the five elements: wood, fire, earth, metal and water, with the twelve animals: mouse, cow, tiger, rabbit, dragon, snake, horse, sheep, monkey, hen, dog and boar. To provide a large number of combinations each element has also been sub-divided into two parts, the upper and the lower.

The year 1906 is represented by the combination the "upper part of the fire" (Hi-no-e) and the "horse" (U-ma) and is hence called "Hi-no-e U-ma." For generations there has been a widely prevalent superstition in Japan that a woman born in that year is bound to kill her husband when married. It is well known that because of this superstition a large number of female births during January-February and November-December, 1906 were, for example, registered by the parents in December, 1905 and January, 1907 respectively. This accounts for the high sex-ratio at birth of 108.7 in 1906 flanked by a low figure of 102.7 in both the years 1905 and 1907. Incidentally it may be mentioned here that the "Hi-no-e U-ma" year comes once every 60 years. Of late it is observed that the superstition attached to the "Hi-no-e U-ma" combination is weakening gradually.