Chapter Title: Mortality, Fertility, the Size-Age Distribution, and the Growth Rate

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Mortality, Fertility, the Size–Age Distribution, and the Growth Rate

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THIS study deals with the ways in which the components of population change are related to growth and age composition. In general all of these relations and their sources are sufficiently obvious. They turn on a few basic facts of life. Birth is the beginning of life and death its termination, but death occurs at every age, whereas all births occur at age zero. It follows that a rise in the birth rate tends both to lift the rate of growth and to increase the proportion of children in the population. On the other hand, whereas falling death rates also tend to increase growth, their effect on the age composition of the population depends on the age incidence of the change in the risks of dying. In the past, peace-time reductions in mortality have had an age incidence that affected the age composition of the surviving populations rather little, tending to increase slightly the proportions in the youngest and oldest ages in a manner that on balance generally somewhat *reduced* the average age of the population.[1]

Basic Patterns in Population Change

Another basic element is the fact that vital events have rather definite age patterns. The human female seldom gives birth before 15 or after

50 years of age, and, within these ages, the rate of childbearing rises rapidly to its maximum between 20 and 30 and thereafter falls off sharply. There is also a typical pattern in the risks of death, which are high in infancy and early childhood, decline to a minimum between 10 and 15 years, rise at first rather gradually and then with progressive speed. Migration, like death, can occur at any age, but has, in fact, a typical pattern of heavy concentration between ages 15 and 35. Obviously, the effect of migration on the growth and age of a particular population depends on the direction, magnitude, and duration of the movement.

In addition to these specific components of growth, there are their interrelations. From the point of view of a particular population, all persons born must eventually emigrate or die, and, before doing either, may have one or more offspring. Those who immigrate may also produce offspring before they emigrate or die. By contrast, death has no subsequent direct relation to the other vital processes. The secondary consequences, however, may be quite important, as, for example, when a shortage of males produced by war casualties increases the proportion of spinsters and reduces the number of births.

Finally, it is evident that the rates of birth, death, and natural increase are sharply influenced by the age composition of the population, as well as by the age specific risks of bearing and dying. At any given instant, the size and age composition of the population is the resultant of the fluctuating rates of birth, death, and migration during its past history.

With so many determinants of growth, each possessing substantial possibilities for variation in direction, magnitude, and age incidence, the number of possible combinations becomes indefinitely large. In principle, the range of possibilities presents formidable barriers to systematic analysis. In fact, however, the problem is more manageable than it appears to be because of the ways in which the variables have operated.

In many countries, emigration has been negligible. In most of the underdeveloped countries fertility has been both high and relatively invariant. Throughout most of the world, mortality has been falling, and in many instances during recent decades it has been falling very rapidly. In many of the underdeveloped countries, therefore, the combination of negligible emigration, high fertility, and falling mortality is producing progressively rapid population growth. Moreover, for reasons already noted, these mounting rates of population growth have been coupled with rising proportions of the population in the ages of young dependency.

The situation in the developed areas stand in sharp contrast with that of the underdeveloped areas. In the latter, mortality has been the

principal variable. Its trend is almost universally downward in a fashion that has a marked effect on the rates of increase but slight effect on the age composition. In the developed countries, on the other hand, fertility is the principal variable. During recent decades, in some countries, it has moved more or less steadily down; in others, it has moved down and then sharply up. In still others, it has moved down, then sharply up, and then down again. Moreover, these movements, affecting as they do inputs at the beginning of the age span, sharply modify both the rate of growth and the age composition of the population. It would require a variety of models, therefore, to illustrate the interaction of vital trends, growth and age structure in the developed countries during recent decades.

Developments in the United States between 1930 and 1955

In the face of this complexity, the simplest approach to the interaction of vital rates and population growth and structure in the developed countries is by means of specific illustrations. In what follows we shall be concerned with developments between 1930 and 1955 in the female population of the United States. The female population is selected instead of the total, both to save computation and to avoid the complexities of dealing with troops overseas and with war casualties. A similar analysis for the male or the total population would give essentially similar results.

The influence of each element of change between 1930 and 1955 may be shown by comparing the actual trends of population with successive projections of hypothetical trends that depart from the actual situation by the alteration of specific components of change. In this manner we can illustrate the effect of the 1930 age distribution on subsequent growth, and show the effect of migration, changes in mortality, and changes in fertility on both the trends between 1930 and 1955, and the size and composition of the population in 1955.

This system of projections has been carried out by rough and ready methods which are sufficiently precise to serve present purposes. The initial 1930 population, for example, has been adjusted for the under-enumeration of children from birth to age 5, but left otherwise uncorrected for even obvious deficiencies. Similarly, fertility rates between 1930 and 1955 have been adjusted for underregistration of births, but fertility rates that run from January to January have been used, although the census figures run from April 1930 to April 1955. Moreover, instead of using annual age specific fertility rates, births have been estimated from general fertility rates for successive quinquennial periods. Surviving populations

have been moved forward in quinquennial age groups five years at a time by means of survival ratios interpolated from available life tables, so that annual variations in mortality have been left out of account. It has been assumed, without serious violation to the facts, that there was no migration between 1930 and 1940. Thereafter, the estimates of migration used by the Bureau of the Census have been used, often with rather drastic interpolation to fit the necessary time periods.

The projected estimates yielded by such procedures are not closely calibrated, but neither are they grossly in error in ways that distort the comparisons needed for present purposes. There has been no attempt to close with the censuses of 1940 and 1950 or with the official estimates for 1955. Chart 1 permits the comparison of the female population, as

CHART 1
U.S. Female Population, 1955
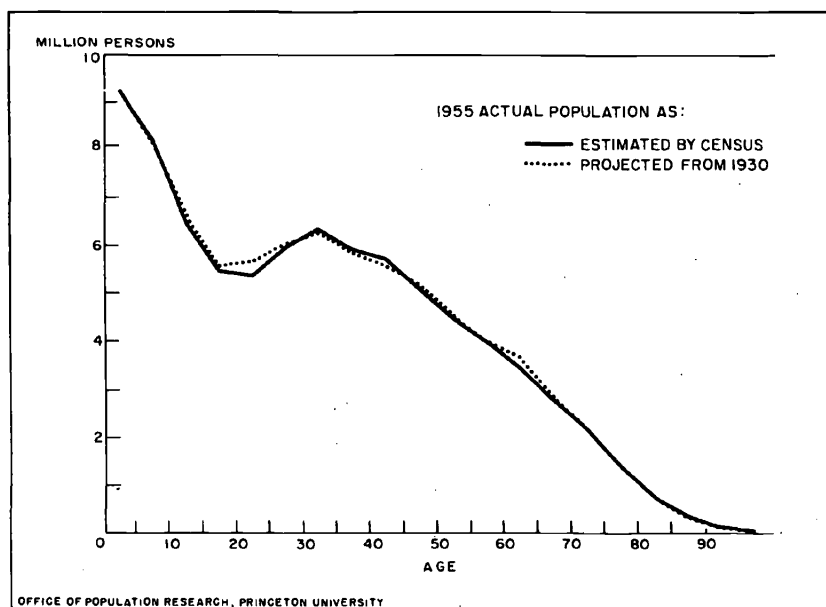
interpolated to April 1955 from the census estimates, with our estimate of the population for that date obtained by projecting the 1930 population with actual migration and fertility and mortality rates for 1930–1955. Panel A of Chart 3 permits analogous comparison for the total female population between 1930 and 1955.

The projected estimates of the actual situation are a trifle high, but it would be difficult to say which of the two results depart further from the truth. The most conspicuous disagreement between the projected figures and the census estimates falls in the group aged 20–25 in 1955, hence that born between 1930 and 1935. This is the least reliable period of birth registration with which we are concerned. A considerable part of the excess population projected for that group may well come from an over-generous allowance for incomplete registration in those years. There is a bump in the projected figures between ages 60 and 65 which is clearly the attenuated reflection of the corresponding bump between ages 35 and 40 in the 1930 census. The projected figures for the ages over 80 in 1955 fall below those of the census, which are almost certainly inflated by exaggeration of age.

Whatever the sources of the discrepancies between the census estimates and the estimates projected from 1930 for the actual population in 1955, it is clear that both series tell the same story. In the remainder of the paper, for consistency's sake, the "actual" population will be represented by the values obtained by projecting the actual course of events from the 1930 census.

Before turning to an examination of the components of change between 1930 and 1955, it should be noted that the results reflect the events of a specific period. Had we dealt with the first thirty years of the century the answers would have been sharply different. Both migration and the decline of mortality tended to increase the speed of growth. Their influence, however, was more than canceled by the steady decline of the birth rate, which was also the source of the rapid aging of the population. Between 1930 and 1955, by contrast, migration was very small and the birth rates moved first down, then up. The gains from rising birth rates canceled the losses of the earlier fall. If the study had closed with 1958 instead of 1955 the gains due to the rise of the birth rate would have been considerably larger than those presented below. In short, this analysis illustrates the principles of change, but the specific results relate only to the period under study.

The object of Chart 2 is to illustrate the extent to which the size and age composition of the 1955 population depended on the age composition of the population in 1930. Panel A shows the 1955 distribution and that for 1930, from which it developed. The relatively small number aged 0–4 in 1930 reflects the fact that births were less numerous between 1925 and 1930 than in the preceding five years. The survivors of this smaller group, born in the years 1925–1930, plus a few immigrants, appear between ages 25 and 30 in 1955. The deeper trough for the younger ages in the 1955 curve reflects the still smaller birth classes of the years 1930 to 1940. The very much larger numbers below age 15 in 1955 are

CHART 2

Effect of 1930 U.S. Age Structure on 1955 Female Population

MILLION PERSONS

A

1930 POPULATION:
•••••••• ACTUAL
———— GIVEN THE STABLE AGE
DISTRIBUTION DERIVED FROM
VITAL RATES OF 1929-31

1955 POPULATION
———— ACTUAL AS PROJECTED
FROM 1930

B

1955 POPULATION:
———— ACTUAL AS PROJECTED
FROM 1930
———— PROJECTED FROM 1930
STABLE AGE WITH ACTUAL
VITAL RATES & MIGRATION

AGE

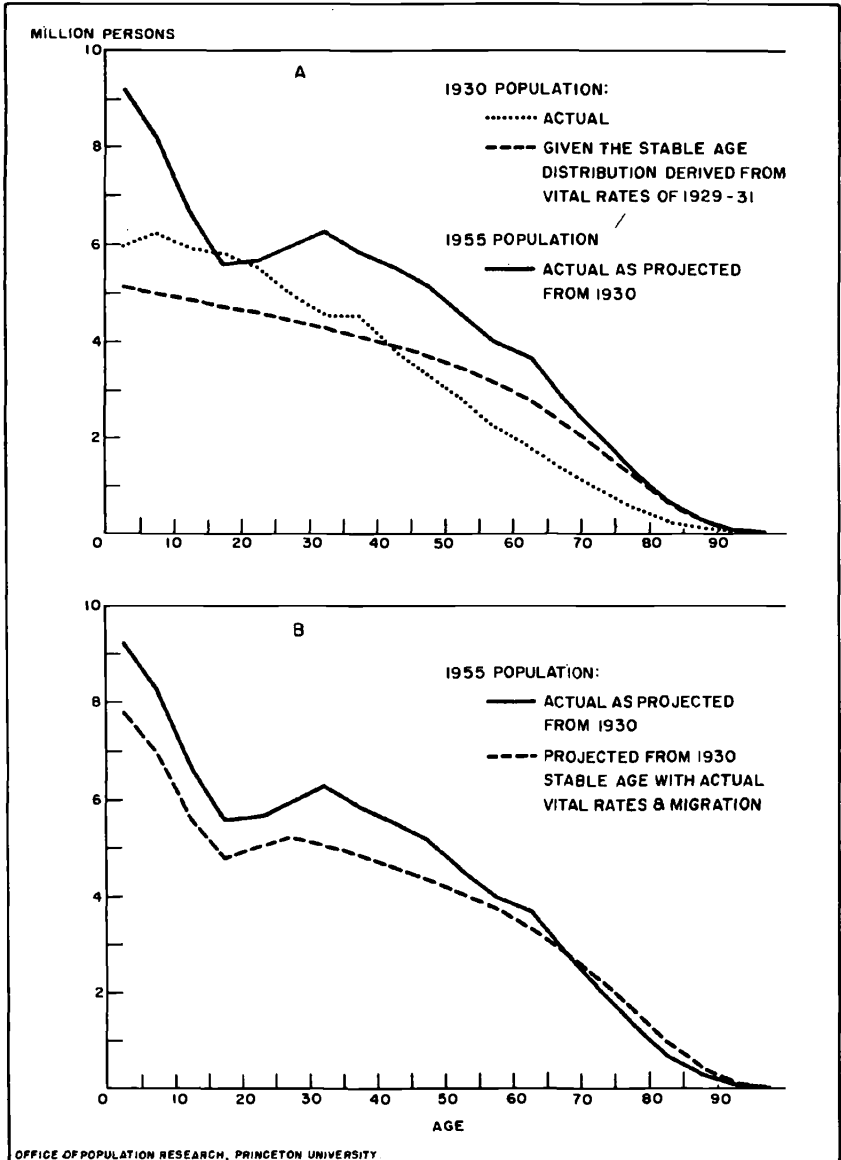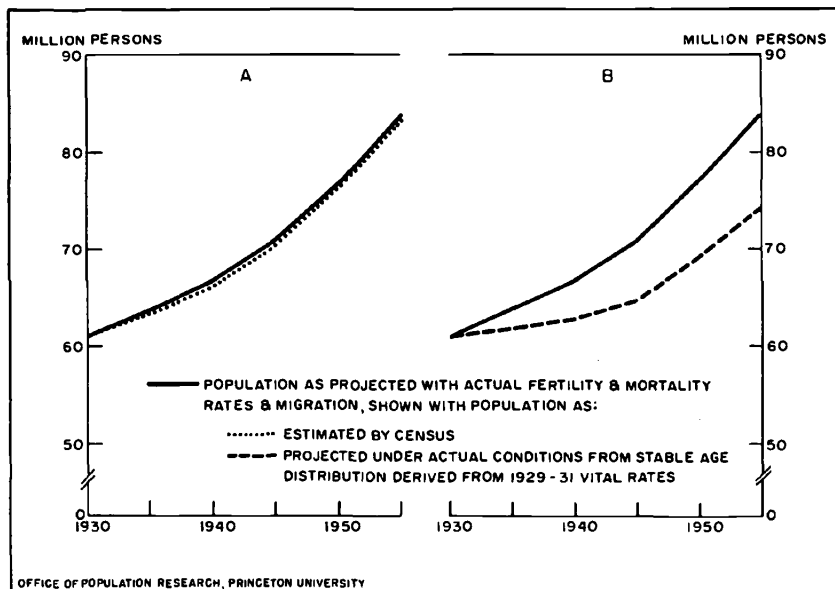OFFICE OF POPULATION RESEARCH, PRINCETON UNIVERSITY

266

CHART 3

Effect of 1930 U.S. Age Structure on 1930–1955 Female Population Size

the result of the sharp war and postwar recovery of the birth rate. Clearly below age 25 the distribution of the 1955 population has been primarily determined by the drastic changes in the course of the birth rate between 1930 and 1955. The actual course of vital rates from 1930 on would have yielded something of the same general pattern in 1955 had it started from any plausible age distribution in 1930.

How much then would the course of events have differed if the actual trends had started from a 1930 population of the same size but a different age composition? Since there is an infinite number of possibilities there is an infinite number of answers. There is no population that is the most reasonable alternative to the actual one. To gain some insight into the influence of the initial age distribution, the stable age distribution obtained from the vital rates of 1929–1931 has been selected as a standard of comparison. This amounts to the age distribution that U.S. females would have had in 1930 if, prior to 1930, the age specific risks of bearing and dying had been fixed at the levels that characterized the years 1929–1931, and there had been no migration. This hypothetical population for 1930 was then projected to 1955 with actual migration and fertility and mortality rates. The difference between the hypothetical

course of events for 1930 to 1955 and the actual one shows the lingering consequences of pre-1930 variations in fertility and migration, which had given the 1930 age distribution its particular structure. Panel B of Chart 2 shows that under these circumstances the 1955 population would have been considerably older than it actually was. Panel B of Chart 3 shows that growth would have been much slower and the 1955 total female population would have been some 10 million smaller than it actually was in 1955. In short, the general shape of the 1955 population under 25 years of age was mainly determined by the course of events after 1930, but both the rate of growth between 1930 and 1955 and the youth of the population in 1955 are due in part to the fact that events prior to 1930 had left the population with rather large proportions in the childbearing ages.

Panel A of Chart 4 permits comparison of the actual trend of the total female population between 1930 and 1955 with the hypothetical trend that results from projecting the 1930 population without migration or change in vital rates from the levels characterizing 1929–1931. Successive panels permit tracing the differences shown in Panel A to their source. Each shows the actual trend and the trend as projected under actual conditions except for a single variable. In the hypothetical case of Panel B there is no migration between 1930 and 1955, in that of Panel C the mortality rates are constantly those of 1929–1931, and in that of Panel D the fertility rates are constantly those of the same base period. Migration and changes in vital rates made rather little difference in the size of the population until 1945, but a growing difference thereafter. By 1955 they had given us some 9 million additional females. It is evident that the effect of migration was rather small, and that the principal gain from changes after 1930 was from the decline of mortality. This decline in the risks of death after 1930 had added some 5 million females to the population by 1955. Changes in fertility were more complicated, since birth rates dropped below the 1929–1931 level during the 1930's and rose sharply in the 1940's and 1950's. A maintenance of the fertility of 1929–1931 throughout the period would have given us a larger female population each year up to 1950.

The net change in the female population from 1930 to 1955 and its sources are shown in Chart 5 for all ages and for each of four broad age groups.[2] Between these two dates the female population grew by about

[2] It is to be noted that the sum of the individual effects of migration, changes in mortality, and changes in fertility as measured here should exceed the total departures from the actual situation from all sources combined which are obtained from the difference between the projection for the actual situation and that which assumed no migration and

CHART 4

Effect of Vital Rates and Migration on U.S. Female Population Size, 1930–1955

MILLION PERSONS   MILLION PERSONS

POPULATION AS PROJECTED UNDER ACTUAL CONDITIONS SHOWN WITH:

A

B

PROJECTED USING FERTILITY & MORTALITY RATES OF 1929-31, NO MIGRATION

ACTUAL AS PROJECTED EXCEPT NO MIGRATION

C

D

ACTUAL AS PROJECTED EXCEPT USING 1929-31 MORTALITY RATES

ACTUAL AS PROJECTED EXCEPT USING 1929-31 FERTILITY RATES

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the maintenance of 1929–31 vital rates. The sum of the differences between the actual population and the projections in which only single factors depart from the actual situation incorporates too much allowance for the interaction of change. The results show the expected discrepancies which, however, are trivial above age 45, where only the interactions of migration and changes in mortality were involved. The discrepancies have been proportionately distributed to equal the total from all factors combined. The required adjustments are not large. The opposite difficulty would have been encountered if the influence of each factor had been measured by the difference between the projection incorporating the changes in that factor and that which provided for no change in any factor. In that case there would have been no allowance for the interaction of change.

CHART 5

Components of Change in U.S. Female Population, by Age, 1930–1955

CHANGE IN MILLIONS

24
ALL AGES

1930–1955 POPULATION CHANGE:*

DUE TO MIGRATION

20

DUE TO CHANGE IN MORTALITY

CHANGE IN MILLIONS

16

DUE TO CHANGE IN FERTILITY

AGES

0–16   17–44   45–64   65+

8

12

6

8

EXPECTED WITH NO MIGRATION & 1929-31 VITAL RATES

4

4

2

0

0

*CHANGES DUE TO INTERACTION OF CHANGES IN FERTILITY, MORTALITY, & MIGRATION WERE PROPORTIONATELY ALLOCATED

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23 million. Of this 23 million increase, 14 million, or about 60 per cent, would have occurred even if fertility and mortality had remained unchanged after 1930 and there had been no migration. The remaining 8.7 million increase is accounted for by 5 million from reduced mortality, and a little less than two million each from migration and increased fertility.

About 50 per cent of the total increase attributable to migration and changes in vital rates falls in the group under 17 years of age in 1955. Indeed, just the rise in fertility accounted for an additional 2.5 million in that group, whereas the earlier decline in fertility below the 1929–1931 level reduced the number of persons aged 17–44 by about 0.8 million. On the other hand, half of the increase due to migration fell in the age group 17–45 years. The numerical gains due to declining death rates were a little larger in the two groups under age 45 than in the two older

groups, but increases from this source were much the most evenly distributed of all.

Chart 6 presents the same series of projections for the age distributions of 1955. Panel A shows the distribution of the actual female population of 1955, and the hypothetical distribution derived from the assumption of no migration or change in vital rates after 1930. The successive panels permit the comparison of the actual distribution with hypothetical distributions obtained from projections of the actual course of events except for a single variable. The hypothetical population of Panel B assumes no migration after 1930, that of Panel C assumes a continuation of 1929–1931 mortality rates, and that of Panel D the continuation of 1929–1931 fertility rates.

Migration and changes in vital rates after 1930 produced marked changes in both the size and the age composition of the 1955 population. The influence of migration was small and concentrated under age 55. Under age 20, the differences in the two lines represent births to migrants as well as migrants themselves. Panel C brings out clearly the fact that reductions in the risk of death since 1930 have saved many lives, and that these changes have had very little effect on the age distribution. It is changes in fertility that have brought the major shifts in the age structure of the population. With the fertility rates of 1929–1931 we would have had some two million fewer girls under 5 years of age than were present in 1955.

For purposes of economic analysis, the shifts in the age structure of the population may be generalized in terms of the ratio of the population in the ages of dependency to the population in the working years of life. Without too much violation of the facts we may classify the population under age 17 and over age 65 as dependents, and that between ages 17 and 65 as workers. Chart 7 presents this "ratio of dependents to workers" over the period 1930 to 1955 for the array of actual and hypothetical populations with which we have been dealing.
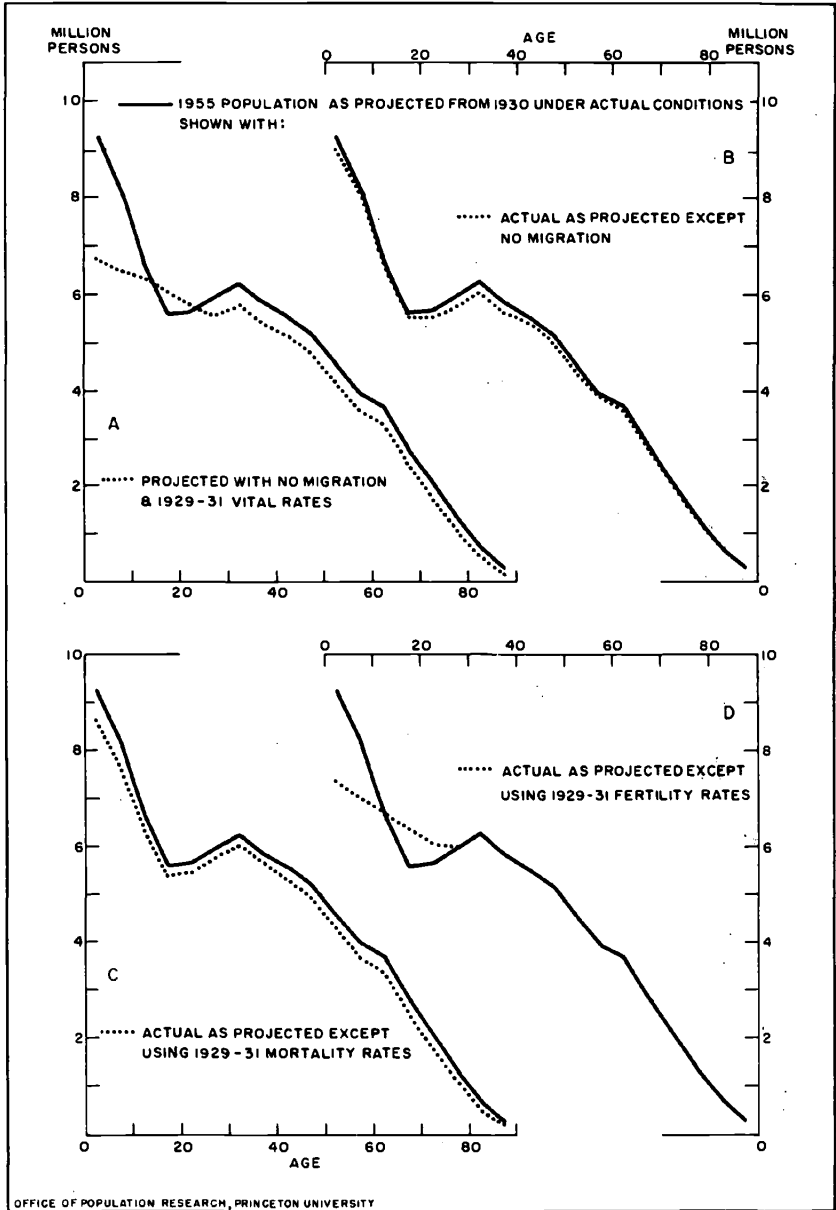
In the actual population, the ratio dropped sharply from 1930 to 1940, was steady during the war, and rose even more sharply to 1955, when it was well above the 1930 level at 68 per cent. The trend was sharply downward during the great depression, and even more sharply upward during the postwar inflationary years. Panel A shows that, if we had had neither migration nor change in vital rates after 1930, the dependency ratio would have been higher through 1945, but substantially lower by 1955.

The influence of migration on the ratio is too small to be shown

CHART 6

U.S. 1955 Female Population Under Various Assumptions, by Age

MILLION
PERSONS

AGE

MILLION
PERSONS

—— 1955 POPULATION AS PROJECTED FROM 1930 UNDER ACTUAL CONDITIONS
SHOWN WITH:

B

······ ACTUAL AS PROJECTED EXCEPT
NO MIGRATION

A

······ PROJECTED WITH NO MIGRATION
& 1929-31 VITAL RATES

D

······ ACTUAL AS PROJECTED EXCEPT
USING 1929-31 FERTILITY RATES

C

······ ACTUAL AS PROJECTED EXCEPT
USING 1929-31 MORTALITY RATES

AGE

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CHART 7

Effect of Changing Vital Rates and Initial Age Structure on Ratio of Females in Dependent Ages to Females in Working Ages, U.S., 1930–1955
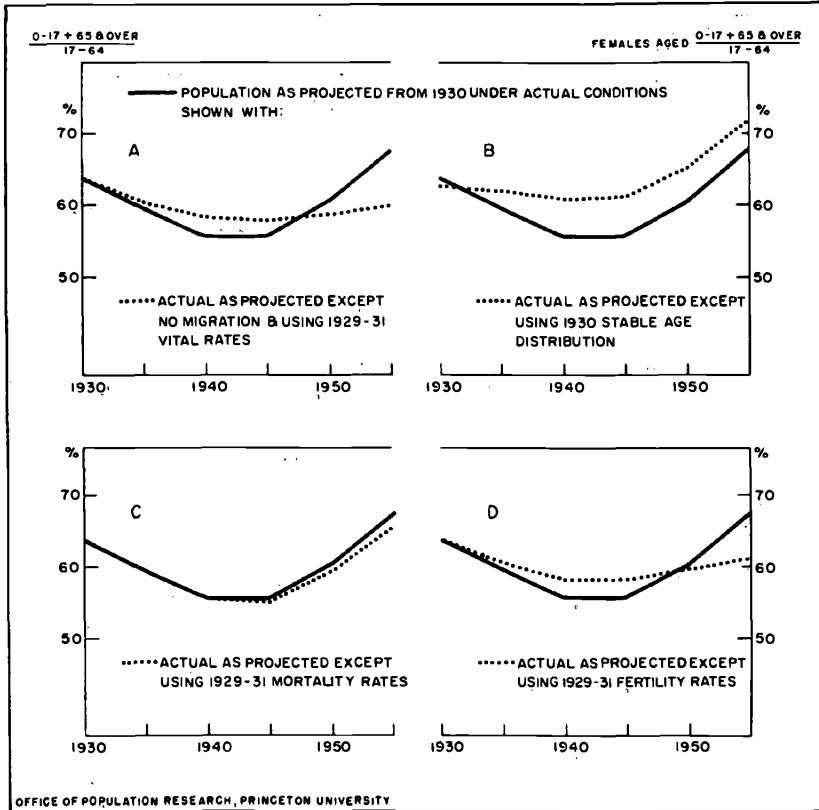
graphically. Panel B presents the comparison of the actual trend with the hypothetical trend that comes from projecting the stable age distribution of 1929–1931 with actual migration and vital rates from 1930 on. Much of the decline in the ratio to 1940 was locked up in the 1930 age distribution, as a product of the vital trends and migration before that date. The dependency load from 1935 on has been substantially lighter than would have been the case if our population had had a stable age structure in 1930.

In Panel C the hypothetical population is real except that the mortality is held to the level of 1929–1931. The reduction of death rates since 1930 has tended to expand the population at each extreme of life a little

more rapidly than in the middle years. Lower risks of death have somewhat increased the dependency load.

Panel D shows clearly that a major source of the dip and rise in the ratio has been the change in fertility. The hypothetical population in this case is real except that fertility is held constant at the 1929–1931 level. Both the decline in the ratio during the 1930's and its rise during the postwar years would have been much less sharp if fertility had remained constant at the 1929–1931 level.

Trends in Other Developed Countries

As already pointed out, the trends considered here are specific to the time and place. Even in the years since 1930 the experience of many developed countries has differed sharply from that of the United States. The decline in peacetime mortality has been very general, but it has stimulated population growth without substantially altering the age distribution. A prominent exception is the changed age structure in nations that suffered heavy casualties during the war. Some nations have also experienced heavy immigration and some emigration in ways that alter both numbers and age structures.

The nations of Western Europe and the English-speaking countries outside of Europe have generally experienced prolonged declines in the birth rates which were checked toward the end of the 1930's and reversed sharply after the end of the war. In some the birth rate declined again, but the usual result is a changing age structure somewhat similar to that which we have experienced with different details and magnitudes.

The large birth classes of the years prior to the first World War are often to be found expanding the labor force during the depression years when the ebb of births was sharply checking the expansion of population in the dependent ages. Even more generally in the prosperous years following World War II the small birth classes of the depression years were yielding only a slow expansion of the population in the working ages, precisely when numbers in the childhood ages were mounting rapidly.

It is not the purpose of this paper to allocate cause and effect relations among demographic and economic factors. Here we need only point out the fact that the depression came at the same time as the sharp decline in dependency ratios, and that the postwar prosperity came at the same time as the sharp rise in that ratio. Indeed, since fertility is under widespread voluntary control, the same perverse association of economic and demographic variables might be expected again if we were to undergo a

prolonged and deep depression, followed in fifteen or twenty years by high levels of prosperity. That is about the time required for the births of the ebb to enter the labor force of the flow.

For the developed economies, about the only safe generalizations are the obvious ones:

1. The size and age composition of a population are heavily influenced by its size and age composition a quarter of a century earlier.

2. The rate of growth can be sharply modified by changes in the course of migration, mortality and fertility in a twenty-five year period.

3. The age composition has been little affected by changes in mortality, but with death rates as close to zero as they now are at ages under 45, the period for which this proposition can be confidently stated is drawing to a close.

4. In countries of low mortality, barring major catastrophe and major migration, changes in fertility provide the most important source of change in both the rate of growth and the age composition.

5. The continuation of a very low mortality and medium fertility, such as that which characterizes the United States at present, yields both rapid growth and high burdens of dependency as conventionally defined.

COMMENT
JOHN V. GRAUMAN, United Nations

Notestein's presentation is so effective and so self-contained that I can add very little while staying within its scope. If my comments are to contribute to discussion, I have no choice but to range beyond the subject treated in the paper.

Within the space allotted to me, I hope to be able to make four points:

1. Developments in other industrialized countries have been quite diverse;

2. Much use can be derived from the observation that age structures are very little affected by ordinary changes in mortality;

3. The age structure of the United States population provides good material for the study of causal relationships between economic and demographic trends;

4. For the further progress of demographic science, it is becoming desirable to study the structural dynamics of population also in terms other than age.

First Point: Other Countries

Notestein's paper makes it very clear that changes in fertility, mortality, and migration all have their effects on the rate of population growth, but

that changes in fertility alone have major effects on population age structure. In industrialized countries, mortality is now so low that its further decline cannot be very rapid, but fertility is apt to fluctuate substantially. In a population of large size, migration is unlikely to have large effects.

The forces which have determined population growth and structure in the United States have also been at work, with varying intensity, in other industrialized countries. The effects, however, have been quite diverse, as illustrated in Chart 1. In this chart, the female population of various countries is shown by five-year age segments as percentages of total female population. Two graphs are superimposed wherever the comparison seemed to be particularly interesting.

The first panel shows the populations of the United States and Australia, which are at opposite poles of the earth. Despite the geographical distance, the structures are so similar that one population can be easily mistaken for the other. Australia has been more affected by immigration than the United States, but the birth rate trends in the two countries have been very similar.

The second panel shows the age structures of two close neighbors: Austria and Yugoslavia. They diverge conspicuously. Birth rates in Austria have long been very low and fluctuating. Yugoslavia's birth rate, though declining, is still comparatively high. One might attribute the difference to the fact that Austria has been more industrialized than Yugoslavia. But this is not the only reason.

France and Italy are compared in the next panel. The size of the age group 0–4 shows that both countries have now about the same crude birth rate. But this birth rate results in France from a smaller proportion of women in childbearing ages than in Italy. French women are now more fertile than Italian women. But France has long been more industrialized than Italy. Because of its larger proportion of aged persons, France has a higher death rate than Italy, though specific death risks are no lower in Italy than they are in France.

The last panel compared the populations of Sweden and Japan. Sweden, relatively little affected by wars, shows perhaps the most typical trend for a Western population. Here, a recovery of the birth rate around 1940 has now definitely ebbed away, and fertility is again very low. In Japan, since quite recently, fertility is now as low as in Sweden. Because of age structure, Japan has a higher birth rate and a lower death rate than Sweden.

CHART 1

Per Cent Age Distributions
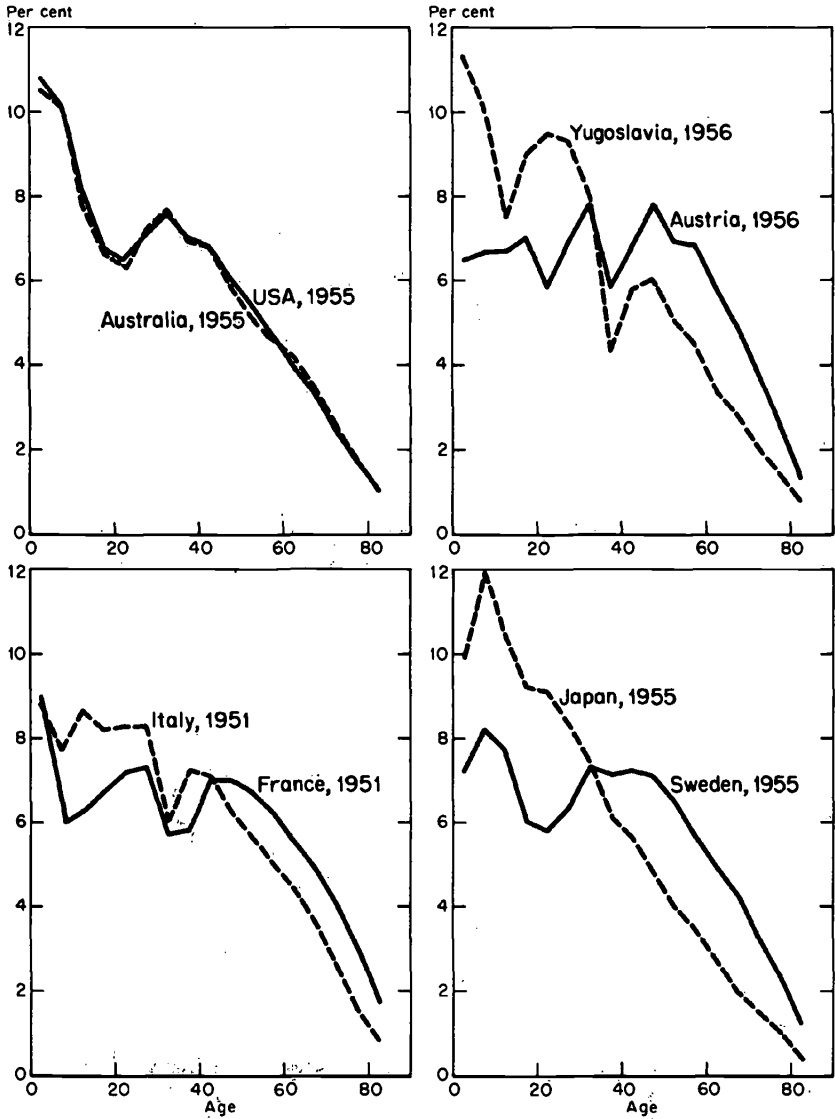
Second Point: Mortality Hardly Affects Age Structure

Notestein's paper shows that the decline of United States mortality has had very little effect on age structure. This observation is very useful because it can be widely generalized. As Coale and Bourgeois-Pichat[1] have demonstrated, the age structure of almost any population is very nearly the same as it would be if mortality had always been at the level attained most recently.[2] Therefore, under most practical conditions, the effects on age structure of higher mortality rates in the past can be almost discounted.

This observation has been used in the work of the United Nations dealing with the populations of underdeveloped countries. In most underdeveloped countries, mortality is declining but birth rates have changed very little, if at all. Since mortality has little effect on age structure and fertility has varied little, the age structures in underdeveloped countries are very similar to those of populations having constant mortality and constant fertility. A system of such stable populations has been calculated at the United Nations from model life tables and has found many uses in population estimates for underdeveloped countries.

For rough-and-ready comparisons, stable population models can also be used in the case of a country like the United States in 1955, whose birth rate has been fluctuating. I will presently show how this can be done.

A population model can be selected according to a level of fertility and a level of mortality. In the United States, expectation of life at birth now approaches 70 years. This level of mortality is also assumed in the model.

United States fertility has fluctuated recently from a gross reproduction rate of only slightly above 1.00 in the 1930's to one approaching 1.75 in the 1950's. Both fertility levels are relevant and the population models of such fertility are shown in Chart 2. The structure of the actual population differs considerably from either of the two extreme models.

Between these extremes, a fertility level can also be selected for a model to represent some reasonable average of recent conditions. The sum of absolute deviations of the actual population from the model was found

[1] Ansley J. Coale, "How the Age Distribution of a Human Population is Determined," *Cold Spring Harbor Symposia on Quantitative Biology*, 1957, J. Bourgeois-Pichat, International Statistical Institute, Stockholm, 1957.

[2] The coincidence of actual age structure with that which would have resulted had current mortality also prevailed in the past is not perfect, but discrepancies are seldom large, except at the most advanced ages.

CHART 2

U.S. Females and Stable Populations
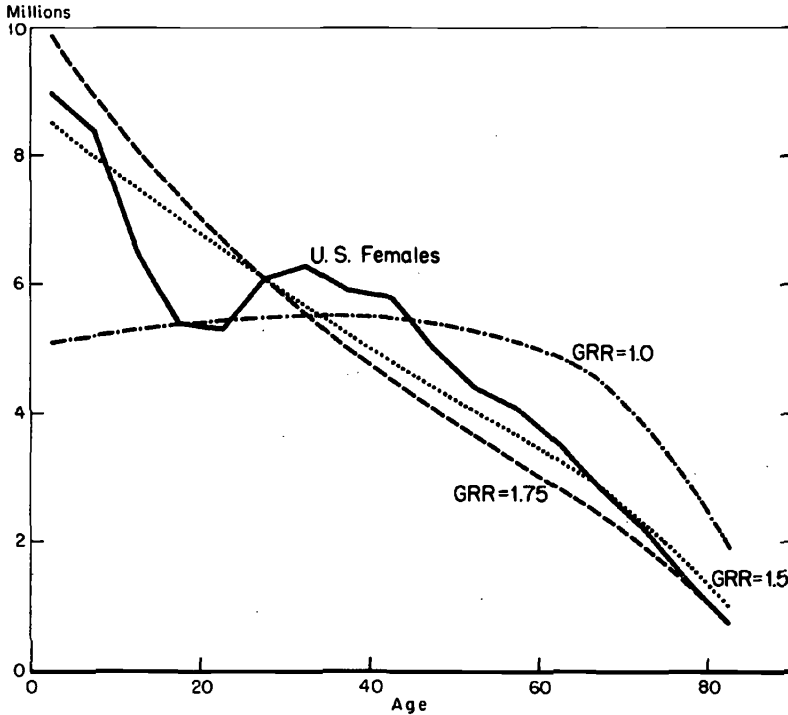
to be least when the gross reproduction rate in the model is assumed to be 1.50. This model is also shown in Chart 2.[3]

The age structures of the actual population and of the average model intersect in three points, near the ages of 10, 30, and 65 years, respectively. Compared to the stable average, the United States, in 1955, had a rather high proportion of small children, rather low proportion of adolescents and young adults, and so far, still a low proportion of aged persons. With time, these relative excesses and deficiencies will move farther up the age scale.

In Chart 3, the sizes of actual age groups are expressed as percentages relative to numbers in the average population model. In a sense, this is a chart of the history of United States fertility relative to that in the average model. Fertility, as a ratio of children to women of childbearing

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[3] This, like any other averaging procedure, is only an arbitrary device which may have some practical uses.

CHART 3

U.S. Females in Each Age Group as Per Cent of Stable Population (GRR = 1.5) in Same Age Groups

Per cent relative to stable population
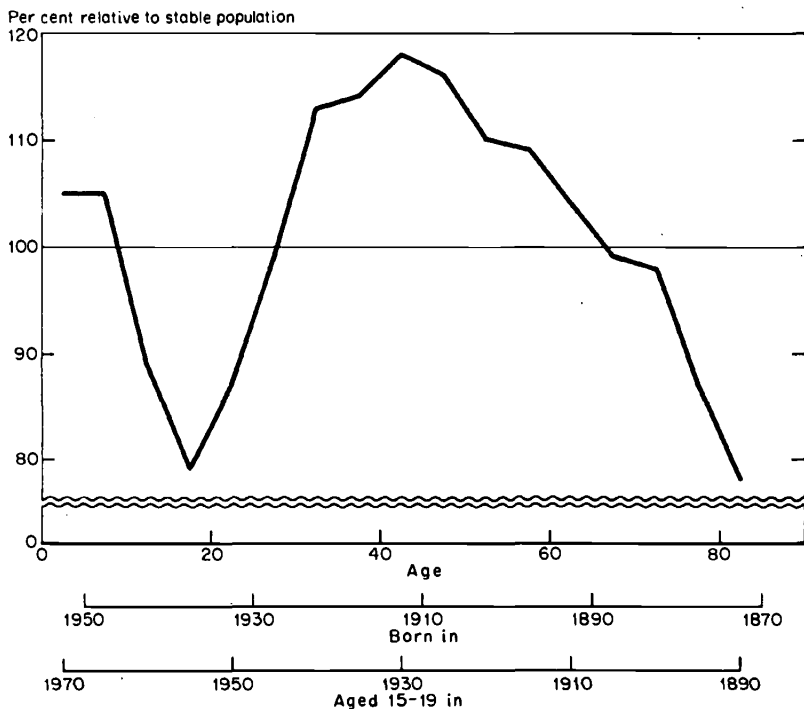
ages, is roughly indicated by the broken arrows in the chart. Recently, this ratio has been somewhat higher than the assumed average. In the 1930's, it was considerably lower. In a still earlier period, it was considerably higher.

Chart 3 has three scales: the age of each group of the population in 1955; the date when each of these groups were born; and the date when they attain ages 15–19 years and, therefore, become candidates for entry into the labor force.

There was a rising trend in birth numbers around the turn of the century, reaching a peak in 1910–1915. Then there was a sharp slowdown until the early 1930's, followed by a renewed steep rise to a plateau which has been maintained for the past ten years.

The rate of growth in potential labor force is mainly determined by numbers reaching ages 15–19. Entrants into the labor force constituted

a rising tide until about 1930. Then, they fell off sharply to a low point which was reached about 1955. From here on, labor force can be expected to grow very rapidly again.

It is possible that the two trends are interrelated. It can be noted for the past 30 years that *when entrants into labor force were many, births were few, and when entrants into labor force were few, births were many.* In fact, there may be a negative correlation between the supply of labor and the birth rate. And this brings me to my third point, namely that a contemplation of the age structure is useful in the study of economic and demographic relationships.

Third Point: Population and the Economy

This possibility is strongly suggested in Notestein's paper, especially in his last chart. It is shown there that everything seems to have conspired to accentuate the change in the ratio of dependents to workers that would otherwise have occurred. The fertility trend, in particular, has contributed greatly to this sharp change in the dependency ratio.

Elsewhere in this Conference it is suggested that a high dependency ratio stimulates demands for goods and services, and that these demands generate a high level of employment. Little consideration, however, has been given at this Conference to the effects of *a changing supply of the labor force itself.*

As a matter of primitive economics, it would seem that when there is a rapid influx of entrants into working ages, the marginal value of each entrant will be low relative to the value of other factors of production, for example, land and machinery. When the supply of labor is reduced, on the other hand, the entrants into labor force will command a relatively high price.

It may be presumed that, early in this century, the economy was geared to a situation in which the ranks of the labor force were swelling rapidly. Eventually, the continued absorption of growing numbers of entrants encountered difficulties. Around that time, fertility came increasingly under deliberate control and declined, at first slowly, and later more rapidly.

After 1930, the rate of entry into labor force slowed down. The economy underwent a reorganization in the depression. It can be presumed that eventually the economy became geared to a situation in which the supply of the labor force was a dwindling one. This situation has prevailed until now and has been associated with prosperity.

During this period of small labor supply and prosperity, persons in the

labor force enjoyed considerable job security and prospects for economic advancement. This period had a high birth rate.

By 1955, the labor supply reached rock bottom. From now until the early 1970's, it will increase greatly. Workers may encounter greater difficulties of employment unless the economy can make a flexible adjustment to this changing situation. With marginal value of entrants into labor force on the decline, it is possible that the birth rate will drop again in the near future. A decline in the marriage rate has already been noted this year.

If this view has any validity, then it can be presumed that the labor market and the birth rate will tend to move in alternating cycles. This may already be the case in Sweden where a relatively early recovery of the birth rate has given way to a renewed decline.

Fourth Point: Population Structure in Terms Other than Age

Notestein has wisely refrained from drawing any inferences of the type which I have just outlined. The truth is that, so long as demography is confined to sex-and-age groups of the population, we are still far from coming to grips with the mechanism by which population trends influence the economy, and vice versa.

As is convincingly pointed out in another paper of this Conference, decisions which affect both the economy and population trends are usually taken within the family, the household, the spending unit, or some other primary groupings of this type.

Demography remains the child of actuarial science so long as it confines its analysis to individuals of varying sex and age. True, the dynamics of age structure and of age specific risks has become a powerful tool of demographic analysis and has been carried to a very high degree of refinement. But demographic analysis must not stop here. Its further progress will depend on the way in which it can meet a new challenge.

We are now being challenged to regard a population as composed of families or households of varying structure. In this population, we must examine the rates at which families of one type are replaced by families of another type. The definitions are still obscure, and the dynamics of a population in terms of family structure are likely to become very complex. Great efforts will be needed to meet this new challenge with as much success as has been attained in the demographic analysis of age structure. When the dynamics of family structure are being explored, great progress in our still limited understanding of demographic, economic and social interrelations is to be expected.

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Notestein makes the point that the size and age of a population are heavily influenced by the size and age composition of that population a generation earlier. Individual units are added to a population at age zero and move through that population in well-defined steps. A few individuals are added at adult ages through migration and they move by similar steps. In our society, since relatively few individuals are removed by migration, virtually all of the losses are the result of deaths. These are distributed over the entire age range, although concentrated in the very young and the older ages. While the United States has not felt the effects of war in the form of deep gashes in its age pyramid, it does have some irregularities. The irregularities in the number of births in some past years are reflected in age groups which today are unusually large or unusually small. The small number of twenty-five-year-olds and the large number of eleven-year-olds in the population in 1958 clearly reflect past developments in fertility.

Rates of growth are subject to sharp changes in a short space of time. Here again the changes that have taken place in the number of births in the last twenty-five years amply illustrate the point.

Notestein has worked out an illustrative computation for a particular time period. Had he chosen another time period, the results would have been somewhat different but the method would have been equally applicable. During the period which he considers, as throughout our national history, the difference between the number of births and the number of deaths has been more important numerically than the difference between the number of immigrants and the number of emigrants. During each decade for which census figures are available, the excess of births over deaths has contributed a larger share of the total increase than the excess of immigration.

An advantage of presenting the computations for this particular period is that they bring into focus the importance of changes in mortality in recent years. The changes in fertility have been so dramatic that attention has generally been focused on them. The period includes the years of small numbers of births in the early 1930's, as well as the years with large numbers of births since World War II. Notestein measures increases against those which would have occurred had there been no immigration and had the vital rates of 1929–1931 prevailed. On that basis, reductions in mortality have contributed 5 million persons to the population increase. This is more than the contributions of increased fertility, 2 million, and increased immigration, about 2 million. Obviously, the relative position

of these three factors would have been different if the selected time period were different.

However, I would like to stress the fact that reductions in mortality are continually being made. There have been very substantial reductions in infant mortality during the twenty-five-year period under consideration, and there have also been reductions in the mortality of persons in the older ages. Some of us spend a good deal of time explaining to laymen that the increase in the average expectation of life does not mean the total span has been increased, or that older persons are living longer. We may have tended to give too small a role to the decreases in mortality that have been taking place at the older ages.

In evaluating the prospects for the future, it would not be appropriate to underrate further improvements in mortality which are possible. Our infant mortality can be further reduced, and there exists the possibility of very significant developments in the control of the degenerative diseases. We do not need to envision the possibilities that travel in space may make time stand still for the few individuals who are likely to be involved in that undertaking in our lifetime. While advances may be slow in coming, improvements in mortality are likely to continue to make significant contributions to the size of our population.

We need not concern ourselves at the moment with whether the period chosen, or the vital rates which are applied, are the best suited ones. The method does permit the isolation of factors, and thus helps to identify the contribution to population growth which is made by the several components.