# AGING POPULATIONS: MECHANICS, HISTORICAL EMERGENCE, IMPACT

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In order to show by enumeration that the perimeter of a circle is less than that of any other figure of the same area, we do not need a complete survey of all possible figures, but it suffices to prove this for a few particular figures whence we can conclude the same thing, by induction, for all the other figures. —R. Descartes, in *Regulae ad Directionem Ingenii*

This paper has to do with the mechanisms that bring about an increase in the relative number of aged persons in a population. For reasons of expositive convenience the relative number of persons aged either 60 and over, or 65 and over, will be conceived of as representing the relative number of "aged persons." The first section of this paper will deal with the quantitative mechanics of the process whereby the relative number of aged persons increases. The second section is devoted to the historical emergence of aging populations; and the third, to some of the responses and circumstances which antedate, or are associated with, the emergence of an aging population. The presentation is essentially theoretical in character, though illuminated with empirical data.

## I

### MECHANICS

Of the population models at hand, that of the stable population is most suited to explain the mechanics of population aging and the emergence of so-called older populations. A stable population is one whose age distribution is constant; its rate of increase may be positive, zero, or negative. Such a population will evolve if the fertility of women at each age remains constant for a sufficiently long period of time and if also age-specific mortality and the ratio of male to female births remain unchanged meanwhile. Should these conditions persist for 50-100 years, a stable population, or at least a very close approximation to a stable population, would come into being.[1] For the age composition of any population is the product of its past natality and mortality, together with the number and age of the migrants who have entered or left this population; and in the absence of such migration, it is determined entirely by past natality and mortality.

Comparison of stable-population models enables one to distinguish the incidence of mortality change upon age composition from that of fertility change, given that external migration is without influence. It will be assumed initially, therefore,

[1] On the genesis of a stable population, see ALFRED J. LOTKA, THÉORIE ANALYTIQUE DES ASSOCIATIONS BIOLOGIQUES. DEUXIÈME PARTIE: ANALYSE DÉMOGRAPHIQUE AVEC APPLICATION PARTICULIÈRE À L'ESPÈCE HUMAINE 64-77 (1939); Coale, *How the Age Distribution of a Modern Population is Determined*, 22 COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY 83-89 (1957).

that a population is closed and that its age distribution is affected only by changes in age-specific fertility or in age-specific mortality. Then, in keeping with the method of comparative statics, the stable end products of assumed changes in mortality and/or fertility may be contrasted. Later on, however, account will be taken of relevant effects both of external migration and of transitional changes associated with movement from one stable age-composition to another.

Tables one and two include data descriptive of stable populations found, respectively, in high-mortality and in low-mortality countries.[2] Since the so-called problem of aging tends to be more acute in countries with *both* low mortality and low fertility than in countries with high mortality,[3] we may turn first to table two for illustrative purposes. The Gross Reproduction Rate (hereafter abbreviated to G.R.R.) is there used to represent the force of fertility.[4] Similarly, expectation of life at birth (hereafter designated E)[5] is used to represent the force of mortality. In table two, six Gross Reproduction Rates, ranging between 4 and 1, have been combined with three life expectancies at birth, ranging between 50 and 70.2

TABLE I

HIGH-MORTALITY STABLE POPULATION

| G.R.R. | E=20 | | | | | E=30 | | | | | E=40 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P. | A. | B.R. | D.R. | N.I. | P. | A. | B.R. | D.R. | N.I. | P. | A. | B.R. | D.R. | N.I. |
| 4.0..... | 52.4 | 2.4 | 63.8 | 53.0 | 10.8 | 49.2 | 2.6 | 59.8 | 35.3 | 24.5 | 47.3 | 2.7 | 57.3 | 24.1 | 33.2 |
| 3.0..... | 57.6 | 3.9 | 50.5 | 50.2 | 0.3 | 54.5 | 4.1 | 47.7 | 33.7 | 14.0 | 52.5 | 4.4 | 46.0 | 23.3 | 22.7 |
| 2.5..... | 60.7 | 5.2 | 42.8 | 49.1 | − 6.3 | 57.6 | 5.5 | 40.6 | 33.2 | 7.4 | 55.6 | 5.9 | 39.3 | 23.2 | 16.1 |
| 2.0..... | 64.0 | 7.1 | 34.2 | 48.6 | −14.4 | 60.9 | 7.7 | 32.7 | 33.6 | − 0.9 | 58.8 | 8.3 | 31.7 | 23.7 | 8.0 |
| 1.5..... | 66.9 | 10.5 | 24.8 | 49.7 | −24.9 | 63.8 | 11.5 | 23.8 | 35.0 | −11.2 | 61.6 | 12.5 | 23.1 | 25.6 | − 2.5 |
| 1.0..... | 68.3 | 16.9 | 14.6 | 54.4 | −39.8 | 65.0 | 18.7 | 14.0 | 39.9 | −25.9 | 62.6 | 20.4 | 13.6 | 30.9 | −17.3 |

SOURCE: See note 2 *infra*.

ABBREVIATIONS: G.R.R.—Gross Reproduction Rate; E.—Expectation of Life at Birth; P.—Percentage of Stable Population aged 15-59; A.—Percentage of Stable Population aged 60 and over; B.R.—Births per 1,000 inhabitants; D.R.—Deaths per 1,000 inhabitants; N.I.—Excess of Births over Deaths per 1,000 inhabitants.

[2] For the source of the data in these tables, see U. N. DEP'T OF ECONOMIC AND SOCIAL WELFARE, THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS (Population Studies No. 26) 27, table 16 (U.N. Pub. Sales No. 1956.XIII.6).

[3] It is here supposed that when mortality is high, fertility also tends to be high; this is not a necessary relationship but one that is highly probable on both social and (as indicated below) actuarial grounds.

[4] The term "total fertility" is commonly used to describe the total number of children that would be born to a cohort of 1,000 women arriving at the age of childbearing, if none died before passing through this age. The Gross Reproduction Rate (G.R.R.) designates the total number of girls born to such a cohort divided by 1,000. Thus, if a cohort of 1,000 women will produce, at current age-specific fertility rates, 3,122 children, given that no member of the cohort dies before completing the childbearing period, and if 1,517 of these children are girls, the Gross Reproduction Rate is 1.517. See ROBERT R. KUCZYNSKI, THE MEASUREMENT OF POPULATION GROWTH 117-30 (1936).

[5] The symbol $\mathring{e}_x$ is usually employed to represent the complete expectation of life at age $x$, or the average number of years lived after age $x$ per person surviving to exact age $x$. E designates $\mathring{e}_x$ when $x$ designates age 0. See L. I. DUBLIN, A. J. LOTKA & M. SPIEGELMAN, LENGTH OF LIFE 20-22 (1949).

TABLE II

LOW-MORTALITY STABLE POPULATION

| G.R.R. | E=50 | | | | | E=60.4 | | | | | E=70.2 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | P. | A. | B.R. | D.R. | N.I. | P. | A. | B.R. | D.R. | N.I. | P. | A. | B.R. | D.R. | N.I. |
| 4.0..... | 45.8 | 2.7 | 55.7 | 16.2 | 39.5 | 44.4 | 2.7 | 54.1 | 9.4 | 44.7 | 43.3 | 2.6 | 52.7 | 4.1 | 48.6 |
| 3.0..... | 50.9 | 4.5 | 44.9 | 15.8 | 29.1 | 49.6 | 4.4 | 43.8 | 9.6 | 34.2 | 48.4 | 4.3 | 42.9 | 4.8 | 38.1 |
| 2.5..... | 53.9 | 6.1 | 38.4 | 16.0 | 22.4 | 52.6 | 6.0 | 37.7 | 10.1 | 27.6 | 51.4 | 5.9 | 37.0 | 5.5 | 31.5 |
| 2.0..... | 57.2 | 8.6 | 31.1 | 16.8 | 14.3 | 55.8 | 8.6 | 30.6 | 11.1 | 19.5 | 54.7 | 8.5 | 30.1 | 6.8 | 23.3 |
| 1.5..... | 60.0 | 13.0 | 22.7 | 18.8 | 3.9 | 58.7 | 13.1 | 22.5 | 13.5 | 9.0 | 57.7 | 13.0 | 22.3 | 9.4 | 12.9 |
| 1.0..... | 60.7 | 21.5 | 13.4 | 24.3 | −10.9 | 59.4 | 21.9 | 13.3 | 19.0 | − 5.7 | 58.6 | 21.9 | 13.3 | 15.1 | − 1.8 |

SOURCE AND ABBREVIATIONS: Same as in Table I.

years, to yield eighteen stable age distributions. In table one the same six rates have been combined with three low life expectancies to yield another eighteen stable age distributions. We thus have thirty-six age distributions characteristic of thirty-six stable populations and fairly descriptive of most of the stable populations that would come into being in various parts of the world if current fertility and mortality schedules were to remain constant for fifty or more years.

Comparison of the percentages reported in table two indicates that up to now the proportion of persons aged 60 and over in a stable population has been *affected only negligibly by changes in the expectation of life at birth and almost entirely by changes in fertility as measured by the G.R.R.* One finds that if the G.R.R. is held constant at 4.0, the percentage (reported in the columns headed A) formed by persons aged 60 and over approximates 2.7, whatsoever the life expectancy, while if the G.R.R. is held constant at 1.5, the percentage approximates 13.0, whatsoever the life expectancy. In general, reading horizontally and to the right along any line in tables one and/or two reveals only minor (if any) changes in the relevant values of A as life expectancy E rises. I say relevant values because life expectancy at birth has seldom fallen below the 30's in the past 150 years, and most of the increase in A that accompanies increase in E is associated with progress in E from 20 to 40. This means that decline in mortality has little effect upon population aging, at least so long as life expectancy does not exceed 70. If, now, one reads the columns headed A vertically, one finds that the value of A increases steadily as the value of the G.R.R. descends from 4.0 to 1.0; it is seven to eight times as high when the G.R.R. is at the level of 1.0 as when the G.R.R. is at the level of 4.0. This means that decline in fertility (*i.e.*, in the G.R.R.) exercises a very great influence upon a population's age distribution. This influence is so great, when contrasted with that exercised by increase in life expectancy at birth, that *one is warranted in attributing the post-1850 aging of populations almost exclusively to decline in fertility.*

What has been said respecting the impact of mortality declines and increase in life expectancy upon the relative number of persons aged 60 and over may be subject to minor qualification. For the effect of mortality declines upon age composition depends upon the distribution of these declines among the members of a population. Mortality declines will not alter a population's age composition if survival rates at all ages increase in the same proportion. If, however, mortality declines are confined to members of a population aged (say) 50 and over, they have no effect upon the number of births and the long-time growth rate, serving only to increase the absolute and the relative number of persons who survive to older ages. If, on the contrary, mortality declines are confined to children (say) under 5, they will affect age distribution much as does an increase in fertility; they will presently (*i.e.*, about 13-17 years hence) begin to increase the number of parents and the flow of births as well as the rate of population growth. In the past century mortality declines have usually decreased the median age of the population somewhat and have decreased the proportion of the population aged 65 and over in about half of the forty-four cases studied. For the age-reducing effect of mortality declines among those aged under 5 has more than offset the age-increasing effect of mortality declines among those over 50, while the probability of survival has increased much less and in similar proportions among those aged 5-50. Whence Coale concludes "that most mortality improvements in the past have produced a younger population than would have resulted from unchanged mortality, other factors the same."[6]

While improvements in mortality may continue to produce younger populations in countries in which mortality still remains high, they will tend to produce older populations in countries in which mortality risks have by now fallen to low levels. For with a life expectancy at birth in the 70's, ninety-six to ninety-eight per cent or more of all live-born females survive to childbearing age (*i.e.*, to 15) and ninety-three to ninety-seven per cent reach an age (*i.e.*, 40) beyond which very few children are borne; there is little scope, consequently, for mortality reduction to increase the fraction surviving to and through the childbearing period.[7] The mortality declines in prospect, therefore, will probably prolong the life of those

[6] See Coale, *supra* note 1, at 83-89; Coale, *The Effects of Changes in Mortality and Fertility on Age Composition*, 34 MILBANK MEMORIAL FUND QUARTERLY 79-114 (1956); Stolnitz, *Mortality Declines and Age Distribution*, 34 *id.* 178-215; Coale, *The Effects of Declines in Mortality on Age Distribution*, in F. G. BOUDREAU & C. V. KISER (EDS.), TRENDS AND DIFFERENTIALS IN MORTALITY (Proceedings of the 1955 Annual Conference of the Milbank Memorial Fund) 125-33 (1956). See also Sauvy, *Le Vieillissement des Populations et Allongement de la Vie*, 9 POPULATION 675-82 (1954); Lorimer, *Dynamics of Age Structure in a Population with Initially High Fertility and Mortality*, 1 U.N. POPULATION BULLETIN 31-41 (U.N. Pub. Sales No. 1952.XIII.2); *The Causes of Aging of Populations*, 4 *id.* 30-38 (U.N. Pub. Sales No. 1955.XIII.1).

[7] Ninety-two to ninety-six per cent of all live-born females attain the age of 45. The above percentages are based upon the model life tables prepared by the United Nations. See U.N. DEP'T OF ECONOMIC AND SOCIAL WELFARE, METHODS FOR POPULATION PROJECTIONS BY SEX AND AGE (Population Studies No. 25) (U.N. Pub. Sales No. 1956.XIII.3); AGE AND SEX PATTERNS OF MORTALITY (Population Studies No. 22) (U.N. Pub. Sales No. 1955.XIII.9). See also Gabriel & Ronen, *Estimates of Mortality and Mortality Rates*, 12 POPULATION STUDIES 164-69 (1958).

who reach 50 more than enough to offset the effects of any further decline in mortality among those under 5. Such at least will be the probable effect of further declines in mortality in Western countries with life expectancies in the neighborhood of 70.[8]

It is when mortality declines appreciably below levels corresponding to a life expectancy of 70 that such decline accelerates population aging. If we replace a population with a G.R.R. of 4.0 and an E of 20 by one with a G.R.R. of 1.0 and an E of 70, the decline in mortality increases the proportion aged 60 and over only from 2.4 to 2.6 per cent of the population. If now we hold the G.R.R. at 1.0 and increase life expectancy (*i.e.*, E) further to 90, the proportion aged 60 and over rises from twenty-two per cent to around thirty-three per cent. Even if the G.R.R. is around the 1.5 level, increase in E from 70 to 90 produces a correspondingly high increase in the relative number of persons aged 60 and over, from around thirteen to close to twenty per cent of the population.[9] With E at 70 it is not possible to increase the rate of population growth much by decreasing mortality; in fact, if death were abolished altogether the growth rate would rise by less than 2 per 1,000. The proportion aged 60 and over would increase markedly, however, if immortality replaced a life expectancy of 70 at birth; with the G.R.R. at 1.5 or lower it would approach 41.4 per cent or exceed this figure, though with a G.R.R. as high as 3.0 it would not rise above 9.1 per cent. It is much more likely, of course, that the G.R.R. will lie between 1.0 and 1.5 than that it will approximate 3.0.[10]

Fertility-reducing forces make for population aging because they reduce the rate of population growth and the rate at which births flow into the lower age groups. In consequence younger cohorts no longer exceed older cohorts so markedly, if at all, in size, with the result that the median age of the population rises, the age distribution itself becomes less favorable to fertility, and the relative number of persons aged 60 and over increases. A rise in fertility produces an opposite set of effects.

The trends illustrated by the data presented in tables one and two hold generally even when a population is in transit from a stable form characterized by relatively high fertility and/or mortality to one characterized by relatively low rates. They are manifest also in the unfolding of populations that have been projected into the future on the basis of an initial set of suppositions respecting fertility and mortality. While a certain amount of oscillation may mark the upward or the downward movement of the relative number aged 60 and over when the G.R.R. or life expectancy are changed and one stable population is gradually transformed into another, it is the upward or downward movement that is paramount.[11]

[8] Stolnitz, *supra* note 6, tables 1, 3, 8 and 10.

[9] THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 28-30.

[10] See Coale, *Increases in Expectation of Life and Population Growth*, in PROCEEDINGS OF THE INTERNATIONAL POPULATION CONFERENCE (held in Vienna under the auspices of the International Union for the Scientific Study of Population, 1959) 36-41 (1959).

[11] THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 30-43.

Transitory effects on age distribution are in the same general direction as the eventual effects on the stable age distribution. A rise in fertility produces an increase in the proportion in the younger age group at the expense of the older; a proportionate increase at all ages in the probability of surviving affects only the growth rate; an extra increase in survivorship at the youngest ages has an effect much like a rise in fertility; an increase in survivorship at the older ages tends to raise the fraction at these ages.[12]

While age compositions tend to be more irregular and notchy and knobby in the world of reality than in that of hypothetical stable populations, inferences drawn from comparisons of the latter continue to hold. In the world of reality both mortality and fertility may vary appreciably from year to year, sometimes rising above and sometimes falling below trend levels and then moving back to these levels. This is true of mortality in that while every person born must die, he may die at any time within the interval separating his birth and the end of his life span (say 110 ± 10 years),[13] with the result that catastrophic events (*e.g.*, war, epidemic disease) may greatly increase mortality for short periods.[14] Natality may vary even more than mortality, for a fecund woman may not only choose to bear a given number of children earlier or later within her effective childbearing period (say between the ages of 15 and 40), but may also determine to make this number larger or smaller within certain limits (say 0 to 10). The birth rate and the annual number of births may vary appreciably, therefore, between times of war and times of peace, between times of prosperity and times of depression, and so on.[15] As a result of such variations in the annual number of births, or birth cohorts, humps and hollows are introduced into a population's age distribution and not only move through it as these abnormally sized cohorts age but also produce positive or negative echo effects when the children of these oversized or undersized cohorts attain childbearing age.[16] In consequence, the rate at which the labor force increases may vary. These transitory waves of high or low fertility may be of some significance, therefore, in respect of the maintenance of full employment; but they exercise little influence upon the course of a population's aging.[17]

[12] Coale, *The Effects of Changes in Mortality and Fertility on Age Composition*, 34 MILBANK MEMORIAL FUND QUARTERLY 79, 113 (1956).

[13] See Freeman, *The Geriatric Limb on the Gerontology Tree*, in AMERICAN ASS'N FOR THE ADVANCEMENT OF SCIENCE, AGING: SOME SOCIAL AND BIOLOGICAL ASPECTS 20 (N. W. Shock ed. 1960).

[14] See, *e.g.*, HENRI BUNLE, LE MOUVEMENT NATUREL DE LA POPULATION DANS LE MONDE DE 1906 À 1936, at 322-89 (1954). Annual mortality among German males was about 70% higher in the period 1915-18, than in 1913, largely because of the toll of war. Mortality among German females was about 30% higher in 1918 than in 1914 or 1915, largely because of the influenza epidemic of 1918. *Id.* at 333.

[15] See, *e.g.*, *id.* at 289-305; ROBERT R. KUCZYNSKI, THE BALANCE OF BIRTHS AND DEATHS 94-97 (1928); U.N. DEP'T OF ECONOMIC AND SOCIAL WELFARE, RECENT TRENDS IN FERTILITY IN INDUSTRIALIZED COUNTRIES (Population Studies No. 27) ch. 2 (U.N. Pub. Sales No. 1957.XIII.2). See also, Kiser, *Changes in Fertility by Socio-Economic Status During 1940-50*, 33 MILBANK MEMORIAL FUND QUARTERLY 393-429 (1955); Ryder, *Problems of Trend Determination During a Transition in Fertility*, 34 *id.* 5-21 (1956); Stolnitz, *Population Composition and Fertility Trends*, 21 AM. SOCIO. REV. 738-43 (1956).

[16] Coale, *How the Age Distribution of a Modern Population is Determined*, 22 COLD SPRING HARBOR SYMPOSIA ON QUANTITATIVE BIOLOGY 83, 87-89 (1957).

[17] Variation in the rate of increase in the labor force arising from variation in annual fertility could give rise to a kind of cobweb effect if the rate of unemployment were positively correlated with the rate

It is very difficult to describe in simple terms the impact of net migration upon a population's age distribution, particularly since migration fluctuates so much in volume and varies greatly in time. One may, of course, say that the ratio of net migration to a country's population is seldom large enough to affect its age distribution significantly and that even this effect tends in time to be swamped by the cumulative influence of domestic natality and mortality. Net immigration will decelerate a population's aging if it increases the younger age groups by a larger fraction than it swells the older age groups, and particularly if the young immigrants are able to increase the flow of births notably. If, on the contrary, net immigration contributes primarily to the increase of those in and above the upper 30's, it will presently accelerate the aging process since the immigrants themselves will move into the older age groups before they have increased the flow of births significantly. The influx of migrants into the United States as well as into many European, Latin American, and Asian countries is now too small to affect the aging process notably. Studies relating to the present century reveal migration to have had little effect upon population aging.[18]

In this section we have established four conclusions. (1) The aging of populations as evidenced in increase in the relative number aged 60-65 and over has been produced almost entirely by the decline in fertility and natural increase. (2) Increase in the average duration of life and even prolongation of life among those over 50 has exercised little influence upon the course of aging, sometimes accelerating it and sometimes decelerating it. (3) While net migration influenced age composition significantly in countries (*e.g.*, the United States) which for a time experienced heavy migration, this influence diminished with the decline of immigration in relative importance; it has since been swamped by the cumulative impact of fertility and mortality. (4) Should life expectancy at birth rise into and above the upper 70's, its extension would begin to affect the course of population aging significantly if the G.R.R. remained relatively low (say between 1.0 and 1.5).

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of increase in the labor force. Suppose fertility is low at time $t=0$ because unemployment is relatively high. Then at (say) time $t=20$ the rate of increase in the labor force will be relatively low as consequently will be unemployment. Whence fertility rises above normal in year $t=20$ only to make for supra-normal unemployment in year (say) $t=40$. In reality, of course, the unemployment-affecting influence of variations in fertility is likely to be swamped by other forces connected little or not at all with the behavior of annual fertility rates.

[18] For a model tracing the impact of continuous net migration upon the age distribution of the populations of Argentina and Venezuela, see U.N. DEP'T OF SOCIAL AND ECONOMIC WELFARE, THE POPULATION OF SOUTH AMERICA 1950-1980 (Population Studies No. 21) 109-39 (U.N. Pub. Sales No. 1955.XIII.4). The age structure is not much affected. *Id.* at 118-23. For an estimate of the possible impact of immigration on France's population at the close of the war, see Sauvy, *Besoins et possibilités de l'immigration Française,* 5 POPULATION 209-28, 417-34 (1950). See also, THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 22, 47-49; *Some Quantitative Aspects of the Aging of Populations,* 1 U. N. POPULATION BULLETIN 42-57 (U.N. Pub. Sales No.: 1952. XIII.2). In nineteenth century America, of course, immigration affected age composition notably.

## II

### HISTORICAL EMERGENCE

Population aging set in only in the nineteenth century, and then only in a few countries. Prior to that century life expectancy at birth was in or below the 30's, and by the close of that century it had risen, in progressive countries, only into the upper 40's or the low 50's, with the main declines in mortality not getting effectively under way until the closing decades of the nineteenth century or the early decades of the twentieth century.[19] In consequence, as was noted earlier, the decline in mortality long tended to retard rather than to accelerate population aging; in any event, it did not intensify the process. Not until recently did this process begin to be reversed, and even now there remain many countries in which further reduction of mortality would not accelerate the population-aging process.[20] As has been remarked earlier, therefore, the historical emergence of population aging has been associated almost entirely with the decline in fertility, and this decline did not, as a rule, get under way until in the second half of the nineteenth century.

While gross reproduction rates considerably in excess of three have been recorded (*e.g.*, 3.65 in the Ukraine in 1896-97; 3.4 in northern Japan in the 1920's; close to 4.0 in the United States around 1800) for large population aggregates, rates in the neighborhood of 2.5-3.0 seem to have predominated in and before the eighteenth century.[21] Moreover, although natality began to fall in France and the United States in the first quarter of the nineteenth century, to be followed later by a decline in natural increase, declines in natality and subsequently in natural increase did not really get under way in Europe until the closing third of the nineteenth century and even then they were confined largely to Western Europe.[22] In the present century, however, the decline in natality spread to all the countries in Europe. There, as well as in Northern America and in Oceania, natality fell with increasing rapidity and so did crude and true natural increase. Elsewhere, with the increasing exception of Japan and with the partial exception of portions of temperate Latin America, natality generally remained more or less at nineteenth-century levels. It remained so even though, with progress in the development of effective public-health and disease-control programs and the consequent reduction

[19] See DUBLIN, LOTKA & SPIEGELMAN, *op. cit. supra* note 5, chs. 2, 3, tables 81-91; Stolnitz, *A Century of International Mortality Trends*, Pt. 1, 9 POPULATION STUDIES 24-55 (1955); Pt. 2, 10 *id.* 17 (1956); U. N. DEP'T OF ECONOMIC AND SOCIAL AFFAIRS, DEMOGRAPHIC YEARBOOK 4-5 (U. N. Pub. Sales No. 1957.XIII.1).

[20] *Id.* at 1-5.

[21] Russell, *Late Ancient and Medieval Population*, 48 TRANSACTIONS OF THE AMERICAN PHILOSOPHICAL SOCIETY (n.s.) Pt. 2 (1958); ROGER MOLS, S.J., INTRODUCTION À LA DÉMOGRAPHIE HISTORIQUE DES VILLES D'EUROPE DU XIV$^{e}$ AU XVIII$^{e}$ SIÈCLE (1954); Durand, *The Population Statistics of China A.D. 2-1953*, 13 POPULATION STUDIES 209-56 (1960); Durand, *Mortality Estimates from Roman Tombstone Inscriptions*, 65 AM. J. SOCIOLOGY 365-73 (1960).

[22] See ROBERT R. KUCZYNSKI, *op. cit. supra* note 15, chs. 1-3; BUNLE, *op. cit. supra* note 14, table 1; E. S. WOYTINSKY, WORLD POPULATION AND PRODUCTION ch. 5 (1953); M. HUBER, H. BUNLE & F. BOVERAT, LA POPULATION DE LA FRANCE 78-85 (1931); W. S. THOMPSON & P. K. WHELPTON, POPULATION TRENDS IN THE UNITED STATES chs. 7-8 (1933).

of the positive correlation of life expectancy with income, mortality fell sharply in most countries, among them many with underdeveloped economies and very low incomes. In and after the 1940's there was an upsurge of natality, especially in low-natality countries, but it has since fallen, though only in a few instances to or below the usually low levels of the 1930's.[23]

While population aging emerged in the late nineteenth century, it proceeded very slowly. Around 1850 in European countries the proportion of the population aged 65 and over was around or below five per cent; only in slowly growing France did it approach 6½ per cent. By 1900 this proportion ranged between five and 8.4 per cent in European countries in which natality had fallen, and generally around or below four elsewhere in the world. By 1950, however, this proportion had moved upwards and into a range of seven to twelve per cent in Europe, Northern America, and Oceania. It was still around five per cent in Japan though rising; but elsewhere in the world it remained around or below four as a rule.[24] The world may thus be described as divisible roughly into two sectors, one in which fertility remains high and the relative number of older persons is quite low, and the other in which fertility is relatively low and the relative number of older persons is large and rising. In 1950 in Africa, Asia, and Latin America, for example, only four to six per cent of the population were 60 and over. In Europe, Northern America, and Oceania the corresponding fraction was eleven to twelve per cent, and in the U.S.S.R. it was eight per cent and rising.[25]

The world picture still remains much as it was in 1950, manifesting little tendency toward homogeneity in respect of population aging. Moreover, substantial change therein is not likely for some decades, given current fertility trends. For the tendency on the part of fertility to fall remains weak in Asia (exclusive of Japan), in most of Africa, and in much of Latin America; and gross reproduction in the rest of the world seems unlikely to rise appreciably. It has been estimated, therefore, that as of 1975 only five to six per cent of the population of Africa, Asia, and Latin America will be 60 and over. In Europe, Northern America, and Oceania, by contrast, the corresponding percentages will be seventeen, sixteen, and

[23] See, *e.g.*, U.N. DEP'T OF SOCIAL AND ECONOMIC AFFAIRS, DEMOGRAPHIC YEARBOOK 1959, at 1-17, table 9 (U.N. Pub. Sales No. 59.XIII.1). It should perhaps be noted that the severing of the connection between improvement in economic conditions and the reduction of morbidity and mortality is by no means complete, being attributable in marked degree to the export of death- and disease-control from high income to low income countries. It remains to be seen how completely this severing can be sustained in the face of high natality, low income, and persisting poverty. Even in advanced countries, mortality and morbidity are somewhat associated with the environmental conditions surrounding individuals, among them income levels (which, within limits, are inversely related to mortality). For information on this last point, see *Recent and Future Mortality Trends*, Statistical Bulletin of the Metropolitan Life Insurance Company, June, 1960, pp. 1-3 [hereinafter cited as Statistical Bulletin].

[24] THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 12; Valaoras, *A Reconstruction of the Demographic History of Modern Greece*, 38 MILBANK MEMORIAL FUND QUARTERLY 116-39 (1960).

[25] U. N. DEP'T OF ECONOMIC AND SOCIAL WELFARE, THE FUTURE GROWTH OF WORLD POPULATION (Population Studies No. 28) table 15 (U.N. Pub. Sales No. 58.XIII.2). In 1959, about 9.4% of the population of the U.S.S.R. was 60 or over. Computed from U. N. DEP'T OF ECONOMIC AND SOCIAL WELFARE, DEMOGRAPHIC YEARBOOK 1959, at 165 (U. N. Pub. Sales No.: 59.XIII.1).

fourteen, respectively. It will approximate eleven in the U.S.S.R. and 11.6 in Japan.[26] Turning to the United States we find the proportion aged 65 and over, which rose from 3.4 in 1880 to 5.6 in 1950, will advance to between nine and ten per cent by 1980 if the G.R.R. remains within the range 1.8-2.0. It could approximate 10.5 if, as seems unlikely, the G.R.R. moved into the neighborhood of 1.3. Should life expectancy increase more than these projections presuppose, the fraction would then be slightly higher at given fertility levels.[27] If our population continues to grow 1.5-1.6 per cent per year and hence numbers around 350 millions by the year 2000, the 35 million persons 65 and over in prospect forty years from now will form about ten per cent of the population.

One can write somewhat (though not much) more firmly about prospective mortality than about prospective fertility, since fertility tends to be more volatile than mortality. What happens in respect of life expectancy at birth can become significant if it rises from below or in the neighborhood of 70 to in the neighborhood of 90; for, as has been noted, such movement would greatly increase population aging should gross reproduction remain at levels now usually encountered in low-mortality, high-income countries. Realization of such an upward movement, however, presupposes the establishment of control over a different set of causes of death than have been curbed in the past. For more than a century, particularly during the past 50-60 years, mortality has been reduced in considerable measure through the successive establishment of control over important epidemic and louse-borne diseases, over gastro-intestinal diseases, over tuberculosis, pneumonia-influenza, and other respiratory diseases, over the communicable diseases of childhood, and over mortality flowing from the cumulative impact of conditions associated with hard, poverty-ridden environments.[28] Today, largely as a result of this mortality reduction, cardiovascular-renal diseases and malignant neoplasms (the incidence of both of which increases with age), together with degenerative diseases, account for considerably more than half of the deaths occurring in advanced countries.[29] The future course of life expectancy, therefore, depends largely

[25] THE FUTURE GROWTH OF WORLD POPULATION, *op. cit. supra* note 25, table 16; U.N. DEP'T OF SOCIAL AND ECONOMIC WELFARE, THE POPULATION OF ASIA AND THE FAR EAST 1950-1980 (Population Studies No. 31) (U.N. Pub. Sales No. 59.XIII.3); THE POPULATION OF SOUTH-EAST ASIA (Population Studies No. 30) (U.N. Pub. Sales No. 1959.XIII.3).

[27] These percentages are derived from U. S. BUREAU OF THE CENSUS, DEP'T OF COMMERCE, ILLUSTRATIVE PROJECTIONS OF THE POPULATION OF THE UNITED STATES BY AGE AND SEX (Ser. P-25, Current Population Rep. No. 187, 1958).

[28] See O. W. ANDERSON & GEORGE ROSEN, AN EXAMINATION OF THE CONCEPT OF PREVENTIVE MEDICINE, HEALTH INFORMATION RESEARCH SER. No. 12 (1960); O. W. ANDERSON & MONROE LERNER, MEASURING HEALTH LEVELS IN THE UNITED STATES, HEALTH INFORMATION RESEARCH SER. No. 11 (1960). Between 1911 and 1960, death rates from selected causes per 100,000 policyholders of the Metropolitan Life Insurance Company declined from 1,253 to 671.2. Of this 582 point drop, 488 points are the result of decline in mortality from four sets of disease (tuberculosis, communicable diseases of childhood, nephritis and nephrosis, and pneumonia and influenza) which by 1960 accounted for about 5% of the deaths instead of the 42% as in 1911. Another 62 points were accounted for by declines in mortality from appendicitis, gastritis, etc., hernia and intestinal obstruction, and complications of pregnancy and childbirth. See *Fifty Years of Health Progress*, Statistical Bulletin, Jan. 1961, p.4.

[29] Of each 671 deaths among the industrial policyholders of the Metropolitan Life Insurance Company, mortality among whom now resembles that in the nation at large, 142 were attributed to

upon what can be done in respect of the control of these diseases.

Undoubtedly man's ability to establish control over these now very important diseases will fall far short of his ability to curb the diseases he has brought under control in the past 100-150 years. It is true, of course, that elimination of all neoplasms as a cause of death would increase life expectancy at birth 2.0 and 2.6 years, respectively, for white males and white females; the corresponding gains at age 60 would be 1.3 and 1.5 years. It is also true that elimination of cardiovascular-renal diseases as a cause of death would increase life expectancy at birth 10.7 years for white males and 10.3 years for white females; the corresponding gains at age 60 would be 9.9 and 10 years, respectively.[30] Were it possible to reduce only by half the mortality attributable to cardiovascular-renal diseases and malignant neoplasms, life expectancy at age 60 (15.7 years for white males and 19.2 for white females in 1958) would rise about five years for each sex.[31] At present, however, it can only be said that progress in the extension of life expectancy at birth has slowed down notably and that, unless cardiovascular-renal diseases and neoplasms can be brought under control more rapidly than in the past, progress in the extension of life expectancy at advanced ages will slow down as well. It is quite possible, moreover, that increase in disease-generating forces (*e.g.*, chemical, atomic, and other pollution of the environment; increasing exposure to urban hazards and stress; excessive avoidance of danger, discomfort, and tension; overconsumption of food, etc.) will worsen man's relevant environment and partly offset progress in methods suited to control degenerative and other diseases of old age.[32] It is to be doubted, therefore, that man's life span will be increased, or that his life expectancy at birth will be raised above 80, and accomplishing this should take 50-100 or more years.

From what has been said in this section we may now draw certain inferences. It is doubtful if, with life expectancy around 70, the G.R.R. will remain as high as 1.5, since this would entail a rate of population growth of about 1.3 per cent per year (see last column in table two). We may suppose, therefore, that in highly

malignant neoplasms, 357 to cardiovascular-renal diseases, and 32 to accidents. *Id.* at 4. Of each 100 deaths reported in the United States in 1959, 68.1% were attributed to diseases of the heart, malignant neoplasms, vascular lesions affecting the central nervous system, and general arteriosclerosis. *Trends in U. S. Mortality*, 10 PROGRESS IN HEALTH SERVICES 1 *ff.* (Feb. 1961). These proportions indicate the orders of magnitude characteristic of economically advanced, low-mortality countries, even though inter-country differences obtained.

[30] *Increased Life Expectancy in the United States*, 9 PROGRESS IN HEALTH SERVICES 1 *ff.* (Dec. 1960). These figures, based on American Life Expectancy in the period 1949-51, are treated more fully in Woodhall & Jablon, *Prospects for Further Increases in Longevity*, 12 GERIATRICS 586-91 (1957).

[31] *Outlook for Gains in Longevity after Age 60*, Statistical Bulletin, Nov. 1960, pp. 1-3; *Trends in Survival at the Older Ages, id.*, Sept. 1960, pp. 1-3. Given a life expectancy of about 70 years at birth, about 81-84% of those born reach the age of 60.

[32] Up to now, of course, these forces have not been effective on balance. As was noted earlier, for example, mortality is lower among those engaged in better paying than in worse paying positions. See *Recent and Future Mortality Trends*, Statistical Bulletin, June 1960, pp. 1-3. Life expectancy at birth among this company's industrial policyholders increased about five years per decade between 1911-12 and 1950, but only 2.3 years in 1950-60, and 0.6 years in 1955-60. *Fifty Years of Health Progress, id.*, Jan. 1961, pp. 1-7. Expectation of life increased 5-6 tenths of a year per decade among white males in the sixties in 1929-54; among white females, the rate was slightly more than twice as high as among the white males. *Trends in Survival at the Older Ages, id.*, Sept. 1960, pp. 1-3.

developed, low-mortality countries the G.R.R. will tend to move below rather than above 1.5. This entails that the relative number of persons aged 60 and over will exceed thirteen per cent and may approach close to twenty per cent. If under these fertility conditions life expectancy at birth were to advance toward 80 years, the fraction aged 60 and over would move above the thirteen to twenty per cent levels. In fact, with life expectancy at 80 and given prospective fertility, this fraction would probably move into the neighborhood of twenty.[33] It is to be expected that gross reproduction in high-fertility countries (wherein live about two-thirds of the world's population) will fall. Should natality fall 0.5-1.0 point per year from current levels of around 40-45,[34] natality in most high-fertility countries might be in or below the neighborhood of 20 by the year 2000. As a result the fraction 60 and over will have moved or be moving into the neighborhood of thirteen per cent. As yet, however, there has been little manifestation of the imminence of so high a rate of decline.

## III

### IMPACT

Our concern in this section is with the implications of the set of changes in the age composition of populations of which population aging is only one. It is misleading to study the impact of population aging as such. For population aging is inseparably connected with other changes in age composition. All of these must be taken into account if the true impact of population aging upon production, income, and dependency is to be ascertained.

It has been shown (see tables one and two) that, with fertility constant, increase in the expectation of life at birth up to the age of 70 usually modifies the fraction of the population 60 and over very little, and then only when life expectancy is in or below the 40's. It has also been shown that population aging is attributable almost entirely to decrease in the G.R.R. (see A-columns in tables one-two). Attention may now be called to the fact that a decline in the G.R.R. eventuates in a decline in the relative number of persons under 15 and hence in an associated increase in the relative number aged 15-59 (see P-columns in tables one-two). For example, with a life expectancy of 60 at birth, the percentage of a stable population aged 15-59 rises from 44.4 when the G.R.R. is 4.0 through 52.6 when it is at 2.5 to about fifty-nine when it lies between 1.5 and 1.0. This increase in the relative number aged 15-59 is entirely the product of decline in the G.R.R., since increase in life expectancy serves, *ceteris paribus,* to reduce the relative number aged 15-59 and increase both that aged 0-14 and (within narrow limits) that aged 60 and over. It should be noted, however, that when life expectancy at birth has reached a level around 50—that is, a level of the sort found in the developed world around

[33] THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 28-29.

[34] In Central Europe during the period (1800's to 1920's) of most rapid decline, natality fell roughly between 0.5 and 0.75 points per year; in Japan and Puerto Rico, about one point per year during the recent period of rapid decline.

1900 and in much of the underdeveloped world today—further augmentation of the average duration of life does not greatly reduce the relative number aged 15-59 until it has moved into or beyond the upper 70's. For, with the G.R.R. given, at any level between 4.0 and 1.0, increasing life expectancy from 50 to 70.2 years reduces the fraction aged 15-59 only three to four per cent (see tables one-two).

Decline in gross reproduction, the cause of population aging, is thus responsible for both the increase that has taken place in the relative number of adults of productive age (say 15-59) and the decrease in the relative number of persons of dependent age (say those aged 0-14 plus those aged 60 and over). For illustrative purposes let us begin with a stable population with a G.R.R. of 3 and a life expectancy of 30, that is, with a population of the sort found in pre-1800 Europe or in parts of present-day Tropical Africa. If now the G.R.R. declines from 3.0 to 1.0 while life expectancy remains unchanged at 30 (or, for that matter, at 40, 50, 60, or 70), the percentage aged 15-59 rises from 54.5 to sixty-five, that is, by 10.5 points or nineteen per cent (see tables one-two). If next life expectancy rises to 70, these 10.5 points are reduced to 4.1, since with a G.R.R. of 1.0 and a life expectancy of 70.2, only 58.6 instead of sixty-five per cent of a stable population are aged 15-59 years. In general, as life expectancy rises, the percentages aged 0-14 and 60 and over rise, though with most of the rise associated with increase in life expectancy between 20 or 30 and 50 years rather than with that between 50 and 70. Decline in fertility thus permits populations to absorb increases in life expectancy without suffering *net* changes in age-composition that are unfavorable to potential productivity.

Should life expectancy increase into and beyond the upper 70's, however, it would finally become impossible, in low-fertility countries, to offset this increase by further reducing fertility. For, given a G.R.R. below 1.5, increase in life expectancy into and beyond the upper 70's would reduce the fraction of a stable population in the age group 15-59 below the fifty-eight per cent level associated with a life expectancy of 70 and a G.R.R. of between 1.0 and 1.5. This fraction would decline to around the fifty-two per cent level if life expectancy at birth rose to 90 while the G.R.R. remained at 1.5. It is unlikely, however, for reasons advanced in section two, that life expectancy will rise above 80. If this argument proves empirically valid, therefore, the fraction aged 15-59 will decline no more than several points below the fifty-eight per cent level, even though the G.R.R. is somewhat below 1.5.[35]

Given the changes in fertility and mortality in prospect, changes in the age composition of populations will not reduce potential productivity per capita and in many instances will increase it as in the past. The movement of the fraction of the population aged 15-59 (or 15-64) may be used to indicate the movement of potential productivity per capita as a population's age composition changes *ceteris paribus* (*i.e.*, with capital per worker, state of the arts, level of employment, etc. given). It will be indicated below that the movement of this index (*i.e.*, the frac-

[35] This argument is based on data to be found in THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 28-30.

tion aged 15-59) is sufficient for the purposes of the present inquiry. Changes in the percentages aged 15-59 and presented in tables one-two suggest that potential per capita productivity has changed very little (perhaps one to three per cent) in the past 160 years. For in a stable population of the sort associated with West European mortality and fertility as of around 1800 (*i.e.*, with a life expectancy of 30 and a G.R.R. of 2.5) 57.6 per cent are aged 15-59; while in one associated with a life expectancy (*i.e.*, around 50) and a G.R.R. (*i.e.*, around 2.0) of the sort prevailing in economically developed countries around 1900, about fifty-seven per cent are aged 15-59. Even in a stable population of the sort compatible with fertility (*i.e.*, a G.R.R. of 1.0-1.5) and mortality (*i.e.*, a life expectancy of 70) in present-day advanced countries, only fifty-eight per cent are in the age group 15-59.

Intertemporal and intercountry comparisons indicate, however, that actual changes in age composition have been greater than is suggested by these comparisons of the stable populations. In a number of representative Western European countries, for example, sixty to sixty-two per cent of the population fell in the age group 15-64 around 1850 and again around 1900. By 1950, however, the percentage had risen to sixty-five to sixty-seven, both in these countries and in a number of countries in which as of 1890-1900 the corresponding percentage was fifty-eight to fifty-nine.[36] It may be inferred, therefore, that because of improvements in age composition potential per capita productivity in these countries increased about eight per cent between the second half of the nineteenth century and 1950. Around 1950 in many high-fertility, underdeveloped countries the percentage of the population aged 15-64 fell in the range fifty-three to fifty-six; this percentage, when compared with that of sixty-five to sixty-seven found in many low-fertility, developed countries, indicates that, because of differences in age composition, potential per capita productivity *ceteris paribus* was about one-sixth lower in the underdeveloped than in the developed countries. Moreover, because the relative number of children of school age was so much higher in these high-fertility countries, about twice as large a fraction of the labor force was required in these countries as in low-fertility countries to supply a given level of educational services.[37]

Potential productivity per capita varies with a population's age composition for three main reasons, two of which are essentially socio-economic in character and only one of which is closely associated with the influence that age as such exercises upon a worker's psycho-physical capacities, work-experience, etc. These three age-conditioned determinants are variation in rate of participation in the labor force, variation in the fullness with which members of the labor force are employed, and variation in output per man-hour worked. Each determinant tends to vary with the age of workers, the first two largely because of the manner in which an

[36] In France, the first country to experience great changes in age composition, the percentage of the population in the age group 15-64 was 66.23 in 1850, 65.88 in 1910, and 66.53 in 1950.

[37] This and the preceding paragraph are based on data presented in THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 7-15. For data relating to Japan, see IRENE TAEUBER, THE POPULATION OF JAPAN (1958).

economy is organized and the last principally because of the effects which aging has upon a worker's capacities. The response of each of these determinants to changes in age is conditioned also by a population's educational and occupational composition. It is to be presumed, however, that when all these various determinants and conditions are taken into account, actual as well as potential productivity per capita will still be found to vary much as does the fraction of the population of productive age (say, 15-59 or 15-64).

While variation in age affects the rate of participation in the labor force among both males and females, male activity rates may be employed to illustrate the role of age which is very much affected by socio-economic conditions and organization. Male activity rates tend to be higher at most ages, and especially at low and high ages, in countries that are underdeveloped and predominantly agricultural than in those which are not. Even so, because of differences in age composition, the fraction which male workers form of all males is slightly higher (around five per cent) in developed than in underdeveloped countries or than in semi-developed countries where activity rates tend to be lower among young and old males than in underdeveloped countries. If we assume stable-population conditions and male activity rates of the sort characteristic of developed, semi-developed, and underdeveloped countries, we find that, whereas increasing life expectancy from 50 to 70 years reduces by only three to five per cent the percentage which active males form of all males 10 years or more old, decreasing the G.R.R. from 3.0 to 1.0 will increase this percentage about two-fifths. We find also that whereas increase in the expectation of life at birth from 50 to 70 years has little effect upon the age composition of the *active* male population 10 years or more old, decrease in the G.R.R. reduces the relative number of active males aged 10-19 and 20-44 years and increases that aged 45-64 and that 65 and over.[38] How labor-force participation rates respond to changes in age composition is affected, as has been noted, by a population's educational composition, education serving to increase and to prolong participation in the labor force and in occupational activities which can be carried on effectively at higher ages.[39]

It should be noted at least parenthetically that one indulges in somewhat spurious assertion when one declares that the labor participation rate is very much lower in developed than in underdeveloped countries among (say) males under 20 years of age and somewhat lower even among those aged 20-24. For most of those under 24 and not in the labor force are acquiring an education which will make them

[38] See THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 51-56; *Age Structure and Labour Supply*, in 3 PROCEEDINGS OF THE WORLD POPULATION CONFERENCE 571-96 (U.N. Pub. Sales No. 1955.XIII.8); *Factors Affecting the Size of the Economically Active Population, id.* at 597-613; GERTRUDE BANCROFT, THE AMERICAN LABOR FORCE ch. 3 (1958); CLARENCE D. LONG, THE LABOR FORCE UNDER CHANGING INCOME AND EMPLOYMENT 144-58, appendices *A, B* (1958); Durand, *Population Structure as a Factor in Manpower and Dependency Problems of Under-Developed Countries*, 3 U.N. POPULATION BULLETIN 1-6 (U.N. Pub. Sales No. 1954.XIII.8); Schiffman, *Marital and Family Characteristics of Workers*, 84 MONTHLY LABOR REV. 355-64 (1961); Stein & Travis, *Labor Force and Employment in 1960*, 84 MONTHLY LABOR REV. 344-54 (1961).

[39] See, *e.g.*, LONG, *op. cit. supra* note 38, at 174-80; BANCROFT, *op. cit. supra* note 38, at 65-69.

more productive later; and they cannot be so engaged and at the same time function as full-time members of the labor force. It is relevant from the economic point of view only that, given the rates and conditions under which capital is available for investment in education and otherwise, such investment be carried out as far as is warranted by the investment alternatives present and by the direct and the indirect net increases in future output imputable to such educational investment. For such investment not only increases the productivity of individuals as such but also augments the pool of technical knowledge, strengthens rational behavioristic tendencies, and generally renders man's milieu more favorable to production. Countries differ in respect of the patterns of investment in education suited to their economic conditions; for countries differ in respect of capital scarcity and discount rates applicable, of income that must be foregone to acquire education, of the rate of increase in productivity associated with the rate of increase in educational investment, and so on.[40] In sum then discussions of the relation of age to labor-force participation need to take into account income-augmenting effects consequent upon nonparticipation in the labor force.

Of the two remaining determinants of the significance of changes in age composition for productivity, by far the most important is the response of the productive capacity of workers to changes in age. It is true that unemployment varies somewhat with age, tending to be relatively higher among younger and older workers; but this variation is essentially a function of social organization rather than of the influence which age exercises upon a worker's psycho-physical capacities, his experience, etc. It is this influence, however, which, together with education, underlies the association of variation in productivity with variation in age. Here it will suffice to indicate that productivity generally rises to a peak in the 45-54 age group and then moves down gradually, or even to assume that it moves to a plateau in the 35-54 age group and then gradually descends. Given the pattern of the correlation of productivity with age, it is unlikely that changes in the age composition of the age group 15-64 will materially affect average output per member of the labor force; for productivity per person tends to be higher among those aged 60-69 than among those aged 15-24 under modern conditions.[41]

Changes in a population's age composition could be influenced by several circumstances which are, but which need not be, associated with such changes. First, when a society is technologically very dynamic, much of the knowledge acquired by older persons in their earlier years tends to become obsolete unless they continue

[40] These matters will be treated in Gary S. Becker's forthcoming study of investment in education, being done under the auspices of the National Bureau of Economic Research.

[41] See Spengler, *The Economic Effects of Changes in Age Composition,* in JOSEPH J. SPENGLER & OTIS DUDLEY DUNCAN (EDS.), DEMOGRAPHIC ANALYSIS: SELECTED READINGS 497-517 (1956); 1 A. SAUVY, THÉORIE GÉNÉRALE DE LA POPULATION chs. 6,8 (1952). Around 1850, about 39-43% of those in the age group 15-64 in then relatively developed countries, were aged 45-64; by 1950, this percentage had risen to 47-54. When fertility is low, the proportion of the labor force aged 45 or more years will be higher than when fertility is high. This proportion is affected very little, however, by differences in life expectancy. See THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 15-18, 54-56.

to refresh their knowledge and replace the old by the new in so far as the latter is technologically and economically superior. Given a low Gross Reproduction Rate and the prolongation of life in prospect, a larger than current fraction of "top" and "choice" decision-making posts could pass into the hands of relatively old persons who were governed by comparatively obsolete ideas and conceptions, particularly if selection for these posts were much affected by bias in favor of older persons, as well as by randomness. Should this gerontocratic result come about, the economy would be less progressive than it otherwise might. This contingency may be guarded against through continuous provision for adult refresher training and education and through making social selection entirely dependent on prospective as well as on past capacity to perform.[42] It is perhaps well to remember, however, that in a traditional and quite static society in which the father has much to teach the son, many of the conditions present (*e.g.*, high morbidity rates, high mortality, superstition, empirically untenable beliefs, etc.) make for the absence instead of the presence of that buoyancy and that set of conditions (*e.g.*, long time-horizons, rationality of approach, good health, this-worldliness, etc.) which are so essential to technical progress.[43] Second, when fertility is very low and hence the rate of growth of the labor force is very low, it may be more difficult to preserve an optimum balance among occupations than when fertility is higher. For then there is relatively more need than in a growing labor force for interoccupational shifts, and the maintenance of optimum balance depends largely on the skill with which newly-entering members of the labor force are directed into occupational areas in which labor-demand functions are shifting to the right. This problem, together with others associated with low rates of population growth, are readily solved; it is necessary only to apply the techniques at hand.[44]

Man's ability to offset an unfavorable age composition is much greater today than it was 100-150 years ago. For today fifty to seventy-five per cent of all increase in output is attributable to increase in physical capital, to improvement in the quality of the labor force, to technological progress, and (in some measure) to increase in scale- and other economies. If increase in these productive forces accounts for two-thirds of an annual increase of three per cent in aggregate output,[45] it does not take

[42] For a fuller account of this problem, see Spengler, *Some Effects of Changes in the Age Composition of the Labor Force*, 8 SOUTHERN ECON. J. 157-75 (1941). On the aging of elites see also THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 60-61.

[43] For an admirable comparison of traditional society in which death is at the center of life with a modern society, see Fourastié, *De la vie traditionnelle à la vie tertiaire*, 14 POPULATION 417-32 (1959).

[44] See my papers cited in notes 41 and 42 *supra*; the papers reprinted in JOSEPH J. SPENGLER & OTIS DUDLEY DUNCAN (EDS.), POPULATION THEORY AND POLICY 234-301 (1956); and my *The Population Problem: Yesterday, Today, Tomorrow*, 27 SOUTHERN ECON. J. 194 (1961). On how the rate of entry into and the rate of departure from the labor force varies with changes in the G.R.R. and life expectancy, respectively, see THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 56-60.

[45] According to Moses Abramovitz, in the United States between the periods 1869-78 and 1944-53, net national product increased 1,325%, although the civilian labor force increased only 393% and the input of civilian man-hours only 290%. See *Resource and Output Trends in the United States Since 1870*, 52 OCCASIONAL PAPERS 8 (1956). I have used the term "attributable" above instead of the term

long to increase income per capita by enough to offset, though not necessarily to eliminate, an initially sub-optimal age composition. For example, suppose that output per capita in country *L* is five to fifteen per cent below that in country *H* because age composition is less favorable in *L* than in *H*. Under the circumstances stipulated and given that per capita income rises very little in *H* for a decade, it would take only 2-7 years for per capita income in *L* to approximate that in *H*. Even if technological conditions were the same in *L* as in *H* and per capita income were five to fifteen per cent lower in *L* than in *H* solely because of differences in age composition, *L* could still bring its average income abreast of that in *H* by recourse to a combination of compensatory measures (*e.g.*, accelerate rates of capital formation and technical progress; lengthen work-week; delay retirement; introduce more women into the labor force).

Recourse to such counterbalancing measures tends to be more difficult when the source of unfavorable age composition is high fertility than when it is a combination of very high life expectancy (*i.e.*, a life expectancy in or beyond the upper 70's) with very low fertility (*i.e.*, a G.R.R. little above 1.0). When fertility is low, it is much easier to augment investment per capita than when fertility is high and population growth is absorbing a great deal of the capital being formed. It is less difficult to lengthen the work-week when this week is relatively short as is common in low-fertility countries than when it is relatively long as is more common in high-fertility countries. It is easier to defer retirement when age of retirement is typically low as in low-fertility countries than when it is relatively high as in high-fertility countries. It usually is comparatively easier also to increase the relative number of women enrolled in the labor force when fertility is low, for then the claims per woman of childbearing and child rearing are lower than in high-fertility countries.

The burden of what has been said is to the effect that increase in the Struldbruggian component of modern populations, or in the relative number of dependent persons (*i.e.*, those aged 0-14 and 60 or 65 and over), will not tend to reduce potential productivity per capita appreciably. Nor need prospective changes in age composition materially affect the overall ratio of dependents to producers, or the dependency cost incident on the average producer. Up to now, of course, decline in fertility, together with increase in life expectancy, has not adversely affected this ratio. Furthermore, increase in working life expectancy kept pace with that of retirement-life expectancy (*i.e.*, separation from the labor force for reasons other than death) until recently, since the average number of years spent in retirement did not until recently begin to increase much faster than the average number spent working. Around 1900 in the male population in the United States the ratio of retirement-life expectancy at age 20 to working-life expectancy at age 20 was .069; it had risen to 0.121 by 1947 and to 0.146 by 1958. By the year 2000 it could

"imputable," since I am dealing with change over time and am not concerned with imputation as of a given time.

easily exceed 0.2. In other words, whereas in 1900 an American male did about fourteen years' work for each year spent in retirement, he may, by the year 2000 if present life-expectancy and retirement trends continue, be doing only about five years of work for each year he spends in retirement. It is doubtful if, should he spend so large a portion of his post-19 lifetime in idleness, he can provide for his needs during retirement at a rate commensurate with his wants, tastes, etc. Under the circumstances, therefore, there might be political pressure for greater support of retired persons by the state and this could result in both inflationary financing and a decrease in the rate of capital formation. It could happen, of course, if such outcome became likely, that steps would be taken to defer retirement and extend the length of working life as would be necessary to prevent a decline in per capita income.[46] For those in the younger age groups, upon whom the cost would largely fall, would be motivated to exercise counter-political pressure, with the result that age differences could become a divisive factor.

Changes in age composition produce changes in the ratio of dependents to producers and these in turn exercise some influence on fertility, on length of working-life, and on the provision made for dependents. (a) Let us suppose that a girl marries at age 18-20, lives in this state for at least 20 years, has a first child a year later, has 6 more at intervals of about 2 years, and may have 2 more at intervals of about 3 years. If half these children die in the first five years as happens when life expectancy at birth is in the lower 20's, only 3-4 children would be living at the close of the mother's effective childbearing period. This number might be around 5-6, 6-7, and 7-8, respectively, if life expectancy were around 30, 45, or 60. If, furthermore, children entered the labor force when ten years of age, the maximum number of dependent children in a family at any time, given these four life expectancies, would be around 2, 3-4, 4, and 5, respectively. If, however, children could not enter the labor force until the sixteenth year, the maximum number of child-dependents would rise to around 4, 5, 6, and 7. Hence both increase in life expectancy and deferment of entry into the labor force increase the dependency burden imposed by children upon parents. (b) That a larger fraction of males under 20, 55-64, and 65 and over remain enrolled in the labor force in high-fertility than in low-fertility countries is attributable in part to the comparative lowness in high-fertility countries of the percentage of the population in the age group 15-59

[46] In 1900-02, male working-life expectancy at age 20, and retirement-life expectancy at age 20, respectively, were 39.3 and 2.7. The corresponding figures were 42.8 and 5.2 in 1947, 43.1 and 6.3 in 1958, and 45.1 and 8.7 or higher in 2000. Life-expectancy and working-life expectancy at birth were 47.9 and 31.1 in 1900-02, 64.2 and 42.3 in 1958, and (as estimated in 1955) 73.2 and 45.1 in 2000. See Garfinkle, *Changes in Working Life of Men, 1900-2000*, 78 MONTHLY LABOR REV. 297-300 (1955), reprinted in SPENGLER & DUNCAN, *op. cit. supra note* 41, at 104-07; *Health and Working Life*, 10 PROGRESS IN HEALTH SERVICES 1-5 (April 1961). On length of working life and its relation to life expectancy, see Wolfbein, *The Length of Working Life*, 3 POPULATION STUDIES 286-94 (1949); Johansen, *Death Rates, Age Distribution and Average Income in Stationary Populations*, 11 *id.* 64-77 (1957); Durand, *supra* note 38, at 9 (comparative tables). Johansen, working with a stationary-population model concluded that as average lifetime increased the upper limit of productive ages needed to increase in order to make possible an appreciable increase in average income. See Johansen, *supra* at 76-77.

(or 15-64) and the consequence that potential and actual per capita productivity is relatively low; but it is attributable also to the agricultural and less-urban character of the economies found in high-fertility countries.[47] (c) Since the needs of dependents vary somewhat with age, changes in the age composition of the dependent population may affect the ratio of needs to dependents, though the general level of needs per dependent is determined largely by socio-economic circumstances not immediately connected with age of dependents.[48] These changes may also affect the attitude of producers toward dependents in that more satisfaction tends to be derived from the support of young than from that of old dependents.

## IV

### CONCLUSION

Several inferences may be drawn in addition to the conclusions presented in various parts of this essay. (1) Population aging in the sense of increase in the proportion of the population aged 65 and over will continue in most parts of the world, but particularly in what are now high-fertility countries. (2) It will be the result primarily, as in the past, of decline in fertility, though it may also be occasioned in some measure in low-fertility countries by decline in mortality, if, contrary to expectations, the average duration of life is permitted to move into and even beyond the upper 70's. (3) Population aging does not tend to be accompanied by increase in the ratio of a population's dependency burden to its capacity to support such burden, even *ceteris paribus;* for increase in the relative number aged 65 and over usually is accompanied by decrease in that under 15 and by increase in that 15-64. Only if fertility is very low and life expectancy rises much above present levels is there a tendency for the ratio of persons of dependent age to persons of productive age to rise. (4) The movement of per capita income is determined predominantly by circumstances other than changes in age composition. (5) The real cost of providing support for persons of dependent age is determined largely by circumstances unconnected with age structure as such, that is, by the level and distribution of income, by the pattern of tastes, by the emphasis being put upon economic growth, and so on. (6) It is easy to modify a population's age structure, in that only the gross reproduction rate needs to be modified appreciably. (7) It is very easy for a low-fertility population to introduce economic measures which offset increases in the relative number of persons aged less than 15 or more than 64 years, but it is not so easy for a high-fertility population to take countervailing measures. The latter has little recourse except to reduce its fertility.

[47] See, *e.g.*, Durand, *supra* note 38, at 9-15.

[48] For a discussion of the variation of "needs" with age, see THE AGING OF POPULATIONS AND ITS SOCIAL AND ECONOMIC IMPLICATIONS, *op. cit. supra* note 2, at 61-81.