Population Appearances and Demographic Reality

NATHAN KEYFITZ

If the world was as seen by common sense there would be no need for science.— Marx

That a country with a higher death rate is less healthy than one with a lower; that overpopulation leads to war; that an excess of births over deaths ensures population replacement: these are some frequently stated propositions on population. They are all common sense, they are all obvious, and yet on closer examination every one of them turns out to be false. I shall elaborate them along with other similar ideas, and show that they pertain to the surface of population phenomena, to appearance rather than to demographic reality. As Marx insisted for social life in general, relations below the surface can be quite different, and we will see how the techniques of demography serve to strip off the superficial relations and, at least in some instances, to produce knowledge of population that has a claim to be called scientific.

Mortality Comparisons

Taiwan recorded 5 deaths per thousand population during 1977. The United States in the same year recorded a death rate of about 9 per thousand, or 80 percent higher than that of Taiwan. A person chosen at random in the

United States is almost twice as likely to die within a particular year as a person chosen at random in Taiwan. Is Taiwan, then, healthier than the United States?

It is nothing of the kind, as can be shown by comparing people of the same age in the two countries. In Taiwan, the chance that a newborn baby will die in its first year is 0.025; in the United States, it is 0.014. At every separate age, Taiwanese mortality is higher, with no exceptions. The reality, then, is that the United States is healthier than Taiwan, notwithstanding the fewer deaths per thousand population in Taiwan.

For demographers it is crucial that the comparison be made age by age wherever the mix of ages between two countries is different. The ages may be grouped, but then they must be given the same weights for the two countries. If Taiwan had the same age distribution as the United States, its death rate would be 13 per thousand population. Alternatively, we note that the expected lifetime for males is 70 years for the United States, compared with 65 years for Taiwan. It is the fact that greater proportions of the population of developing countries are in the young age groups that gives several of them crude death rates lower than those of developed countries.

Thus, the use of age-specific rates does indeed strip off a layer of appearance and gets closer to the truth. But can we be sure that age is the only variable that has to be controlled in order to make the comparison valid? We cannot, even though age is probably the interfering variable that acts most strongly. That other variables operate as well can be seen by comparing mortality in the states of Arizona and New Hampshire in the United States.

The expectation of life of males at birth in Arizona was 65.38 years in 1967; in New Hampshire it was 67.13. Since population age distribution does not distort the calculation of life expectancy, other factors must be at work to produce this effect. Climate would seem likely to work in the opposite direction; one would think that the Arizona climate would help preserve old people better than the more rigorous temperatures of New Hampshire. That may well be true. A process of self-selection may explain lower life expectancy in Arizona; people in good health may continue to live in New Hampshire, while the less healthy move to Arizona. We would have to go deeper and compare people similar in other respects as well as age to separate out the salubrious effects of climate or other variables of interest.

What is striking in such cases is the ease of drawing a wrong conclusion from exact statistical data even when they are known to be quite accurate. Without breaking the data down by age, we find Taiwan healthier than the United States; without breaking them down by some indicator of personal health, we find New Hampshire more salubrious and conducive to long life than Arizona.

This is why demographers are suspicious of comparisons that try to infer the extent to which mortality is governed by environmental conditions. Los Angeles had a death rate of 8.5 per thousand in 1975 compared with Atlanta's 6.9 per thousand. Los Angeles also has greater frequency and intensity of smog. A breakdown by cause of death strengthens the suspicion that mortality and smog are connected; death from lung diseases is proportionally greater in Los Angeles. But the evidence is not conclusive; we must satisfy ourselves that Los Angeles' older age distribution does not account for the difference, and having done so we must look into other variables by which people in the two cities might be different.

Of course to relate mortality to smog, we ought not to stop at two cities but compare a large number of them. But such a comparison is still not conclusive if there is some variable that sticks, so to speak, to the one that we are correlating with mortality. Suppose the data show a negative correlation between the number of days per year with high smog levels and expectation of life at birth, and suppose that the smog is caused by industrial activity (as against employment in trade or government) and that it is the rigorous employment in industry, not the smog, that causes the shorter expected lifespan. If this were true, then pollution controls that would eliminate smog would be a futile way to attempt to reduce mortality.

Sometimes a variety of evidence, no one part of it very strong, can build up to a powerful case. The effect of cigarette smoking on mortality is the classic instance. The mere fact that smokers had higher death rates than nonsmokers, observed as early as 1938 and confirmed in 1956,[1] did not prove that cigarettes are harmful. After all, people smoke to relieve tension, and it may be the tension that causes the higher mortality; perhaps smoking even lessens mortality, as people thought in the eighteenth century. But then it was determined that mortality rates increased with the amount smoked—with very high rates for those smoking a pack a day. Again, not in itself conclusive. Men smoke more than women and have higher death rates, but there are far more substantial differences between male and female lifestyles than the number of cigarettes smoked per day. Animal studies showed clear effects of exposure to smoke, but could these effects be transferred to humans? It was the accumulation of evidence, every part of which taken alone was flawed, that forced the recognition of the relation between smoking and death rates.[2]

Often the true direction of a relation is easily observed, but its size or strength is not. At most ages men have about double the death rates of women. For instance, according to the life table for 1966–67, the chance that an American male of 50 will die in the succeeding five years is 0.059, while the chance that a female of 50 will die during the same time is 0.031. This difference is fairly typical of many other ages as well. Yet women live only seven or eight years longer than men. How can it be that men in the United States have mortality consistently much higher than women, but women live only 10 percent longer?

Certainly for a species whose death rates were the same at all ages, double mortality would mean half the length of life. But mortality rates for humans are not the same at all ages, following instead an asymmetric u-shape, sometimes described as a bathtub curve. And on this curve the very high rates at the oldest ages, up to now little affected by medical advance, set an upper limit on the length of life. Because of this upper limit, women obtain only a relatively small advantage from the fact that their mortality rates at any given age are much lower than those of men.

The stubbornness of this ceiling for both sexes, in the face of improved treatment for every known disease, suggests that there may be a factor below the surface that is not touched by disease-oriented medicine. Death is usually attributed to some well-defined ailment—stroke, cancer, kidney failure—that is called *the cause* of death. The implication is that if the individual had been cured of that particular ailment, he or she would have rejoined the healthy population. But this could be a superficial way of looking at the matter. It is a perspective arising from the way that sick people are treated—always for specific diagnoses—and the way that deaths are described, by lay people, by physicians, and by statisticians.

Biological research suggests that the underlying cause of aging and death may be defective cell reproduction.[3] After a relatively fixed number of cell generations, DNA loses its ability to reproduce exactly, and the new generation contains errors. The errors or mutations show themselves as dangerous growths or as weakened organs. It is theorized that each organism has its own clock of aging, which dictates that it will age at a particular rate and die after a set time. Every animal species has a characteristic point of inflection in the upper segment of its survival function—the three years for rats corresponding to 12 years for dogs and 70 years for humans.

To follow up the evidence on the way aging occurs requires the application of highly technical genetics and microbiology: these areas of investigation appear to represent the chief hope of prolonging life. All this suggests that the popularly and statistically recognized causes of death may not ultimately be what kills us. They represent a certain layer of reality, but without penetrating below them we can have little hope of greatly expanding the span of human life.

Inferring Causation from Historical Data

On some points demographers are simply reticent; they have spent enough time gathering and examining population data to become aware of complex relations underneath observed numbers, yet without knowing what the relations are.

It is often said that large populations, living in conditions of high density, make democracy impossible; they inevitably lead to regimentation and tyranny. Plato thought so, as did Harrison Brown,[4] and it is true that Bangladesh and China are less democratic than the United States; concentrating on these cases we can convince ourselves of the general proposition. But what about Holland, both denser and more democratic than the Soviet

Union? This counter example does not by itself prove that the relation does not exist, for there could be special circumstances in Holland and the USSR. But, at least it proves that the relation cannot be as simple as one would surmise from Plato or Brown. There are bound to be other variables that affect the relation, and until they can be disentangled any statement is as likely to deceive as to enlighten.

Take, for example, the common view that population increase and high density in relation to resources lead to war. A careful examination of the evidence by a political scientist who reviewed scores of cases found density to be associated with war in many historical instances, but not in many others.[5] Even if the data had shown a perfect correlation between population density and frequency of occurrence of war, we could not say that the former caused the latter; it could be just the opposite. It could be that countries of militaristic bent pursue population policies that provide the needed cannon fodder. This is one of many instances in which we have to consider the possibility that the common-sense causal relation may be literally the opposite of the true causal relation.

Stripping Population Increase of Age Effects

Nothing would seem more certain than that the population of the United States is now increasing, even if we disregard the balance of migration. In 1978 the country had about 3.3 million births, against about 1.9 million deaths. For the moment, let us consider the present native population of the United States as a closed unit. The natural increase of this closed population was 1.4 million in 1978, or about 0.7 percent. In 100 years at this rate the population would double; in 500 years it would multiply by 32 and number over 6 billion. Yet the demographer claims that in reality the current levels of fertility and mortality are such that the population of the United States is not even replacing itself. How can such a statement be justified in the face of visible, countable increase?

The answer comes out of a very different perspective from simply noting that births exceed deaths. It does indeed start with such statistics, but it takes them by age and converts them to probabilities. Think of a female child just born in the United States, and suppose that she will be subject to the same regime of birth and death as the United States showed for the year 1978. Then calculate the probability that she will survive to age 18 and at that age have a baby girl; that she will survive to age 19 and have a girl; and so on for each year of reproductive age. Adding these up we get the expected number of baby girls by which that baby would be replaced according to the birth and death rates for 1978; it turns out to be 0.85. The expected number of female births a child will have is the same as the ratio of the size of the next generation to this generation, still at 1978 age-specific rates of fertility and mortality. Those rates imply an ultimate decline of 15 percent per generation.

If a baby girl will not in the next generation give birth to at least one baby girl on the average, then the population is not replacing itself, and it will sooner or later decrease if these rates continue unchanged. We can carry the idea of replacement to a per-year rather than a per-generation basis by noting that the average time for a girl to grow up and become a mother is something like 26 years; taking the 26th root of 0.85 we obtain 0.994, a decline of about 0.6 percent per year. This is part of the reality of the present birth and death regime. The reason for the difference between this and the superficial conclusion that the US population is increasing is the exceptionally large number of women of childbearing age in the present native population—a consequence of the baby boom of the 1950s. We have to strip off the effect of these temporarily large numbers and focus our attention on the amount of childbearing women are on the average undertaking.

So far so good, but all of these considerations are within the narrow framework of birth and death classified only by age. It is all very well for the demographer to enclose himself in this strictly bounded area: within it he does indeed uncover a deeper reality than that accessible to common sense. Yet, surely there are other classifications than age, opening up further layers of explanation below this. Without digging deeper we can hardly hope for useful policy advice or accurate forecasts. We have to go outside of demography and see what else is going on in the society, in addition to women having so few children.

Why Births Will Remain Low

During the 1960s and 1970s, the fall in the US birth rate was accompanied by a sharp rise in female participation in the labor force, an unprecedented increase in divorce, and greater participation of women in the education system at higher levels. Smaller families are thus congruent with other tendencies in the society; for the immediate purpose we do not need to struggle with the difficult question of causality. Do women have few children because they want to be free to work? Or do they go out and take jobs because they have few children and hence less responsibility in the home? If we had to wait for direct statistical answers to such questions, we would be in suspense a long time.

Without answering the question of causation, demographers have noted further aspects of the new context of American fertility.[6] The bundle of disparate elements includes later marriage than was previously customary, more cohabitation without marriage, and proportionally more illegitimate births, all paralleling rising divorce rates and increased participation of women in the labor force. If these tendencies are interrelated, then one would not be likely to change without a change in the whole configuration. For the birth rate to rise substantially, women would have to go back to housework—some would say to being domestics in their own homes; they would give up the satisfactions of work and independent incomes in favor of the satisfactions of having many children; they would put up with unsatisfactory marriages rather than undergo divorces. All this is hard to imagine, and that it is unlikely is the basis of the forecast that we will have low birth rates for at least the remainder of the century.

Going still further from the demographic variables, we recall that those who grew to young adulthood in the 1970s have been dubbed the "me" generation. "Look at me" was the quintessential expression of their preoccupation with self. When a "me" person marries an admiring other, the marriage can be stable and satisfactory. But what happens when two "me's" marry? Divorce and resulting single-person households are a likely outcome. More study of conjectures along such lines is needed to understand the demographic configuration.

One might think that greater certainty is necessary for forecasting; if we do not know why something is occurring we cannot say whether the trend will continue. But without knowing precisely why the birth rate is falling, we know that its fall is tied to a number of specific social changes. These changes together are a cluster that will not easily be reversed, and one can say with some confidence that the birth rate will remain low for the foreseeable future, both in the United States and in all other industrialized countries.

Labor Force Participation

It was long ago said that as a society becomes richer, agriculture is bound to occupy less of the labor force;[7] after all, the amount of income that we can generate through food production is limited. Economists also saw that the same must apply to manufactured goods—there is a limit to the number of cars, television sets, and other artifacts a society can use. When the society becomes saturated with primary (agricultural) and secondary (manufactured) goods, it moves into a service economy.

Yet in industrial societies, expansion of the services that people once thought they wanted is exactly what has *not* happened.[8] Barbers, shoe repairers, taxi drivers, domestics (both live-in and not) are among the occupations that have declined most sharply, both in the number of persons employed and in value of product. Some of these traditional service occupations in the United States dropped by as much as half in the single decade between the 1960 and 1970 census. What has expanded spectacularly is government, trade, insurance and banking, and education. It is well to avoid stretching the label "services" to cover both these and the traditional service occupations, and to refer to them simply as tertiary.

The forces in the US economy that are bringing the tertiary sector up to half of the labor force and beyond are not well understood. In the mid-1960s, many economists predicted that with the large number of young people about to enter the labor force, and with increasing productivity of those already working, it would be impossible for married women to break into the labor force. Yet, in the event, the late 1960s and the 1970s have shown a continued increase in the already large number of married women working outside the home. Only a small fraction of the newcomers have taken jobs in manufacturing; the great majority have taken up tertiary employment.

On the one hand is the puzzle of how the economy has been able to absorb the large number of young people of both sexes, as well as the newly entered married women. On the other hand is the question of why married women want to work outside the home. When women themselves are asked, they tend to reply that they need the money, and common sense is satisfied with this answer. But the answer cannot be correct, since in earlier decades their husbands were earning less, presumably families needed money, and yet wives were content to stay home. Needing money is a universal, a constant, and a first rule of method is that one cannot explain a variable (in this instance, far more women having jobs in the 1960s than in the 1920s) with a constant.

Apparently, a huge cultural shift has taken place, but that also is less an explanation than a name for the phenomenon. Once again, it is the responsibility of the scholar to know when the observed phenomenon is an expression of forces working far beneath the surface, and not to be satisfied with brushing the problem of cause aside by giving it a name. To say that women are no longer raising children because of a shift in the culture is by itself merely scholastic. To make the statement useful, we would need some way of independently measuring how the culture was shifting.

In the area of labor force participation, as earlier in fertility, mighty social forces are churning below the surface. The census and vital statistics indicate that deeper changes are taking place, but they are not easily delineated from present data. The demographic facts are formed by events occurring at deeper layers, and this is what makes analysis and forecasting so difficult.

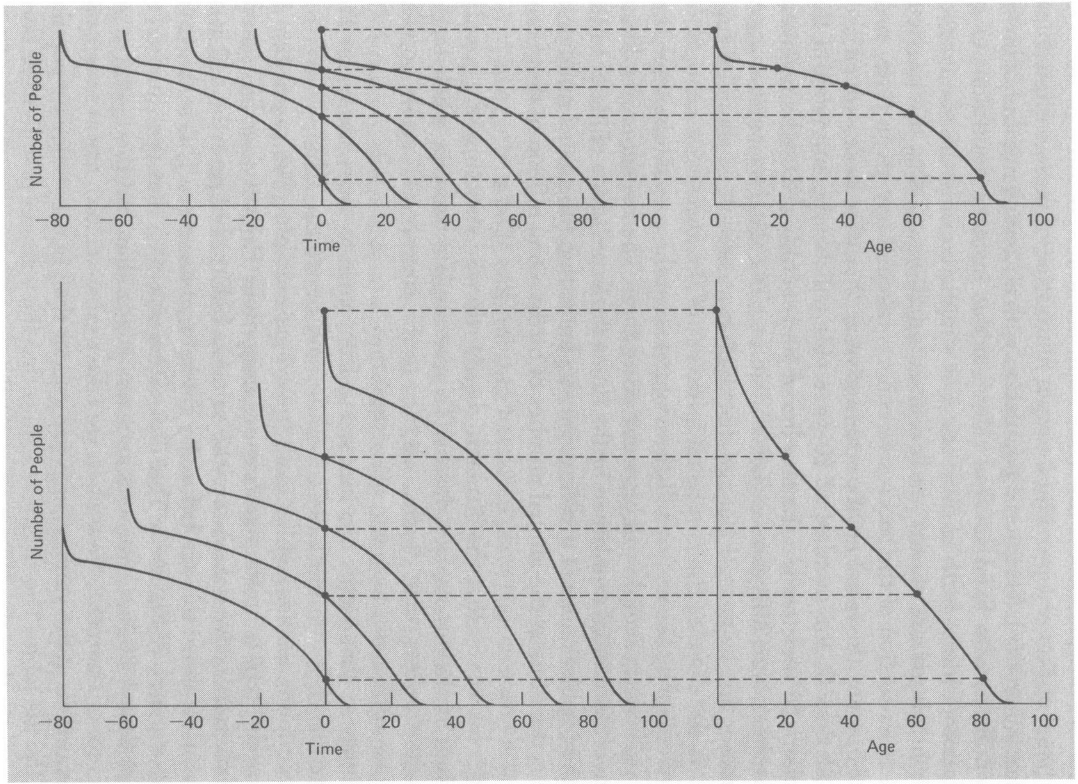
Abstract Relations: The Stable Population

Age distribution at any moment is a cross-section of the survivors from among previous births. In a population in which there are the same number of births each year and no net migration, the curve tracing the age distribution at any time is exactly the same as the curve showing the probability of individuals surviving to any given age as calculated in a life table. This age distribution—the so-called stationary age distribution—is also the same as the distribution traced by the curve showing the attrition of the members of a cohort, that is, showing the attrition of the number of survivors from a group of individuals born in the same year and followed through life. The upper panel of Figure 1 provides a simple illustration of these relationships. The diagram on the left depicts a population with an annual number of births of one million, with fixed survival rates—in this instance equivalent to an expectation of life at birth of 50 years. For simplicity, only the survivors of five birth cohorts are shown, each originating 20 years after the previous one. A cross-section of the successive cohorts taken at any given time, such as at $t=0$, gives the number of persons alive at that time at any given age. Thus, at time 0, the number of 20–year olds will be the survivors of the cohort born 20 years earlier; the number of 40–year olds will be the survivors of the cohort born 40 years earlier; and so on. The diagram on the upper right shows this cross-sectional age distribution at time 0; its shape, if fully traced, is the same as the survivorship curves of the successive cohorts. (A little reflection by the reader will also suggest what the size of the population in this particular example will be at any given time. The answer is 50 million: the size of the annual number of births times the expectation of life at birth. Since the population is not growing, we also know that the annual number of deaths is the same as the annual number of births—one million in the example.)

We have seen that the life table depicts the age structure of a population when births just replace deaths. To contemplate the case when births are greater (or less) than deaths, we turn to the concept of a stable population—one with a constant rate of increase.

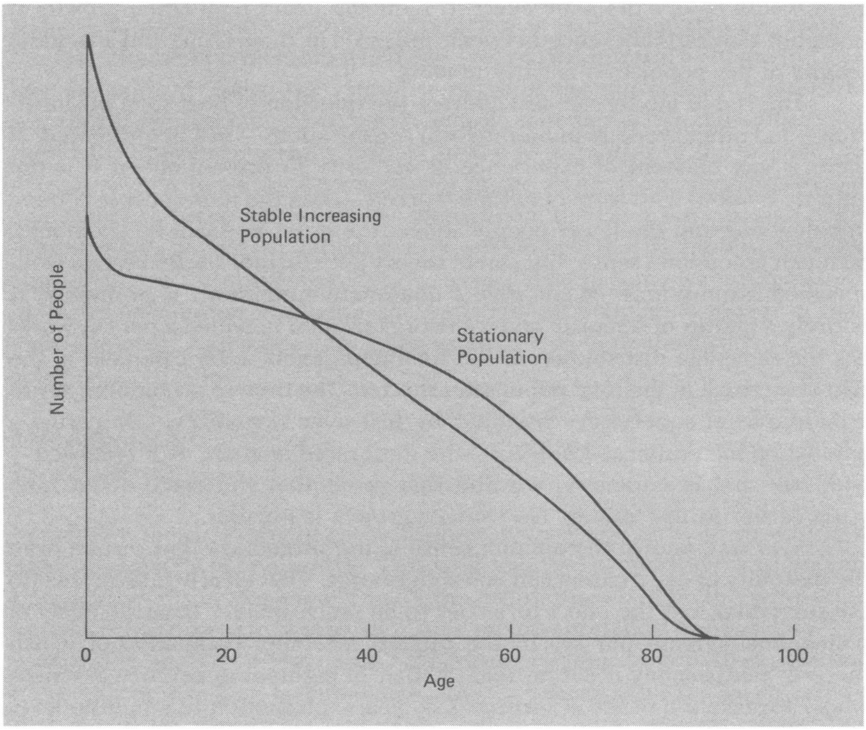
Suppose that births are increasing from year to year, always in the same ratio, while the mortality schedule, and hence the table of survivorship, continues unchanged, as in the previous example. The population is still closed: there is no immigration or emigration. The survivorship schedules of the successive cohorts are the same as before, but now the origin of each is raised above the one before by the ratio of increase. This is shown in the lower panel of Figure 1. The illustration assumes that the number of births at time -80 (i.e., 80 years ago) was one million but increasing at an annual rate of 1 percent. Now when we take a cross-section, say at time $t=0$, the proportions at the younger ages are greater than in the stationary population of the life table. The simple reason is that the younger people were born more recently than the older ones, and they are more numerous insofar as births are steadily increasing. This is further illustrated in Figure 2, where the two cross-sectional distributions are drawn so that the total populations in each case are the same size (i.e., the areas under the curves are the same). With higher rates of growth, the contrast between the stable population distribution and the stationary population would, of course, be sharper.

Figure 1
Age Distributions Resulting from Fixed Survivorship in a Stationary and a Stable Population



NOTE: Curves drawn from a Coale-Demeny West model life table with life expectancy of 50 years and, in the stable case, growing at 1 percent per year.

Figure 2
Stationary and Stable
Age Distributions Compared



Under many circumstances the stable model tells us how fast population is increasing when we have only a census report of the age distribution. We could know from Figure 1 that the steeper the slope of the age distribution, the faster the population must be increasing, but technical theory is required to obtain an actual estimate of the rate of increase based on the observed age distribution and the life table.[9]

As another application of the stable age distribution to tell us quantitatively what we can surmise qualitatively, think of a country that wants to reduce the population in a region by inducing people to migrate to another region. Indonesia is mounting a major program to take people off crowded Java and settle them in Sumatra and elsewhere in the archipelago. Clearly if the migrants are couples about to enter the childbearing ages, this program will be more effective in holding down the size of the population in Java than if the migrants are predominantly old people who are about to die. But what is the numerical effect of different age distributions of migrants on the subsequent population trajectory? Stable theory can show that having women of about age 17 migrate reduces growth in Java about 1.5 times as much as the same number of migrants selected at random from all ages; that having women of age 30 migrate helps about half as much as having babies go (assuming that the babies could migrate without their parents). Administrators in Indonesia had thought that the departure of relatively few people in their teens would have a dramatic effect in reducing Java's population growth; it turns out that the difference between migrants in their teens and a random sample of the population is fairly modest.

The stable model can also address the question of how soon businessmen—and other workers in hierarchical organizations—will be promoted. If there is any element of experience or seniority in promotion—if it is not entirely random with respect to time worked—then the more people coming in below one and the fewer people above, the faster one will be promoted. So much is common sense, but stable theory goes further under certain well-specified assumptions—it can give a quantitative measure. If promotion is entirely a matter of seniority and if the organization in which a person works has the same age distribution as the total population, each 1 percent of the rate of increase in the total population shortens the time to promotion, say to a middle-level supervisory position, by just over two years. Comparing a population increasing at 4 percent—the most rapid increase ever recorded—with one that is stationary, we find that promotion will come about nine years earlier in the former. No wonder growth is popular.

Also well known to common sense is the promotion that results from the mortality of one's elders and contemporaries. That clearly is favorable (to the survivors), but the effect turns out to be much smaller than the effect of population increase per se. In the highest mortality population of which there is a reasonably accurate record, that of eighteenth-century Sweden, whose expectation of life at birth was 30 years, promotion to a middle-level position would occur about three years sooner than in the low-mortality population of the contemporary United States. (This comparison is made at given rate of increase.) The population increasing fastest among those of which we have records provides promotion about nine years sooner than the one increasing most slowly. Thus, the effect of the highest recorded mortality on promotion (for those who survive) is only about one-third the magnitude of the effect of the highest recorded increase.

As a final example of the use of stable theory, consider two kinds of pension plan. How does the cost of pensions under a pay-as-you-go system, in which the working population of this year pays the pensions of the people who are past working age this year, compare with a reserve scheme, in which each person saves up for his own old age, either through an insurance company or on his own, receiving interest on savings? And how do the plans vary with the increase of the population? And what happens to the two approaches as a population moves toward stationarity? It turns out that the rate of interest enters the reserve scheme in exactly the same way as the rate of population increase enters the pay-as-you-go system. A pay-as-you-go scheme will be about one-third as expensive if the population is increasing at 3 percent as it is if stationary; it can gain nothing from interest because it has no reserve. A funded scheme gains nothing from rapid population increase, because each individual—strictly speaking, each cohort—pays for itself, but it is about one-third as expensive if interest is paid at 3 percent as it is if there is no interest.

Other factors being equal, this would suggest the pay-as-you-go scheme is preferable when the population is increasing rapidly, while a funded scheme is preferable when the rate of real interest is high. In times like the present, when the rate of increase of the population in industrial societies is approaching zero, pay-as-you-go schemes are in difficulties, and they will experience greater trouble in the first quarter of the twenty-first century, when the baby boom cohorts of the 1950s reach pensionable age and there are proportionally fewer members of the labor force paying taxes. A pay-as-you-go system initiated in a population that is rapidly growing, hence has a youthful age distribution, has a defect in some ways reminiscent of that of a chain-letter scheme: the participating population sooner or later stops growing. And when this happens costs rise dramatically.[10]

The Approach to Stationarity

Population increase cannot go on forever; growth can only be an interlude between periods of nongrowth. This well-founded proposition is commonly translated to mean that some time in the future there will be the same number of births from year to year. But such an interpretation is erroneous. The proposition about the inevitable long-term cessation of growth means that there will be a ceiling to population size, but there is no reason to believe that it will be approached smoothly and that, once attained, population growth will settle down to a steady zero rate. Nothing in the argument proving that population cannot increase forever prevents great oscillations in the number of births from year to year, either in short or long waves, regular or irregular. Indeed, such a pattern, with an average nonincrease over extended periods, seems most likely.

Likewise, stationarity need not imply that individual localities will have fixed populations. The population of a country as a whole can be stationary, and yet in any particular year or decade one of its regions can increase and another decrease. There can be depressed areas and booming areas, in respect of population as well as of income. The inevitable long-term slowing of growth, down to what is called stationarity, does not mean constancy and stability for the country as a whole; and even less does it mean constancy for any particular region.

The common contrary interpretation seems to have originated in mistaken labeling. We choose a word—stationarity—for the inevitable cessation of growth, and then we are deceived by our own word into accepting something that is far from inevitable: the absence of oscillations. The gap between appearance and reality in this case is not caused by one layer of reality covering up deeper layers; the problem is simply one of semantic self-deception.

The Renewal Process for Births

The contrast between what is apparent to common sense and what is going on in the demographic reality can also be illustrated with cases from microdemography, in which actions of individuals are considered.

As a first example, let us consider the problem of estimating the effect of abortion on number of births. During 1977, 1.2 million legal abortions were performed in the United States. Does this mean that there would have been 1.2 million more births if abortions had not been legalized? Let us overlook the possibility that the legal abortions took the place of illegal ones, and take account only of pregnancies that would have led to a live birth had they not been artificially interrupted. Common sense would say that if each pregnancy would have led to a live birth (i.e., disregarding spontaneous abortions and fetal deaths), then 1.2 million pregnancies would have led to 1.2 million live births. We will show that although each abortion considered by itself averts one birth, 1.2 million abortions avert fewer than 1.2 million births. The individual cases cannot be added together in a straightforward manner for a population.

The procedure for arriving at this finding is to contrast (hypothetical) women who have successive pregnancies and births with (hypothetical) women who have successive pregnancies and abortions.[11] If a fertile woman, having unprotected intercourse, has a chance of conception in any month of one-fifth, then on the average she will become pregnant in five months. After pregnancy there will be about nine months to delivery and, thereafter, a period of infertility that can easily average 8 months, indeed more if children are breastfed. For this example, then, suppose that the time in which the woman cannot conceive is 17 months. After the 17 months the woman is fertile again; assume that she resumes intercourse and that the same cycle of pregnancy, birth, and postpartum infertility is repeated. If it is repeated again and again, she will give birth every 22 months; this is more frequent than any large population attains, so it is conservative from the viewpoint of our example to suppose that in a large population of women of reproductive age using neither contraception nor abortion the birth rate is 1/22 per month. Among 1,000,000 such women there would be 1,000,000/22 = 45,000 births each month.

Now take a second population of women of reproductive age who are also not using contraception, who also become pregnant on average in five months, but who abort all pregnancies. Assume that abortions always occur in the second month of pregnancy and that postabortion sterility lasts one month. These women would then have an abortion every eight months. Their abortion rate per month, analogous to the birth rate, would be 1/8; among 1,000,000 such women there would be 125,000 abortions each month.

Compare the two groups of 1,000,000 women. Those who are bearing children at the maximum rate would have 45,000 births per month; those aborting each time would have 125,000 abortions. If 125,000 abortions were prevented, 45,000 births would occur. Thus, under the simplified assumptions we have made, on the average it takes nearly 125,000/45,000 = 2.8 abortions to avert one birth.

This is the answer for populations with a probability of conception of .20 per month, no spontaneous fetal death, and sterile periods of 17 months for a birth and three months for an abortion. But suppose that the abortion is a backstop to a method of contraception that is 90 percent efficient (the efficiency attained by withdrawal in some settings). Then the chance of conception in any month becomes one-fiftieth, and on average there will be a conception leading to a live birth after 50 months. If postpartum sterility remains 17 months, then the renewal process occurs after a period of 67 months. In a large population, again say of 1,000,000 women, the birth rate will be 1/67 per month, and the monthly number of births 15,000. For abortions, the renewal process will take 50 + 3 = 53 months, and the number of abortions among 1,000,000 women will be 1,000,000/53 per month or 19,000. In the two populations we are comparing, there will be 15,000 births in the one and 19,000 abortions in the other. Now 1.27 abortions are equivalent to one birth; if the abortions are a backup to 90 percent efficient contraception, then 1.27 abortions suffice to avert one birth. If the contraception is more efficient, then the number of abortions to avert one birth will come even closer to one.

Thus, 1.2 million abortions avert anywhere from about 0.4 million to nearly 1.2 million births, depending on what means of birth control a population is using and with what efficiency. Without knowledge of a population's contraceptive practice, we cannot state more precisely what the birth rate would have been in the absence of abortion.

Renewal theory can also be used to estimate the number of births averted by contraception. We saw above that among one million fertile women with 90 percent efficient contraception, the number of births each month would be 1,000,000/67 = 15,000, as compared with 1,000,000/22 = 45,000 with no contraception. Casual common sense might suggest that 90 percent efficient contraception ought to reduce births by 90 percent, but this example shows that it reduces them by only 66 percent. Similarly, 95 percent efficient contraception reduces births by only 81 percent.

Until not long ago, it seemed to be fairly generally agreed that the great advantage of contraception was that it permitted women to recover fully from one pregnancy before having another. Some even argued that child spacing, rather than having fewer children, was its main object. Yet what has happened is the opposite of the anticipation: more effective contraception has led couples to plan births closer together and to have all their children at nearly the same age. In the United States between 1920 and 1960, the variance of ages at childbearing diminished from about 44 to 34. How can this be understood?

When contraception was uncertain, couples interested in limiting fertility would try to avoid having children throughout their entire reproductive careers, knowing that contraceptive failure alone would lead to all the children they could want. With 90 percent efficient contraception a childbearing career of 20 years would result in 240/67 = 3.6 children, using the assumption developed earlier. A couple with a chance of 0.01 of becoming pregnant in each month (corresponding to 95 percent efficient contraception) will on the average have more than two children over the same 20 years. The chance that even these fairly efficient contraceptors would have an accidental pregnancy is more than 90 percent. The two children they would average would be separated by roughly 10 years. On the other hand, a couple that command a sure means of contraception can have the two or three children they want with intervals of three years or less, knowing that they need not worry about having further children later on. Irrespective of what has been said about the health advantages of child spacing, couples want to crowd their children together; the mother can look after two or three in practically the same time that she can look after one, and all three of them will be in school after a few years so that she can return to her career.

Lessons from Failed Forecasts

One of the troubles with common sense is that it so quickly accommodates to what it sees happening, and hence does not know what to be surprised by. In fact it loses the faculty of being surprised at all. That is the advantage of records, including records of past forecasts, especially forecasts that failed. Having these and looking at the present we know what it is that requires explanation.

Forecasts that do not materialize are objective indicators of the operation of previously unsuspected factors. The 15-hour week, forecast by Keynes[12] and many others, was to be with us by now. In fact the long-term decline of hours worked has slowed since the 1960s, and a projection of the curve looks as though it may level off at about 30 hours. It seemed obvious in the 1920s that with increasing productivity in manufacturing industries, there would be less need for labor. Edward Bellamy's popular *Looking Backward* forecast a workinglife from age 21 to 45.[13] People would work no longer than they had to—increased productivity would be devoted to leisure. At least for the US economy this has just not turned out to be so—less than 10 percent of the increase in productivity from 1960 to 1970 was devoted to leisure.

And we noted that the same forecasters said that there would be plenty of people to man the traditional services—the barbers, domestics, and taxi drivers mentioned earlier. Since productivity in these areas could increase little, there would be a shift of labor toward them. Yet all three of these occupations have shown a decided absolute drop in employment over the last 15 years. This decline may be due to a shift in the tastes of consumers, a shift in relative prices, a new disinclination to work in these occupations, provision of new sorts of jobs by government and the private sector with which these traditional service occupations cannot compete, or a combination of these factors.

As one further example of failed forecasts, women recently married were asked around 1960 how many children they intended to have, and their replies averaged nearly four. Yet those same women averaged no more than three and caused the overall decline of the birth rate in the 1960s. It seems that they were not reporting a serious estimate of the number they themselves would have, but the number their older sisters, older neighbors, and friends were having. The women themselves were influenced by changed conditions and had fewer than three children on the average. This was a blow to population forecasts, but in another sense it gave us deeper knowledge. For it said that there are forces impinging on each cohort that are below the individual's level of consciousness at the start of their childbearing.

When people of good judgment made what seemed a perfectly safe forecast and something quite different materialized, we know that there must be changes, linkages, and variables operating in the depths of our society that strongly influence what appears on the surface. Indeed, perhaps the biggest difference between professional demographers and others who deal with population is that the professionals know just enough to realize that the surface phenomena are influenced by these deeper ones.

Conclusion

The exposition in this article has used a didactic artifice: making a commonsense assertion with which the reader is inclined to agree, and then showing that the assertion is false. It is false, though based on true observations, because it is partial; elements are operating that it does not take into account.

In addition, the article suggests a method for revealing the existence of those important deeper layers of reality that would otherwise escape attention: learning from failed forecasts. However embarrassing these may be to the practitioner and to the profession, they are a valuable resource for uncovering those all-important subsurface forces.

Notes

1. See R. Doll and A. B. Hill, "A study of the aetiology of carcinoma of the lung," *British Medical Journal* 2 (1952): 1271–1286.

2. For a summary review of the evidence, see US Department of Health, Education, and Welfare, *Smoking and Health*, Report of the Advisory Committee to the Sur-

geon General of the Public Health Service, Public Health Service Publication No. 1103 (Washington, DC: US Government Printing Office, 1964).

3. John H. Pollard, "Factors affecting mortality and the length of life," in *Population Science in the Service of Mankind* (Liège, Belgium: International Union for the Scientific Study of Population, 1979), proceedings of an IUSSP conference on science in the service of life, Vienna, 1979.

4. Harrison Brown, *The Challenge of Man's Future* (New York: Viking, 1954).

5. Nazli Choucri, *Population Dynamics and International Violence: Proportions, Insights, and Evidence* (Lexington, Mass.: Lexington Books, 1974). See also Quincy Wright, *A Study of War* (Chicago: University of Chicago Press, 1965).

6. Charles F. Westoff, "Marriage and fertility in the developed countries," *Scientific American* 239 (December 1978): 51–57.

7. Colin Clark, *Conditions of Economic Progress* (London: Macmillan, 1940).

8. Daniel Bell, *The Coming of Post-Industrial Society: A Venture in Social Forecasting* (New York: Basic Books, 1973).

9. Nathan Keyfitz, *Applied Mathematical Demography* (New York: Wiley, 1977).

10. A detailed explanation of why this is the case is found in Nathan Keyfitz, "Why social security is in trouble," *The Public Interest* 58 (1980): 102–119.

11. Christopher Tietze and John Bongaarts, "Fertility rates and abortion rates: Simulations of family limitation," *Studies in Family Planning* 6, no. 5 (May 1975): 114–120.

12. John Maynard Keynes, "Economic possibilities for our grandchildren," in *Essays in Persuasion*, vol. 9 of *The Collected Writings* (London: Macmillan, 1972).

13. Edward Bellamy, *Looking Backward* (Hendricks House, 1946).