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SOME IMPLICATIONS OF CURRENT DEMOGRAPHIC TRENDS

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SECURITY is the real subject of actuarial science. The first application of the science was to mortality: in the face of sudden and unpredictable death, a hazard no father of young children could overlook, actuaries discovered a means within the free market of insuring the individual family against at least the financial consequences of the loss of its chief earner.

A demographer sees this achievement in terms of the progress of a cohort, a group of children born at the same moment, through the stages of schooling, work, parenthood, and retirement. A fraction of the cohort is certain to die after marriage and before the children are launched, and these children must somehow share the income of the cohort. The device of life insurance permits the surviving parents to pay the expenses of the orphaned children of their own cohort.

Several demographic factors have made this classical form of life insurance less significant than it was at the turn of the century. Mortality has declined; the probability that a man of twenty will survive to age fifty has gone up from 0.75 to 0.91. Marriage now takes place at earlier ages, when mortality is lower. Children are born when their parents are younger—the last child in a family may typically be born when the father is thirty rather than when he is forty. The number of children in the family is smaller, and the need for protection is correspondingly less. Wives more often take a job, and, even when they prefer not to work outside the home, they may have a profession that they can fall back on in case of need. All of these demographic factors operate to de-emphasize classical life insurance.

But demographic trends have at the same time brought other financial needs into prominence. More of the population is middle class; about twenty years ago the United States and Canada passed the point at which the number of blue-collar workers was equal to the number of white-collar workers, and the 1970 census will show that the latter now greatly exceed the former. The distribution of income in a middle-class cohort is concentrated in the older working ages; the peak of income occurs after age sixty, while the peak of family responsibility under modern condi-

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tions may be as early as age forty-five. When a man is sixty, his children have left home, his wife may be working, and the family income is higher than it was a few years earlier and much higher than it will be a few years later.

Can the cohort somehow manage to spread this income, in order to overcome the discrepancy between the age of earning and the age of disired spending? Further, can it do so without governmental compulsion, through an actuarial solution of the technical problem as elegant and as perfectly adapted as is classical life insurance?

In principle the redistribution of income within a cohort, from the ages of peak earnings backward to the ages of greatest family need, can be met by loans based on the subsequent high earning power of the cohort. The difficulty here is finding suitable collateral for the loans. The distribution forward, to the ages beyond retirement, is to be met by pension funds. What the cohort and its members want, however, is a certain supply of goods and services. They want not money income but real income. In a time of inflation the two are not the same.

Inflation either is a result of governmental policy or else is inadequately guarded against by government. As a result of inflation, private pension funds in money terms become unsatisfactory, so that, in a country like Italy, government has taken over pensions, paying beneficiaries out of current revenues, at rates that are as high as 80 per cent of current wages. The actuarial basis has been destroyed, and with it any possibility that the foresight of individuals operating through insurance companies in a free market could provide the service. In those countries where inflation is moderate, the question is whether contracts can be written in real terms, so that beneficiaries will be provided a pension that increases with retail prices. To determine an investment policy that would permit contracts in real terms is no simple matter and involves issues far beyond those a demographer can speak of with confidence, but I would like to draw attention to a demographic reason for proper pension fund reserves.

This reason is found in the fluctuations of the birth rate that characterize modern populations. The number of births in the United States was 3.0 million in 1925; it decreased to 2.4 million in 1935, increased to 4.3 million in 1960, and decreased to below 3.5 million in 1970. The very different sizes of cohorts determined by these births make it awkward to pay pensions out of incoming premiums to those individuals who happen to be old at a given moment. Thus those who are part of a large cohort will pay too little when they are of working age to support their small-cohort predecessors, and, when they themselves come to be pensioned, they will suffer because the succeeding small cohort will find it hard to raise the money to support them. It is absurd to make the payments by a cohort depend on the size of the preceding cohort and the payments to them on the size of the following cohort.

Most of the case for a nonreserve system assumes what demographers call a stable population, in which births are increasing steadily. In these circumstances pensions can be paid out of premiums currently received without great unfairness. With modern contraception, however, birth rates vary with the ups and downs of social and economic conditions, producing such huge fluctuations in the sizes of cohorts that the most elementary considerations of equity require that each cohort provide for its own old age through a proper system of reserves.

Thus some demographic changes (lower mortality at working ages, younger marriage and childbearing, fewer children, working wives) have shifted the emphasis from the intercohort redistribution of classical life insurance to the intracohort distribution of pensions. Fluctuations in birth rates and hence in cohort sizes make proper reserves for old age pensions more important than ever. Just when government policies bring about inflation, the inflation makes actuarially sound pension schemes unsatisfactory to the public, and the resulting dissatisfaction is used in Italy and elsewhere as a pretext for governmental pre-emption of the pension field. Thorny as are the technical problems for insurance company actuaries arising out of this situation, still more difficult issues lie ahead. Let us consider uncertainties in the environment as an aspect of economic security.

ENVIRONMENTAL INSTABILITY

The limits set by the environment were recognized two centuries ago. In the simple world of Malthus population pressed against subsistence, and Nature exercised a firm but steady discipline. No sooner do there come to be too many people in the Malthusian world than misery brings the number back to what the land can support. To Malthus the very severity of Nature was a blessing, for the steady and unceasing operation of her controls prevented population from getting out of hand, ensuring stability and so avoiding more drastic remedies.

Superior technology has since introduced a new element: the possibility that population will continue to increase for a period of time after the long-term ceiling has been passed and then be brought back to environmental reality with a sudden crash. Some argue that, with 3.7 billion people on the planet, we are now above the long-term ceiling, which may be as low as 1 billion.

At least a hypothetical example of the mechanism that might cause a crash in the human population of the earth is easily constructed. With new crop varieties we may go to 6.5 billion people by the end of the century. Suppose that in the year 2000 the new varieties develop rusts or other enemies. If by then we have lost the varied genetic material out of which the new varieties were selected, so that we cannot modify them sufficiently and in the right direction, humanity will be restricted to consuming what survives the rust or to the use of rust-resistant but low-yield varieties. This is but one of many mechanisms that could induce a crash, and the danger increases as we become more clever at partial technological solutions, unless we take account of broader aspects of our ecological predicament.

No one concerned with security can be indifferent to the possibility that equilibrium in conformity with long-term carrying capacity could be restored by elimination of a considerable fraction of the world's population. Yet the world population problem is of such apocalyptic magnitude that I withdraw from any attempt to treat it here and consider instead the easier problem of the developed countries. This easier problem is what the currently poor countries will work themselves up to if they succeed in raising their per capita income above $500 per year, as have Europe, the U.S.S.R., Japan, the United States, and Canada. We shall see that this problem is difficult enough.

The population-environment issue is now in the vocabulary of every educated member of the developed countries. Too many people, the concentration of these people in the very small areas of cities, and the use of too many units of individual transport are some of its features. Treasures of petroleum, the residues of fern forests decaying over hundreds of millions of years, will be needed for lubrication for the thousands of years we hope our mechanical civilization is going to last. Under the peculiar conventions of economic accounting, the wanton dissipation of this irreplaceable resource and the accompanying air pollution are called "production" and are added into the national income. Ecologists have called our attention to many equally destructive features of our high standard of living. They show that we are living off environmental capital in a fashion that cannot long continue. One immediate need is an accounting system that will set aside proper depreciation reserves for the environment. Sound accounting would show that our income is lower than is currently estimated.

IS POPULATION OR INCOME THE VILLAIN?

What ultimately has caused all the dying fish, vanishing bird species, dead lakes, spreading deserts, and unbreathable air? Something is known of the immediate mechanisms—oil spills, DDT, disposal of chemicals, excessive plowing, incomplete combustion. On a more general level, however, the question is whether the pollution and depletion are caused by population growth or by affluence. Have they occurred because there are too many of us, or because we are too rich?

The question of whether our troubles are due to population alone or to income alone is unanswerable. It painfully resembles the argument over whether labor or capital is responsible for production of goods. Serious economists no longer debate whether labor or capital is the active agent, the "cause" of production; instead, they set up a joint production function of the two independent variables and then fit to actual data. The aim is to establish in what degree variations in the output of goods are determined by variations in labor and in what degree they are caused by variations in capital.

The same technique ought to be usable to account for the output of "bads," as Kenneth Boulding calls pollution and the exhaustion of irreplaceable materials. We would concede that both population and affluence are causes of pollution, and ask such questions as whether, at a given income, pollution increases in proportion to population or more than in proportion. We need to determine in what circumstances a 1 per cent growth of population makes 1 per cent, 2 per cent, or 3 per cent more smog. Probably the impact on the environment is less than proportional up to a certain point and then more than proportional; a kind of threshold may exist beyond which (to exaggerate somewhat) one more automobile would cover the San Francisco area permanently with smog. Consumption of nonrenewable resources probably is proportional to population, when income is held constant, and so probably are space and water. Let us, as a first approximation, suppose that "bads" are proportional to population when every other factor is fixed.

In this first approximation, then, the production function for bads involves population, say N, linearly, and income per head, say $\bar{Y}$, to a power b:

$$\text{Bads} = kN\bar{Y}^{b},$$

where k is a constant.

The quantity b is what economists call elasticity; if b is equal to 3, then a rise of 1 per cent in mean income would increase bads by 3 per cent. Research is required to find what b is for our present technology and our present practices, averaging over the several sources and causes of the running down of the environment. The research would try to distinguish between one kind of production and another, and between one kind of population, say city dwellers, and another, say farmers. Each might have its own value of b, and that for the country as a whole would be a suitably weighted mean. The nature as well as the volume of production can change, and b depends both on the kinds of things being produced at a particular moment and on the manner of their production.

SCOPE FOR ACTION

If nothing could be done about the quantity b, if it were inevitably tied to income and inevitably and under all circumstances equal to 3, then each time we raised our income by 1 per cent we would have to lower population by 3 per cent to keep the impact on the environment constant. When we reached the environmental ceiling, such a tradeoff would be forced on us.

Fortunately something can be done about b. It depends in the most intimate way on how we produce and how we consume, and we know that our pattern of production and consumption can be affected through the price system. When the price of a car includes an allowance for scrapping it and reducing it back to the steel slabs from which it started; when the maker of alcohol keeps the river running by his distillery at the temperature at which he found it or is charged a suitable price for each degree of temperature rise; when municipalities process their garbage back to fertilizer that can be converted into food, instead of pouring it into the rivers as sewage or into the air as smoke—then they are reducing the elasticity of pollution b by devices that can be put under the head of *recycling*. To lower b past unity and down toward zero must be an object of science and technology, if massive populations and high incomes are both to continue.

OUR HALF-DEVELOPED TECHNOLOGY

A large part of the damage done to the environment by technology results not because technology is so advanced but because it is only half-completed. Agriculture will serve as an example. Starting from the farmers before World War I who plowed, planted the crop, and waited for the harvest, we have come a long way. Over a whole generation, agriculture has increased by about 6 per cent per year in output per man, much more than has manufacturing industry. Plowing and harvesting are done with large-scale machinery; irrigation water is brought to the crop just when it is needed; massive amounts of nitrate and other fertilizer are applied. The fertilizer is mostly hydroelectric and other electric power converted into plant nutrients, which in turn constitute human nutrients.

We are moving toward more and more highly capitalized conversion of solar energy into food that provides human energy, using smaller and smaller amounts of labor and land. We already raise chickens in cages and beef cattle in feedlots. Tomorrow we may raise rice in shallow ponds above a sheet of plastic that keeps the fertilizer from flowing into the river system.

It is at the present halfway point that agriculture is most destructive. We know how to make fertilizer cheaply and distribute it lavishly but not how to confine it to the crops whose growing it aids. We do not yet confine DDT to where it will work for us and not against us, and so it poisons the waters, becomes concentrated in the fatty substances of the bodies of domestic animals, and works its way up food chains until it reaches our own bodies. In some instances it hurts our pests less than it hurts other species that prey on them, and its use can encourage the pests it was intended to destroy. Mindless application of still more pesticide is never the right answer in this situation.

Once we get all the way to the food factories we have half-attained already, it should be easy to keep the fertilizers and the insecticides where they belong. This is another approach to reducing the *b* of our formula—we can call it *containment.*

The destruction of the environment through primitive, not advanced, technology is to be seen in the field of transport. The original wood-burning locomotives destroyed the countryside as they picked up fuel along their rights-of-way and filled the air with smoke. Coal-burners were on the whole less destructive than wood, and oil-burners less destructive than coal. Now we move not by train but by air, and destruction per person-mile is further reduced. Think of the damage that would be done across the land by 50,000 coal-burning locomotives, the minimum number that would be required for the present 125 billion passenger-miles per year of long-distance travel.

Further advance in the *miniaturizing* of artifacts will reduce their use of materials. Information stored on magnetic tape occupies less space and takes less material than information stored by marks on paper or punched holes in cards. Musical "information" on microgroove records represents an advance in economy over the old 78 r.p.m. recordings. If possessions are made more compact, houses can be more compact, and if houses are better designed they can be considerably smaller without loss of convenience.

In some instances *larger units* economize space per person served. As planes carrying 400 passengers replace planes carrying 100 passengers, only one-quarter of the time on the runway will be required for the same traffic, and hence fewer runways need be built. Fuel consumption per vehicle mile goes up, but not fourfold, so fuel per passenger-mile goes down.

Moreover, a reduction is possible in the number of passengers that need to be transported; in the future, busy people may actually travel less then they do now. With further cheapening of long-distance communication, including facsimile transmission, business matters that now require people to cross the country could be settled by microwave exchange of information. Precious time would be saved and pollution diminished. In this example a wholly new means is substituted for the old way of attaining an objective: it *moves information rather than people.* The impact on the environment of moving information can be brought close to zero.

The means of lowering b thus include recycling, containing, miniaturizing, the use of larger units, and moving information rather than people. Under these five headings and others, a great variety of specific measures can be devised. We may hope that the direction of technological change, which is less and less determined by the whim of inventors and more and more influenced by the conscious scientific policies of government and corporations, will be such that our b, the income elasticity of production of bads, can be rapidly reduced during the next decade.

Any reduction of b raises the ceiling on population and income. Given an environment that will stand only so much, the lowering of b permits both a larger population and a larger per capita income than would otherwise be possible. Attention ought to be given also to the impact on the environment of a more even distribution of income with given mean $\bar{Y}$ and population N; my guess is that a lower variance of income acting by itself has an adverse effect. This is not an argument against economic democratization; it is rather a further argument for reducing b, since that will permit a more equal distribution of income as well as a higher mean, the presence of more people, and more stability.

If technology can be redirected, the opening of the third millennium could show as large a population as is now on the planet, three times today's mean income, more equal distribution of that income, and greater ecological stability. Many things will have to be changed, however, if this desirable goal is to materialize. There can be no encouragement for facile optimism that it will come about without trouble—that is, without a very serious attack on a whole constellation of technical, economic, and political problems.

The optimism of the preceding paragraphs is indeed highly provisional and may not be able to withstand the results of research, which could show the problems to be more intractable than is here suggested. Even the most tentative optimism depends on bringing population under control. Rapidly increasing population N could frustrate all attempts to hold back the production of bads based on reducing b in our formula $kN\bar{Y}^b$. I shall devote the final section of this paper to a discussion of population control in advanced countries.

POPULATION AS THE RESULTANT OF TWO INTERACTING SYSTEMS

The population problem exists at several levels, and at each it takes a distinct form. At the regional and national levels, there may come to be so many people that the air and water will be insufficient to carry off their waste, and they may suffocate like flour beetles poisoned by their own garbage. (That is in a rich country; in a poor one there may be too many people in relation to capital, and overpopulation shows itself as massive unemployment.) Whether the country is rich or poor, we can think of it as having a certain ideal population size under some kind of natural ceiling.

At the level of the individual household a wholly different population problem appears. It concerns the number of children that can be fed, clothed, and educated, given the income of the parent couple. Paying the rent and buying the groceries are their problems; if they have too many children to accomplish these things comfortably, they are overpopulated. Much depends on how much they want children as compared with other things and how much they are willing to sacrifice to have children. Whether they buy a car or have another child is, we say, their own private business. Each family aims to have the right number of children for its circumstances and goals.

What number of children individual families decide to have is not influenced in any obvious way by what the country as a whole can stand. The family is one system; the country is another system. Individual families may have children to their own pleasure and benefit in numbers that collectively outstrip the capacity of the national economy and ecology.

The effect of the family system on the national system is strong but delayed. The nation faces problems associated with children for their entire prospective lifetimes, that is, up to seventy or eighty years after the parents have made the decision to have the children. No one can tell what the employment situation is going to be twenty to sixty-five years hence, while these children will be in the labor force. We are lucky to obtain good estimates even a few months ahead, and the most expert predictions for longer periods are notoriously fallible. The average parent is not an expert predictor; he gives little thought to employment prospects twenty years from the time he decides to have a baby; his objectives are different from those of the community.

Would it not, then, be an extraordinary coincidence if the number of children couples produced to suit their own needs and wishes turned out to be just the right number for the country as a whole twenty to sixty-five years later? The most rational parents do not determine whether to have another child in the light of national requirements for workers in the next generation; even less do they take into account ecological constraints that will be operative after they are dead.

Because of the exponential law, it is not sufficient that parents have approximately the right number of children—they must in the long run average *exactly* the right number. They cannot average three children over several generations, when infant mortality is as low as it is now, without a population explosion. Averaging two children, on the other hand, leads to extinction. Individual couples have placed on them a heavy burden of judgment and action: those who marry and are not sterile must have exactly 2.3 children on the average, with present United States mortality and nuptiality, if the community as a whole is to be acceptably populated in the centuries and even the decades ahead.

We need some kind of thermostatic control, by which a population increasing too fast can somehow turn off its births and can turn them on again when it is increasing too slowly. The decisions of individual couples must somehow be made to depend on larger considerations.

A THERMOSTATIC CONTROL OF BIRTHS?

The growth of the American population has seemed a cause for alarm, to the point where compulsory limitation of families has been seriously proposed. To avoid dictation to individual couples and yet attain a balance between what parents want and what the ecology can stand, Kenneth Boulding proposed that every girl be given twenty-two coupons when she arrives at puberty. Ten coupons would suffice for permission to have one child. Coupons could be bought and sold, and a market would spring up. An ambitious couple not interested in children could sell their coupons for enough to start a business. The scheme, like free markets generally, would attain the social objective while leaving maximum choice to individuals. Of course enforcement would be necessary, as it is necessary to enforce present immigration laws and laws against bigamy, and other rules governing population. Guarding the nation's frontiers against illegal entry would have its counterpart in guarding the nation's wombs against illegal reproduction. This is one kind of thermostatic control of the family reproduction system by the larger society.

Such an apparatus is unnecessary, however, if parents are going to want as few children as the trends now indicate. Their wishes are easily implemented with present and prospective contraceptive methods. They do seem to respond to the publicity given national problems of all kinds, including the ecological problem. The mere prediction that we will be overpopulated seems already to have had its effect on parents, who thereby (happily) are making the prediction wrong. There may exist a natural mechanism by which the national population problem acts on the motives of individual couples.

The latest figures on births permit some hope that such a thermostatic control, operating without compulsion on parents, does in fact exist. Total births in the United States were about 4.5 million in the peak year of 1960 and now are down to about 3.5 million per year, a drop from 25 per thousand population to 17. This fall of one-third in the crude birth rate is not due to any relative decline in the number of women of childbearing ages, for present mothers include the large cohorts of the late 1940's, while those of ten years ago were the smaller cohorts of the late 1930's. Births per thousand women 15–44 years of age reached 120 in the late 1950's and by 1968 had fallen to 86. The latest figure I have is for July, 1971, when the number had dropped to 77. The fall has affected even more the main childbearing ages—the births per thousand women aged 20–24 fell from 258 in 1960 to 167 in 1968.

An even steeper downtrend is found in Canada. Over a long period of time Canada had a crude birth rate higher than that of the United States, by about 3 or 4 per thousand population. Thus Canada's peak in the late 1950's was 29 per thousand compared with 25 for the United States. But its decline has been even sharper since, and by 1968 in both Canada and the United States it was about 17.5. Any Canadian backwardness in the birth rate was fully made up during the 1960's. Quebec had traditional fertility until a generation ago; now it is a full point below the remainder of northern America.

Within the United States some differences remain among races and social classes. By 1968 the birth rate for whites was 81.5 per thousand women aged 15–44, while the birth rate for blacks was 114.9. The differentials have become somewhat smaller in recent years, partly, at least, because of the diffusion among all groups of more effective methods of birth control. Ryder and Westoff (1971, p. 358) find that Negroes intend to have fewer children than whites, but their lower efficacy in using contraception causes them to end up with more children. Could modern methods of contraception underlie the decline of the birth rate in general, so that further diffusion would eliminate all differentials? Probably not: Catholics express the intention of having more children than non-Catholics.

WHY DOES THE BIRTH RATE FALL?

If demographers knew why people sometimes have more and sometimes have fewer children, they would have been able to predict the drop over the last ten years; the record of forecasts shows that most did not do so. We know a great deal about differentials in fertility—about the fact that middle-class people have fewer children than do lower-class people, Protestants fewer than Catholics, and whites fewer than blacks. Differentials are susceptible of accurate measurement, but they do not make understandable the lower or higher fertility that they describe. We are reduced to speculation to answer the question that most wants answering. Is it possible that the evident labor shortage during the 1940's and 1950's influenced parents to have more children? Sure that their offspring would be needed, they could conceive with confidence. The population may have risen in response to the demand for labor, as Adam Smith saw it doing in eighteenth-century Scotland. His population thermostat, however, was different from ours; when jobs were plentiful, couples could marry young and there would be adequate food for their children.

Can a social-psychological factor have entered now, related to the conflict of the generations? Children do their own thing, wear their hair the way they like it and not the way that suits their parents, and go to school or drop out in disregard of their parents' notions of preparation for a respectable career. Couples know that their influence cannot prevail over the youth culture in which their young will inevitably participate. Children mean trouble and expense, considered well worth while in those times and places where family discipline holds, for disciplined children act as a continuation and prolongation of their parents' lives and careers. Where the family line is a sacred trust, children will be wanted in numbers suitable to ensure it; yet there is a degree of rebellion among the young that makes parents unwilling to take on the burden. The danger of having unconventional children would trouble conventional couples. Unconventional couples, on the other hand, might ask themselves, "What if my children do to me what I did to my parents?" Both kinds of couples would be restrained in their childbearing. This may be a feature of our culture that is causing parents to want fewer children than were wanted ten years ago.

The disinclination of parents to have children likely to prove undisciplined is an extension of a very general principle. The autocratic ruler wants more subjects; as long as the subjects are obedient, he can stand to increase their number up to relatively high density, just as the farmer can stand an increase in the number of his cows; no one wants an increase in the number of dangerous wild animals roaming about free. The number of obedient tenants needed to maximize a landlord's income is greater than the number of free farmers on the same land that will maximize their own incomes. The optimum population goes down as freedom goes up. Once the subjects, the animals, the tenants, or the children become independent, the farmer, the autocrat, the landlord, or the parent wants fewer of them. When the farmer, the autocrat, the landlord, and the parent are no longer able to control their subjects but still have responsibility for the subjects' welfare, then the hour of population restriction has come.

Even if this speculation is correct, however, it will not lead to exactly the right number of births to replace deaths. Judging from all precedents, we will find by the 1980's that children have been too few; we will see a shortage of youthful personnel to fill junior positions as in the 1950's. The response could well be a return to the high birth rates of the 1950's. We must expect birth rates to rise and fall, making waves of considerable amplitude and, in particular, causing cohort sizes to go up and down in long cycles.

SUMMARY

This paper, concerned with population and security, has been an attempt to explore some aspects of demography that would interest actuaries. It started with a suggestion that certain population trends may limit classical life insurance (which provides an intergeneration transfer of funds) and may expand pension funds and similar intrageneration transfers. If the population is growing uniformly, each generation can provide pensions to the generation that precedes it without great variation in costs. If, on the other hand, births are now increasing, now decreasing, then the way to avoid drastic variation in costs and benefits is to have each generation provide for itself through actuarially calculated reserves.

One dismal way in which Nature could make waves is by periodic overpopulation and crash, as with lemmings. Malthus never dreamed that technology could enable human population to rise above its long-term ceiling, but we know that it can. Our production of goods is accompanied by production of bads, and, unless we do something, the bads will build up until equilibrium is catastrophically restored. The fact that advanced technology permits borrowing against the future is an especial danger with the crude national accounting schemes now in use. These conceal the fact that we may have a large loan outstanding in Nature's bank, in danger of coming due when we are least prepared to pay it.

In the worst of cases human populations could oscillate back and forth like those of lemmings. We hope to gain stability at high levels of population and income by reducing the effect of b in the formula for the produc-

tion of bads, $kN\bar{Y}^b$. But we will have successes and failures, and certainly in particular places population numbers will oscillate.

Equally suggestive of oscillations in our future is the determination of births as the interaction of two systems, the national system and the individual family system. Although, a priori, the two systems may seem to go their separate ways, nevertheless the evidence of the past few years indicates that the larger system influences its small components. Unemployment in the nation as a whole, ecological problems, and a decline in the discipline of children do seem to influence the childbearing decisions of couples. It would be too much to hope that the resulting thermostatic effect would operate to keep us at exactly zero population growth. Devices to aim the birth rate at the death rate—which for the long run must be its target—will operate in intermittent fashion, so that cycles of growth and decline in births, and hence in cohort sizes, seem inevitable. The action of parents in having too many children makes for unemployment and other difficulties twenty years later and for ecological problems some time after that. These difficulties of the larger system act back on the family and reduce the number of children, but such a feedback with delay notoriously results in cycles.

The various mechanisms described in this paper by which population waves are generated all imply insecurity for individuals. Readers may see ways in which actuarial techniques can be extended to offset that insecurity.

These are problems of rich countries. The advance of poor countries to the point where they also face such problems is delayed by low rates of economic growth and continuing very high birth rates.