TECHNOLOGY AND HUMAN POPULATIONS

By

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Most writings on population begin with Thomas Malthus and his thesis on the relationship of population to food. However, this does not mean that concern with human numbers had its beginnings at that time. Theses on population have been traced to the beginnings of written history.

According to a report of the Population Division of the United Nations (1), the earliest writings on population were by Confucius and his followers. These writings centered on the concept of optimum numbers. Excessive population growth was equated with the possibility of reductions in worker output, a reduction in the standard of living, and an increase in the dangers of strife among the masses.

These writers also attempted to relate population dynamics to various operating checks. Observed were increasing mortality with insufficient foodstuffs; increased infant mortality being related to premature marriage; and a decreased marriage rate when the costs of ceremonies were high.

Early Western philosophers were also concerned with similar questions. Plato and Aristotle considered questions of population optima in their discussions of the ideal city-state, which was visualized as a place to develop the highest in the potentials of mankind. Plato, in Laws, postulated the ideal population to be one that ensured economic self-sufficiency and capability for self-defense. He felt that 5040 citizens was the ideal[1/] because

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1/ This ideal size was probably much higher since Plato did not consider slaves, which were quite numerous, in this estimate.

this number has "fifty-nine divisors" and "will furnish numbers for war and peace, and for all contracts and dealings, including taxes and divisions of the land."

Plato and Aristotle also contemplated methods of controlling population size. Plato proposed restrictions on births among those "in whom generation is affluent" as well as inducements to reproduce in times of need through the use of rewards and rebuke. Aristotle, in Politica, mentions abortion as a means of preventing excessive numbers of children.

Such philosophizing on population optima has continued into the present. The concern is similar but the arguments are much more dramatic. They range from scenarios of cataclysm as the result of the "population bomb" to pseudo-scientific computer printouts linking a growing population to global catastrophe (cf. 2; 3).

Apart from a general concern with growing populations, these writings have in common the notion of population growth being independent of constraints. Visualized is human populations continuously increasing in numbers unless direct measures are applied to check this growth.

Such an assumption appears extremely naive in the light of the rationality that is credited to humans. It would be more reasonable to view population as being conditioned and constrained by forces within the social system. After all, if an optimum in human numbers is assumed, this optimum has to be based on certain conditions. Also, if abortion or other birth control measures are to be initiated, they have to be forced upon the social system by occurrences or preconditions from within.

Thomas Malthus can be credited with viewing population as a dependent variable that is affected by economic and social forces. It is in such a context that changes in human numbers will be viewed in this paper. Although numerous forces condition population changes, this analysis will center on a changing technology and its affects on human numbers. Technological change was one of the factors that Malthus was unable to forsee in his analysis and as a result his treatise on population lost relevance.

A few studies have been made investigating technological change as affecting population dynamics. These will be examined. Also, some attempt will be made to overcome some of the difficulties inherent to these studies through a systems approach which will be subsequently outlined. However, before such an analysis is undertaken, it would be helpful to examine population dynamics in historical perspective.

The Growth of Human Populations

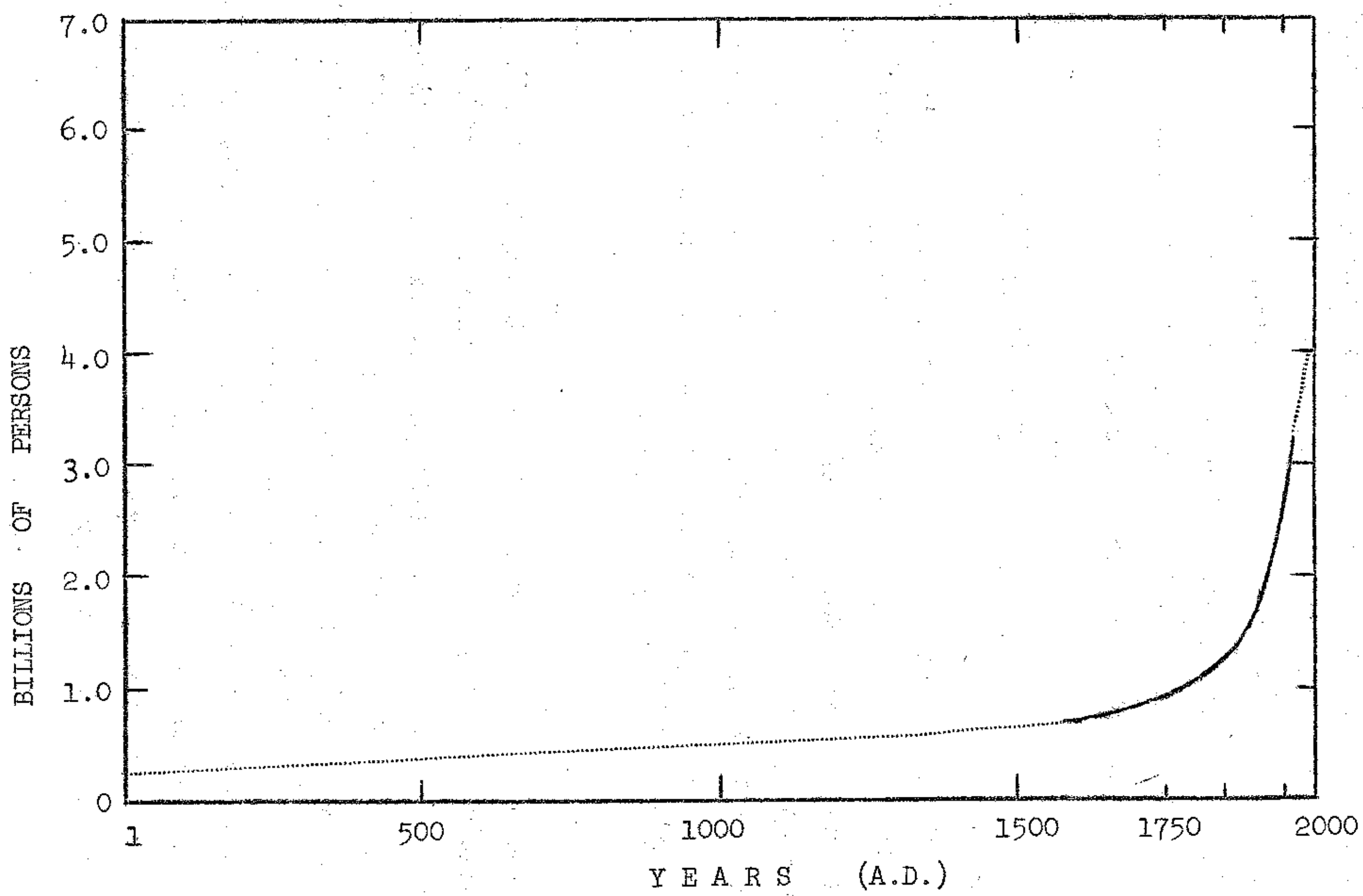
Regionally, population growth is the result of fertility, mortality, and migration. These three processes, or human experiences, govern changes in population size. However, when analyzed by themselves, they are of limited value. Meaning is supplied to these components of population growth through an analysis of population size, its characteristics, and its distribution (4, p. 6). So, in order to duly understand population dynamics, all six components have to be considered.

Growth in numbers

The Population Reference Bureau estimated the world's population to be about 3.5 billion persons in 1969. This approximation rests on a shaky foundation since only "educated" guesses exist as to the population of China and many regions of Africa. Even less is known about the world's population in the past. Nonetheless, numerous scholars have pieced together many fragmentary statistics and tied them together with guesses into a somewhat consistent picture of the world's population since 1650 and extrapolated these estimates into the past two thousand years. Figure 1 is a presentation of the generalized picture of world population growth, in numbers, during this time span.

This graph depicts, very dramatically, a phenomenal burst in world population since the 18th century and its postulated continuation of rapid increase into the future. It also illustrates near stability or minimal increase in world population prior to this period, which includes the major part of man's record on earth.

FIGURE 1. ESTIMATED POPULATION OF THE WORLD FROM 1 A.D. to 1960 A.D. AND THE PROJECTED POPULATION 2000 A.D.



Source: H. F. Dorn, "World Population Growth," in P. M. Hauser (Ed.), <u>The Population Dilemma</u>, 1963.

Some insight into the dynamic nature of world population growth is provided in Table 1. This table reflects the affect of population size on future growth--the larger the existing population base, the larger will be the future population size. Dorn (5) points out that enough knowledge exists to support the belief that many millenia passed before mankind reached a world population of one-quarter billion persons about 2,000 years ago. Since then changes have been more dramatic. The next quarter-billion persons was added in sixteen centuries. While two centuries elapsed to reach the second half billion persons, the most recent half billion required a little more than ten years.

Natural increase

Although the cited examples provide insight into historical patterns of population growth, they do not explain the near stability of population levels throughout most of man's history or the relatively recent upsurge in population growth. A descriptive framework called the demographic transition, which relies on the pattern of natural increase, the excess of the crude birth rate relative to the crude death rate, can be utilized to provide a partial explanation to these developments. The concept of the demographic transition was formulated by Warren Thompson (6) and refined by Frank Notestein (7) to characterize population changes, as the result of the interplay of mortality and fertility, brought about by economic changes in Western society largely through industrialization.

The demographic transition has been accepted as a valid description of events as they occurred in the Western world but has been questioned as a predictor of outcomes in Third World countries (4). However, these questions have been posited largely in regard to the effects of economic development and industrialization as causal links in population dynamics rather than to the sequence of change in mortality and fertility through time. It is the latter aspect, the descriptive, that will be dealt with in the following discussion.

TABLE 1. ESTIMATED POPULATION OF THE WORLD AND THE NUMBER OF YEARS REQUIRED FOR DOUBLING THE POPULATION

YEAR (A.D.)	POPULATION (billions)	NUMBER OF YEARS TO DOUBLE
1	0.25 (?)	1650 (?)
1650	0.50	200
1850	1.1	80
1930	2.0	45
1975	4.0	35
2010	8.0	?

Source: H. F. Dorn, "World Population Growth," in P. M. Hauser (Ed.) The Population Dilemma, 1963.

Figure 2 presents a generalized picture of the changes in death rates and birth rates in Western society[2/] that have occurred in recent history. It should be noted that this sequence in natural events did not occur simultaneously throughout Western society nor did the sequence strictly follow the pattern, through time, as outlined. Nevertheless, the differences are minute and do no harm to the analysis.

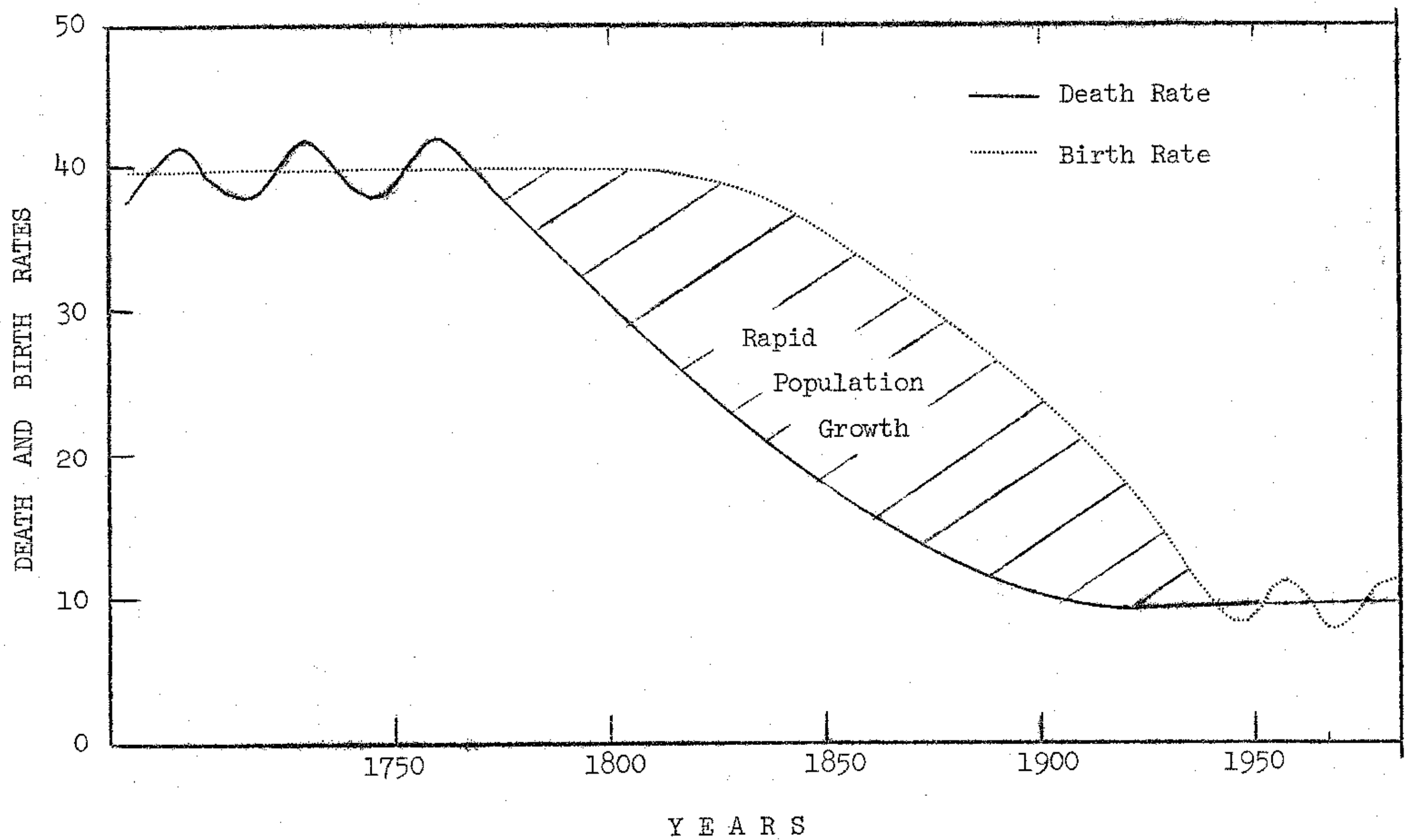
The demographic transition that occurred in the West can best be discussed by examining stages in the pattern of fertility and mortality. Three stages are generally recognized.

The first stage characterizes the condition of mankind through most of history. It is one of stability or minimal growth in human numbers. During this stage birth rates have traditionally and consistently been high, approaching the maximum in terms of human reproductive capacity within particular cultural normative patterns, and the death rates have also been high but fluctuating. Characteristic of this stage of the demographic transition were extremely high infant mortality rates. In addition, positive checks in the form of famine, war, and pestilence were operating to keep deaths at a high level and population growth, through the course of history, extremely low. In today's language, zero population growth or its near equivalent was the historical situation, but the price of stability was high, with low life expectancy and much hardship and misery.

This harsh cycle was dramatically disrupted by the Industrial Revolution which ushered in the second stage of the demographic transition. Industrialization brought advances in agriculture, a rise in the standard of living, and major advances in sanitation. In time there occurred advances in medical science and with it control of many infectious and contagious diseases through the use of drugs and innoculations. The product was a gradual but continuous decrease in the death rate. The birth rate, however, continued to remain high. Such a condition of a decreasing death rate coupled with a high but slowly decreasing birth rate produced a situation of high population growth.

2/ As used in this paper and as generally accepted, Western society refers to North America, Europe, Australia, and New Zealand.

FIGURE 2. A GENERALIZED PICTURE OF THE DEMOGRAPHIC TRANSITION AS IT OCCURRED IN THE WESTERN WORLD



Some writers, notably Krause (8), argue that high population growth resulted not only from a decreased death rate but also because of increased fertility due to changes in family patterns, such as more frequent marriages and an earlier age at marriage. Such a situation is quite realistic but the impact most likely was minimal. The more plausible explanation of increased population growth, during the age of industrialization, seems to be a decreasing death rate and a lagging birth rate. This sequence seems more realistic since mortality decrease was affected largely through external measures that made the social environment healthier. Changes in the birth rate rest largely with the family and these are conditioned by culture and are subsequently slow to change.

Anderson (9) illustrates the pattern of change in mortality and fertility initiated by the Industrial Revolution. During a period of about 175 years, roughly from 1750 to 1925, the death rate in industrializing countries of Northern Europe declined from about 40 per 1000 population to about 10. Most instrumental in this decrease were reductions in infant mortality. But other age-groups of the population also benefited through rising levels in sanitation and through disease prevention and control. Birth rates, however, continued to remain at high levels for some time. For example, in England the death rate fell to 21 per 1000 population in 1850 but the birth rate did not reach this level until 1925, some 75 years later. In Sweden this lag of birth rate behind the death rate was 130 years.

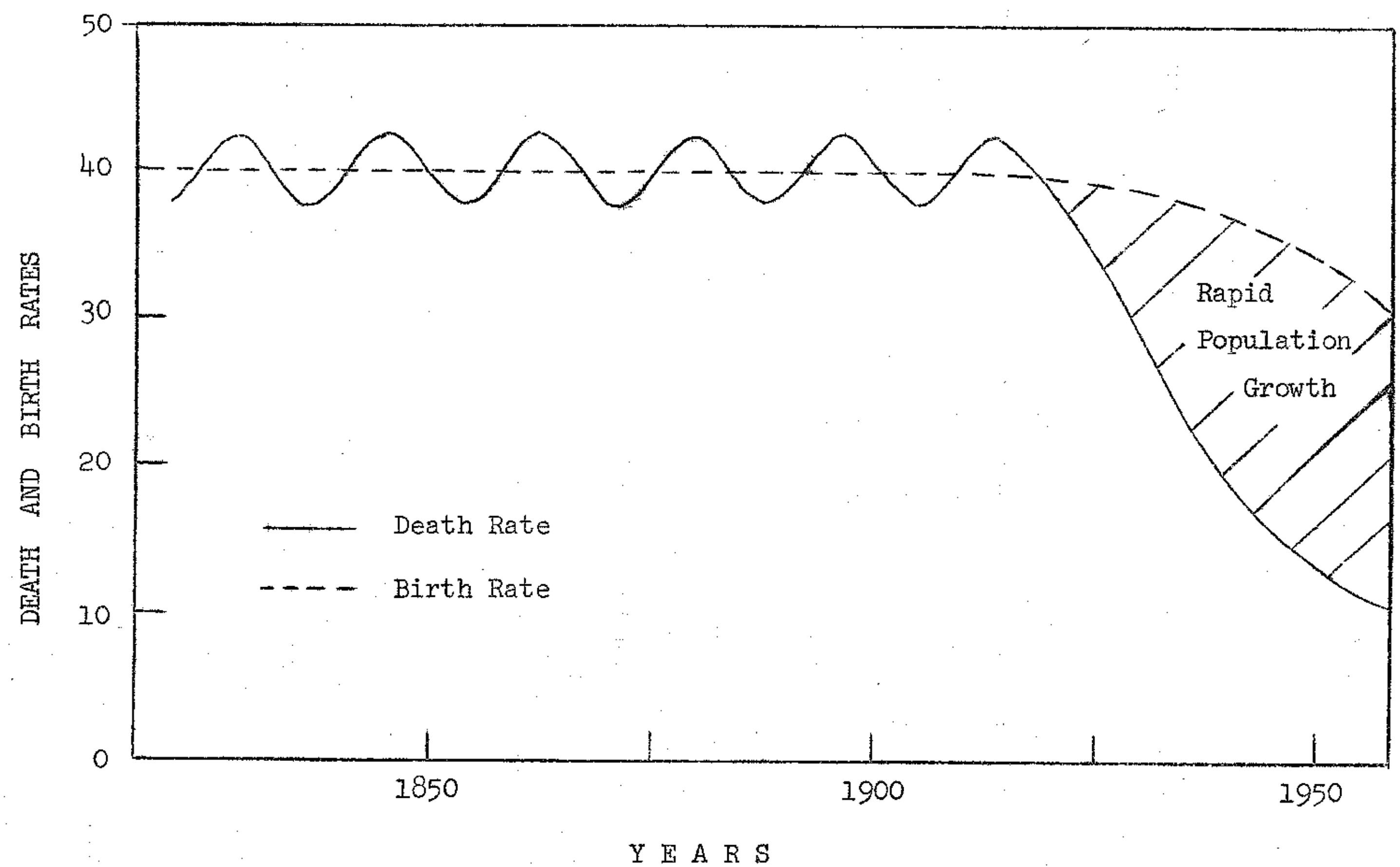
It is during the transition phase that rapid population growth occurs. The wider the gap between death rates and birth rates, the longer is the period of rapid population growth. Newly industrializing nations face explosive population growth because of the rapidity with which the transition phase has been initiated. Borrowed technologies of death control have lowered the death rate significantly and with ease. The birth rate, however, is proving a difficult component to lower largely due to cultural constraints.

A notable exception has been the experience in Japan. The Japanese experience is generally used as an example of the dramatic chain of events that is possible through the industrialization process. While a period of more than 100 years elapsed in the West for the birth rate to reach the low death rate levels, in Japan this sequence occurred in less than 18 years (10). However, the Japanese experience is being viewed by more and more writers as being the exceptional case. Historically, Japan has condoned and practiced various forms of birth control and the cultural norms were not antagonistic to abortion and other methods of rapid birth control and therefore enabled it to make an unprecedented advance through the transition phase from high to low death and birth rates (11). Such has not been the case with other Third World nations, even with prodigious inputs of money and effort in attempts to reduce the birth rate.

Figure 3 is a generalized picture of the demographic process that is occurring in the Third World. It illustrates the rapid decrease in the death rate, largely through "borrowed" techniques of sanitation and disease control, and the continuing high birth rate. What took almost the full period of industrialization to be realized in a low death rate in the Western World took only about 10 to 15 years to be realized in the Third World (12). These same improvements have even raised the birth rate in some countries from their already high levels. In Mexico the birth rate rose from 32 per 1000 population in 1911 to 46 in 1964, and in Ghana from 33 in the decade of the 1940's to 56 in 1960 (13).

The wide gap between death rates and birth rates in the Third World coupled with the great potential for further increases because of the high proportion of the populations being young represents a situation of explosive future population growth. It is such a prospect that is spawning a mass of fearful and pessimistic literature regarding the future of mankind.

FIGURE 3. A GENERALIZED PICTURE OF THE DEMOGRAPHIC TRANSITION IN THE THIRD WORLD



The final stage of the demographic transition is characterized by a low and stable death rate and a low but fluctuating birth rate. Only some countries in Northern Europe appear to have reached this level and only inferences exist about its dynamics. Wrong (4) postulates that the birth rate in this stage of the demographic transition will vary because it will be acutely responsive to social and economic changes and will therefore be the key to future growth in the advanced industrial nations.

Migration and urbanization

The impact and interplay of population size and natural increase can provide meaningful insight into the growth of human populations. However, by themselves, they do little to provide answers to questions of optimum population size or a meaningful assessment of population pressures. Questions of population optima can only be answered when a multitude of other factors are considered, such as resource base, social and economic organization, and cultural norms. Such is a very difficult undertaking. But questions of population pressures, especially within a demographic context, can be more easily approached. A partial assessment of population pressures can be made through an analysis of migration and its affects on population distribution based largely on the changing character of urbanization.

Many typologies of migration can be found in the literature. The most useful are those by William Petersen (14) and Everett Lee (15). Petersen's outline of migration types is largely descriptive and documents the patterns that have occurred in history. The typology by Lee is an attempt to link processes to the patterns and will be used in the following discussion.

The foundation of Lee's migration typology rests on factors that condition people to move. These he summarizes as push and pull factors. Push factors are disruptive and promote movement from a certain region outward while pull factors are attractive and promote movement into a certain region. In theory these factors are analyzed separately but in reality they operate simultaneously. A generalized picture of this process in industrial-scientific society is movement from the hinterland into urban centers. For example, an industrial economy may force the marginal farmer to be unable to compete successfully in a changing market structure and force him to seek a livelihood in the industrial-urban sector. Such a combination of being "pushed" off the land and "pulled" to the city explains, to a large degree, the pattern of rural to urban migration that has occurred in the Western World and which is occurring in Third World nations.

It is this pattern of rural to urban migration that has resulted in the growth of cities that is unprecedented in the history of mankind and which has resulted in population pressures that have mistakenly been equated with population growth. The barrios of Latin America and "slum" developments throughout the world are conditioned by high growth rates in population but are in reality the result of a high influx of rural populations into cities as Barbara Ward (16) vividly describes. It is possible to have population pressures within a country without any population growth largely through an expanding urban population. Through rural to urban migration it is possible to have urban growth, and consequently population pressures, without natural increase until all the population is urban (17).

Table 2 shows the increasing urbanization of the world's population since 1800. While the world's population increased threefold from 1800 to 1960, the population in cities of 5,000 people and larger increased 34 times during the same period. In the decade from 1950 to 1960, the population in cities of 5,000 and above grew at 3.2 percent per year. This compares to an annual growth rate of 2.5 percent in the world's population during the same period.

In summary, the world's population picture is one of grwoth and of concentration in urban areas through time. Throughout the discussion some attempt has been made to relate processes to this pattern of growth and concentration. Mentioned were the effects of industrialization, economic development, and medical advances on changing the pattern of natural increase and subsequently population growth as well as the affects of migration on

TABLE 2. WORLD POPULATION AND WORLD URBAN POPULATION, 1800-1960

Year	World Population (millions)	Population in Cities 5,000 and Larger (millions)	Percent in Cities 5,000 and Larger	Percent in Cities 100,000 and Larger
1800	906	27.2	3.0	1.7
1850	1171	74.9	6.4	2.3
1900	1608	218.7	13.6	5.5
1950	2400	716.7	29.8	13.1
1960	2995	948.4	31.6	20.1

Sources: 1800-1850: Kingsley Davis and Hilda Hertz, "Patterns of World Urbanization," 1957.

1960: United Nations, Demographic Yearbook, 1962.

the pattern of urbanization. These processes can be briefly summarized as technological change and some writers have attempted to outline these patterns within such a context.

Technology and Human Populations

The most profound writings relating technological developments to population processes in historical context are those of V. Gordon Childe (18) and Edward Deevey, Jr. (19). Although their theses differ in point of view, Childe's being aimed at the development of civilization and Deevey's being an analysis of the growth of human populations, they are in agreement about three "revolutions" having occurred in man's history.

The three "revolutions" outlined by V. Gordon Childe were the Neolithic revolution, the Urban revolution, and the Industrial revolution. The revolutions are used to account for profound changes in subsistence and social patterns that produced the "birth of civilization" and to explain the changing and progressive character of the growth of cities.

According to Childe and further developed by others (20), the Neolithic revolution marked the beginnings of sedentary agriculture and saw the development of the first permanent settlements. Technological achievements were the domestication of plants and animals and development of sharpened stone tools, pottery, and weaving. It ushered in the potential for supporting a growing population.

Childe uses archeological evidence to support his thesis. He estimates that the beginning of the Neolithic revolution was approximately 7000 B.C. This is estimated to be the date of the formation of the oasis village of Jericho in the Jordan valley. It was a village of about eight acres and shows evidence of support not only through hunting and gathering but also through the growth and cultivation of crops, watered by a spring, and the domestication of sheep and goats (21).

The Neolithic age, according to Gist and Fava (22) set the stage for the emergence of cities because it made possible permanent settlement by providing the means for a stable food supply. They point out, however, that the Neolithic villages were not themselves cities but rather collections of farmers. The crucial element for the emergence of cities, in addition to the development of Neolithic skills, was a social organization "that could effectively distribute this surplus so that some individuals would not have to engage in food production, but would be free to perform other tasks and to live apart from the farms" (22).

The notion of an agricultural surplus has been widely accepted as a precondition to the urban revolution. Jane Jacobs (23) specifically takes issue with this popular notion and provides an interesting and thoughtful thesis that the growth of cities precluded surplus production and enabled this surplus to be produced. Both arguments are logical and the truth probably lies somewhere in between.

Childe himself does not emphasize a surplus agricultural production as initiating the Urban revolution. Rather, he emphasizes social organization and invention as being the key variables in initiating the development of cities. Childe (24) lists ten criteria that characterized cities during the Urban revolution. These define the city and show its dependence on a complex and highly differentiated social structure. The ten criteria are as follows:

1. Specialization and social division of labor,
2. Larger and denser populations,
3. Production of art by specialists,
4. Invention of writing and numerical notation,
5. Development of sciences such as arithmetic, geometry, and astronomy,
6. Payment of tribute and the collection of taxes,
7. Social organization based on residence rather than kinship,

8. Monumental public buildings,
9. Growth of trade with other regions, and
10. A class-structured society based largely on specialized activities.

Childe documents Sumerian cities with the birth of civilization and the beginnings of the Urban revolution. The time is placed at 3000 B.C. These cities were over 100 acres in area and had populations of several thousand compared to villages with areas of about 10 acres and populations of about 100 during the Neolithic age.

The third revolution in the process of civilization was the Industrial revolution. It began in the second half of the 18th century. Its main aspect was the development of the factory system. The consequences were an unprecedented growth of cities, especially where the factories were located, and the beginnings of truly urban civilization.

While Childe only inferred population dynamics in his historical analysis of the birth and growth of civilization, Deevey daals specifically with the growth of human populations. He views the course of history following a similar pattern of three technological revolutions. However, the three revolutions as visualized by Deevey are somewhat different than those outlined by Childe. The rationale for this difference is difficult to comprehend since Deevey relied on information that had its roots with Childe.

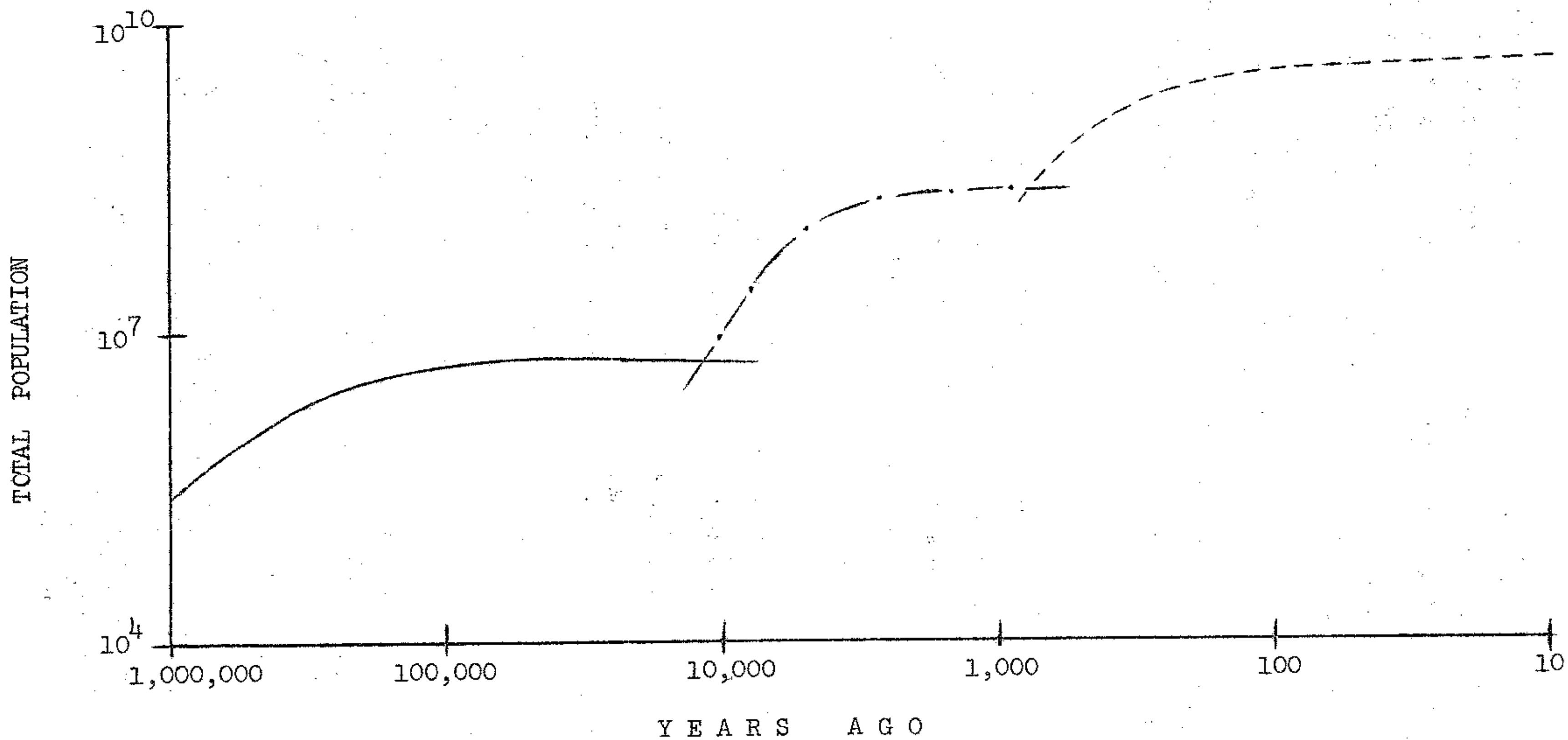
The three revolutions as outlined by Deevey are the toolmaking or cultural revolution with its beginnings about one million years ago; the agricultural revolution with its beginnings about 10,000 years ago; and the scientific-industrial revolution that began about 300 years ago. Both Deevey and Childe are in agreement about the date of the most recent revolution. On the surface, they appear to widely disagree on the nature and beginnings of the other revolutions. But, closer inspection reveals that their differences are not that great. What Childe views as the Neolithic and Urban revolutions, Deevey combines into the agricultural revolution. This difference is largely conditioned by the answers that are sought. To Childe, having an Urban revolution was important in his analysis since it marked the "flowering" of civilization. To Deevey, the important element was a revolution in agriculture and did not merit discussion within the context of the growth of cities.

The major difference in the two theses lies in consideration of the toolmaking or cultural revolution that Deevey emphasizes and Childe ignores. Again, the point of view conditions their arguments and delineation of this revolution in the history of mankind. The toolmaking or cultural revolution did not concern Childe since it marked a lack of civilization and he was interested in progression from this state. Such may be the more proper reasoning. Deevey seems to view the slow development of mankind from the Paleolithic as a revolution in itself.

Figure 4 is a logarithmic population curve revealing three population surges as reflected by the three revolutions as outlined by Deevey. These curves are the result of estimates of population densities, based on archeological findings, that were necessary and capable of supporting humans within the economic systems existing during these periods.

Whether one accepts the thesis of Childe or Deevey as to the sequence or character of the three revolutions, one can readily see an obvious relationship of population growth to technological breakthroughs. Probably a better way to view this relationship is in terms of stability in human numbers as being the historically normal condition with spurts in growth occurring with technological achievements. Deevey's graph (Figure 4) shows this relationship quite vividly. Through the course of man's history, stability or near stability has been the common condition with spurts occurring with the inception of a new technological age only to stabilize again at a new level.

FIGURE 4. THREE SURGES IN POPULATION REFLECTING THE AFFECT OF THE THREE TECHNOLOGICAL REVOLUTIONS IN MAN'S HISTORY: THE TOOLMAKING OR CULTURAL REVOLUTION; THE AGRICULTURAL REVOLUTION; AND THE SCIENTIFIC-INDUSTRIAL REVOLUTION



Source: Edward S. Deevey, Jr., "The Human Population," <u>Scientific American</u>, 1960.

These bursts in population growth did not occur in a short time. Deevey's figure clearly shows that these cycles of growth took considerable time. Although Deevey shows population stabilizing during the age of the industrial-scientific revolution, such a presentation seems to be a bit premature, especially when looking at a graph (such as Figure 1) which is largely a presentation of the current situation with its condition of rapid population growth. Even though the Industrial revolution occurred about 300 years ago, it is still occurring, especially in the Third World, and only inferences can be made about the time when stability will be reached.

Before leaving this discussion on the interplay of population and technology in history, we should take a look at Malthusian theory in this context. Malthus was pessimistic about the future of mankind. This pessimism was based largely on the thesis of population growth outstripping its subsistence base.

Writing in 1798, and elaborating his ideas in many subsequent revisions, Malthus (25) postulated the following:

> First, That food is necessary to the existence of man.
>
> Second, That the passion between the sexes in necessary, and will remain nearly in its present state . . .

These postulates have been fairly well accepted with little questioning. However, the following extension of these postulates came under heavy attack and continues to suffer much criticism into the present:

> Assuming then, my postulata as granted, I say, that the power of population is indefinitely greater than the power in the earth to produce subsistence for man.
>
> Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. A slight acquaintance with numbers will shew the immensity of the first power as compared with the second.
>
> By that law of our nature which makes food necessary to the life of man, the effects of these two unequal powers must be kept equal.

> This implies a strong and constantly operating check on population from the difficulty of subsistence . . . The race of plants, and the race of animals shrink under this great restrictive law. And the race of man cannot, by any efforts of reason, escape from it. Among plants and animals its effects are waste of seed, sickness, and premature death. Among mankind, misery and vice. The former, misery, is an absolutely necessary consequence of it. Vice is a highly probable consequence . . . I see no way by which man can escape from the weight of this law which pervades all animated nature . . .

Almost any general population text takes issue with the Malthusian thesis and provides an overview of the criticisms aimed at these theoretical formulations. Generally, these criticisms are aimed at the empirical invalidity of the framework (26; 27).

This empirical invalidity has been shown to be largely a product of the times that Malthus was writing about. Malthus was writing at the crossroads of the third revolution, the industrial-scientific revolution. Great technological advances and the opening of new frontiers, such as the colonialization of the Americas, released man from the tightening grip of subsistence and therefore weakened the dire prognostications of Malthus (27).

A Societal Perspective

Many difficulties are inherent in analyses on the grandiose scale of Childe and Deevey. They chronicled events that shaped Western society and population dynamics that occurred within its changing character and extrapolated these into a picture encompassing the world. But moreover, they suggest that a uniform pattern of change occurred through history. These typologies do little to explain the diversity of human types and social systems that can be found in the world today. Some parts of Europe may have witnessed the technological revolutions as were outlined by Childe and Deevey within the chronology they describe. But it is naive to say that such has been the course of the world.

Childe seems closer to reality for he deals with "cradles" of change that had profound effects on the course of civilization. He attempts to document shifts in the patterns of civilization through revolutionary changes in patterns of subsistence and social organization. Deevey, however, seems to overgeneralize these events across the spectrum of human types and social systems.

It would be more meaningful to view the interplay of technology and human population, or the progress of civilization, in a societal context. Society is a broad unit that is difficult to accurately define. Parsons (28, p. 9) defines society as "a type of social system, in any universe of social systems, which attains the highest level of self-sufficiency as a system in relation to its environment." Lenski (29, p. 9) defines society in more diffuse terms as "a territorially distinct organization and that it is made up of animals of a distinct species." Whatever definition one adheres to, society has the readily identifiable properties of self-sufficiency, commonly united populations, a distinct environment, and physical bounds or boundaries.

Although the above definitions provide some insight into society as an entity they are not operational, especially toward an understanding of the interplay of technology and population. The "ecological complex" variables of population, organization, environment and technology as outlined by Duncan (30) provide this operational link. As originally formulated and generally accepted, the ecological complex variables centered on the analysis of social organization. In this context, social organization is viewed as the dependent variable influenced by the other three variables (31).

Such a distinction of variables appears quite valid for analyses of small-scale social systems, such as those groupings of social units within a societal framework. However, in the analysis of society, all the ecological complex variables should be viewed as independent variables for it is the interplay of all these variables that determines, to a large degree, the character of a societal system.

The evolution of society can be wholely explained through the interplay of the ecological complex variables. The expression of these variables, in the context of evolution of society, is culture and the pattern is the societal unit. However, in studies of complex, modern systems, culture becomes an additional variable to the ecological complex variables. It, however, tends to operate as a constraint to societal change. An example would be birth control practices. Birth control is often cited as a prerequisite to modernization or economic development (32) that is difficult to realize largely through cultural norms defining many children as being necessary to personal status within the society or as being an economic necessity (33).

Therefore, society can be defined as the product of the interplay of population, organization, environment, and technology within the matrix of culture that operate within a territorially distinct or boundary-defined unit that attains self-sufficiency.

Before proceeding any further in the discussion it is necessary to define these variables for their dynamics can only be understood when one understands the framework of analysis.

Population

Within demography, population refers to the number of people, their age and sex composition, their distribution in space, and their dynamic characteristics of fertility, mortality, and migration. In this paper, only population size will be dealt with. This is not to deny that the other factors are of less importance but rather because, within the limits of the discussion, it would be extremely difficult to quantify these other components.

Organization

According to Brooks and Associates (34, p. 233) organization is "the social patterning that takes place in the population as individuals compete for limited resources to sustain life." Although they specify organization as being "social patterning" it would be more meaningful to include economic patterning as well. Such a distinction is especially valid in the analysis of "modern" societal units because economic structures, to a large degree, define social structures.

Environment

The environment, as defined by Hawley (35, p. 12), "is a generic concept under which are subsumed all external forces and factors to which an organism is actually or potentially responsive." Although accurate, this definition is quite vague for it includes everything that impinges on the individual. For the purposes of this paper, environment can be viewed as the complex of climate, natural resources, biota, topography, and geology. Environment largely conditions the way of life and livelihood that a population can sustain.

Technology

Numerous definitions of technology can be found in the literature. However, most are vague and tend to reflect the character of the times or the situation that is being written about. One of these is Anderson's (9) definition which reflects the nature of technology in the sense of scientific-industrial society. To him technology involves planning, the use of engineers and technicians to design and operate the computers used in decision-making processes. On the other end of the spectrum technology is defined not as a process in itself but rather as a component of the cultural system (34, p. 234).

Neither of the above definitions is wrong. However, they are deficient in that they define technology only in the context of the system being evaluated. Technology took various forms throughout the course of man's history. In the Neolithic age technology meant the domestication of plants and animals while in the Industrial-scientific age it means machines and fossil fuels. Restricting the definition to a specific era in the history of mankind does not permit an analysis of technology and its affects through time.

One of the best definitions of technology and one which will be used in subsequent analysis is provided by Galbraith (36). He defines technology as scientific and other organized knowledge and its systematic application to practical tasks. An important characteristic of technology, within this definition, is the application of this organized knowledge to performance within a system of division of labor.

Ellul (37) takes the meaning of technology one step further. He conceives of technology as being of two forms: 1) as a means of serving man, and 2) as an end in itself. In the former sense, technology is seen as increasing leisure and comfort and allowing for contemplation and esthetics. In the latter sense, technology is order, predictability and control, with all else secondary, operating within a matrix of efficiency and yield maximization.

Culture

As was mentioned earlier, culture can be viewed as the product of population, organization, environment, and technology in the evolution of society. Subsequent study of society involves using culture as a variable that conditions and sometimes constrains the dynamics of societal change. The generally accepted textbook definition of culture refers to the "totality of what is learned by individuals as members of society." It is the "complex whole which includes knowledge, belief, art, morals, law, custom, and any other capabilities acquired by man as a member of society." (38). The conditions are a system of patterns of behavior which are transmitted by symbols and the constraints are the traditional ideas and attached values.

Culture is a difficult variable to quantify. It does exist and does exert much influence. However, it does change, largely through changes within the ecological complex variables.

Interplay of Technology and Population Within Society

Although the primary concern of this paper is the relationship and the influence of technology, and its changing character on human populations, such understanding can only be realized through an examination of all the previously outlined variables. In this sense, a case could be made on centering on all the variables in a discussion of societal dynamics and societal change. However, as will become evident subsequently, technology appears to be the key "independent" variable initiating changes in society and population appears to be the key "dependent" variable in that the greatest influence and change has occurred with this component when viewing societal dynamics through the course of man's history.

The key to an analysis of societal dynamics is understanding the nature of societies themselves. Mentioned were some definitions of society which were amended for the purposes of this paper. However, these definitions do little to explain the nature or character of societies in historical perspective.

It was previously suggested that society is not a static entity. It is ever-changing. At times these changes are quite dramatic, especially in the case of civil strife or revolution, but the normal condition is one of gradual, oftentimes hardly noticeable, change.

A void exists in sociological literature in terms of a valid explanation of societal change. The dominant paradigm being used to document societal change is social evolutionary theory (41), which emphasizes progressive and linear development of societies from the "primitive" condition to the climax situation that is construed to be Western society. Again, as was the case with the demographic transition model, the Western experience is being used as the framework to pattern societal change.

Although social evolutionary theory has failed to provide many meaningful answers to an understanding of societal dynamics (41; 42), it is a valuable typological construct that characterizes stages of societal development. The typologies of societal development will be used in this paper to document differences among societies. However, I feel that the key to understanding societal differences lies in ecological systems theory rather than in evolutionary theory.

The ecological system, or as more popularly called, the ecosystem, refers to a community and its habitat (39, p. 2). The functional dynamics of the ecological system centers on matter, energy, and the interaction of population units in the quest for matter-energy. In biological systems, this interactive process begins on a matter-energy base with microbial life forms and proceeds through time, in a succession of plant and animal development toward a dynamic equilibrium of life forms to one another and to the environmental limits and constraints. Odum (40, pp. 82-86) characterizes this pattern of progressive change toward a state of equilibrium by the ratio of production to respiration. Equilibrium is approached when the production-respiration ratio approaches zero.

Society can be likened to an ecosystem. Differences in societies can be equated to differences in the ecological system moving from a state of relative "disequilibrium" to a state of equilibrium. Cottrell (43) approaches the ecological model of societal dynamics in an analysis of societal development from the point of view of energy consumption and utilization. He divides societies into polar types: low-energy societies and high-energy societies. Within this framework Cottrell examines societal change through differences in energy utilization, largely through differences in technological inputs--low-energy society is equated with low levels of technology; high-energy society with high-levels of technology.

Other typologies of societies can also be viewed within the framework of the ecological systems model. The changing character of the ecological system represents a continuum of events and structural changes through time.

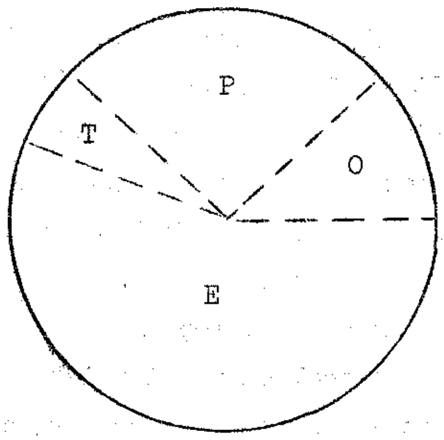
To get a meaningful measure of change, this continuum can be characterized at a particular point in time and would produce a picture expressing its composition at that time. Figure 5 is an attempt to represent the character of societies through the polar types of "primitive"-agricultural society and "modern"-industrial society. These polar types are used in order to relate the changing character of societies and the changing relative dominance of the system components of population, organization, environment, and technology. In the historical sequence outlined by Childe (18) and Deevey (19), these types would conform to societies in the Neolithic and the latter part of the Industrial-scientific stages of man's development.

Figure 5 merits elaboration on two points: 1) the changing character of the societal system in terms of culture area; and 2) the changing character of the societal system in respect to the relative dominance of components within the system.

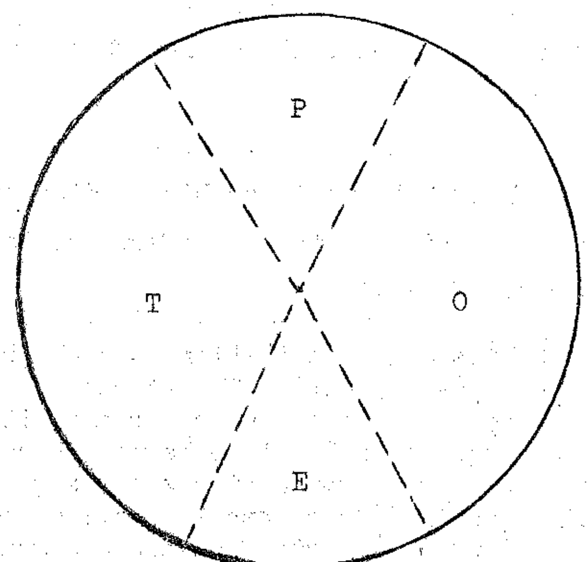
The culture area of a societal system can be viewed as that area where subsistence and interactive activities of the indigenous population occur. Duncan (44, p. 57) suggests that ecological expansion of the culture area is the key to societal transition from one type to another within the range of societies along the continuum from primitive to modern. Childe (21) cites evidence from the archeological record that during the Neolithic age the communities were extremely small, about ten acres in size, and the subsequent culture area being rather constricted. At the other extreme, modern industrial society, the culture area has been significantly enlarged. For example, in the United States, the range of economic activity not only encompasses all parts of the country itself but extends to all corners of the world.

Ecological expansion of the culture area has not occurred uniformly across and within societal systems. According to Goldschmidt (45), the triggering mechanism for ecological expansion and societal change and development has been technological change. Each advance in technology is seen as an expansion of the possibilities for further advance in societal

FIGURE 5. THE RELATIVE DOMINANCE OF SYSTEM COMPONENTS: POPULATION (P); ORGANIZATION (O); ENVIRONMENT (E); AND TECHNOLOGY (T) WITHIN "PRIMITIVE" - AGRICULTURAL SOCIETY AND WITHIN "MODERN" - INDUSTRIAL SOCIETY



"PRIMITIVE" - AGRICULTURAL SOCIETY



"MODERN" - INDUSTRIAL SOCIETY

development. Goldschmidt sees technology as initiating dramatic changes in the social system because of its affects on group structure, values, status systems, role differentiation, and ideology, by altering the size and life conditions of a population.

It therefore appears that the primary change in societal systems that has occurred in the history of mankind is their ecological expansion largely through a changing technology. This is a most important point for it shows that gains in societal development have been largely in terms of boundary expansion and not, as quite commonly and somewhat unquestionably accepted, through gains as the result of technological revolution (19) or cultural evolution (46). This is not to say that technological change or cultural acceptance of such change were not important. In reality, they were instrumental to societal change and development. The point that is being made, however, is that technological change initiated a process of ecological expansion in culture area. Although there are always some gains in efficiency through applying scientific principles to practical tasks, the greatest gains through a developing technology on a societal level appear to have been the opening of new frontiers for further settlement and therefore increasing the potential for population expansion. To paraphrase the above, societal change came about through changes in technology resulting in ecological expansion of the culture area which increased the potential for population growth.

Ogburn (47, p. 10), reknowned for his studies on technology and social change, provides some insight into the effects of technological change on societal development. He writes:

> Groups, habits, and institutions are all being altered by technological developments. The technology of early agriculture increased the size of groups from small wandering bands of hunters to larger stabilized villages. Domesticated animals and plows brought about communities with larger populations, making possible many kinds of small organizations not possible in a hunting culture. The steam engine changed the large family which was an economic institution producing a variety of goods into a small one producing little or nothing, with the members of the family becoming producers in other economic institutions . . .

Although Ogburn stresses technology as the key to change, he outlines this change as occurring through an expansion of the culture area. From wandering hunters the progression is to larger villages and subsequently to economic society--each encompassing a larger area of activity in physical space.

Regarding system components, these have also changed in terms of relative dominance within societal systems from the "primitive" condition to the "modern." Figure 5 is an attempt to outline the relative dominance of system components within polar types of societal systems. "Primitive"-agricultural society was dominated by environmental constraints. It was characterized by a somewhat mutualistic relationship of man-in-nature (48). Such a relationship was a necessity for survival largely because of a limited technology making man unable to successfully exploit the environment. Subsistence activity depended on heavy inputs of human effort and therefore large group size, relative to culture area, was a key to group survival. In order to coordinate the activities of the group it was necessary to have a well-defined organizational network. In summary, "primitive"-agricultural society was dominated by the environment; had a poorly developed technology; had a large population size relative to the size of the culture area; and had a limited organization.

At the other end of the continuum, "modern"-industrial society is characterized by considerable ecological expansion of the culture area and, as a result, a reorientation of the relative dominance of system components. As emphasized by many writers, technology was the prime force initiating these changes (44; 45; 48). Therefore, technology is shown to have had the greatest increase in relative dominance, through time, in the societal system. But technological changes by themselves are of limited value unless there are concomitant changes that occur in social organization.

Toennies (49) outlines the changing organizational character of societies from the primitive to the modern condition. He sees this change as movement from an artistic-religious to a scientific-rational orientation.

He classifies the primitive condition as being dominated by the family and a rural life-style with an economic organization centering on agriculture and limited cottage industry. The modern condition is seen as being dominated by legislation and convention in a city-life style with an economic organization that centers on commerce and industry.

Some measure of process changes, in moving from the primitive to the modern condition, is provided by Levy (50). He outlines movement from traditional to rational society as change from non-specialized to highly specialized economic organization; as change from high levels of self-sufficiency to high interdependence and low levels of self-sufficiency; and as change from limited trade and use of markets to extensive trade and a well-developed market system.

Numerous other typologies of societal change and development emphasize vast organization changes occurring concomitantly with technological change. Therefore, both the technological and the organizational components are outlined in the diagram of "modern"-industrial society as increasing in relative dominance within the system simultaneously. Also, because of their powerful effect in initiating and promoting change, they are seen as the dominant components within "modern"-industrial society.

While the technology and organization components have increased in relative dominance within "modern"-industrial society, the other components namely population and environment have to be visualized as decreasing in relative dominance.

The rationale for this argument lies with the concept of ecological balance which has been overshadowed in ecological literature by the competition based frameworks that so easily explain dynamics within narrowly-defined systems and fail to provide meaningful answers to dynamics within complex systems. Although it is a relatively obscure concept within ecology, the concept of ecological balance is an extremely logical one, especially in the light of the laws of conservation of energy and entropy (51). Oosting (52) provides the following example of the concept of ecological balance:

> Natural communities are made up of groups of species adapted to living together within a particular complex of environmental factors. The requirements of the organisms are in balance with, and an expression of, the potential productivity of the environment. If the ecosystem is disrupted by the elimination of a species, for any reason, others of the community may increase in size or numbers to take its place, or this may provide the opportunity for an incidental species to become a part of the community . . . Then adjustments must be made within the community, and a new balance among its members must be established. Such a species might even become a dominant, and then the adjustments would result in an entirely new community . . .

The societal system is an ecological system on a grand scale. When the societal system expands in area, broadens its physical boundaries, there is room for expansion of all the system components. Such expansion rests on technological advances which increases the environmental component, through the opening of new frontiers, and triggers organizational changes and provides opportunity for settlement and subsequent population growth. However, in a constricted system, one that has its boundaries well-defined and further expansion is not possible, such as is the case with highly industrialized societies, any increase in dominance in one component must result in decreased dominance in another. This is the reason for showing the substantial decrease in relative dominance of the environment components and a slight decrease in relative dominance of the population component.

The dynamics involved in the above outlined interactive societal system have been lucidly outlined by Cowgill (53). In order to do justice to the formulation, its tenets will be quoted verbatim. They are as follows:

1. Any population has the capacity to increase at a geometric rate.
2. Unless inhibited by environmental factors, any population will tend to increase at a geometric rate approaching maximum capacity.
3. At a geometric rate of increase, any population will quickly fill up any finite environment, taxing its space and resources.

4. As a population begins to press upon the limits of its environment, inhibiting factors will come into play to slow down the growth.
5. If the limits of the environment cannot be expanded or the resources used more efficiently, population will cease to grow.
6. At any given time, most species have long since passed their maximum rate of growth and have achieved a condition of equilibrium characterized by a relatively stationary population.
7. Like other species, the most common, if not the normal, condition of man is stability of population.
8. However, the human species has a unique capacity for expanding the limits of his environment and of improving the efficiency of utilization of the resources of his environment.
9. Thus, man has from time to time achieved technological breakthroughs which have made it possible for him to utilize the resources of an enlarged environment and to make more efficient use of the resources of any specific area.
10. Any such technological advance increases the potential carrying capacity of the environment and, given the persistent tendency of population to increase, tends to increase the size of the population.
11. When such an advance occurs, it tends to be followed by a cycle of population growth.

The above outlined cyclical sequence can be used to explain the dynamics of the three technological revolutions as pictured by Deevey (19) if one accepts his framework of analysis. As was mentioned earlier, Deevey uses the archeological record to place the three technological revolutions in a chronological sequence and then proceeds to extrapolate a picture of population growth. There is much agreement in the literature as to the historical occurrence of great technological breakthroughs, so this aspect of Deevey's argument cannot be questioned (cf. 18; 20; 47). I do, however, question the validity of Deevey's three concomitant surges in population growth.

Deevey obtains a measure of population densities as they have been documented by others in the course of man's settlement patterns through time. He then uses these densities to obtain a picture of population size for large land masses which had settlements within their confines. In the

Lower Paleolithic cultural stage he documents Africa as being the populated area; in the Paleolithic it was Africa and Eurasia; and about 6,000 years ago it included the whole world. Deevey then proceeds to calculate an "assumed density per square kilometer" for the populated areas, that is the continental land masses that had settlements, and obtains a measure of the total population during the different cultural stages in man's progressive development through time.

This is extremely fallacious. He altogether ignores the concept of cultural area. During the course of man's history the world did not include the continental land mass where he has his settlements but rather it was the subsistence area, the area where he conducted his survival and economic functions. In this context, if it is assumed that man had his origins in Africa, his "world" was not all of Africa but rather the restricted area of his activities.

As a result, Deevey's "assumed densities" are rather nebulous figures. The bursts in human population that he documents can be as much a statistical accident as the real situation. Since he attempts to document the human condition, in terms of population through the span of his assumed existence on earth, Deevey has nothing but conjecture or "educated guesses" as to the situation of man through 99 percent of his assumed existence. It seems rather convenient for the first "real" burst in population growth to have occurred some 10,000 years ago, the earliest documentation of village life, and the first real measure of the earliest condition of man.

It is therefore felt that Deevey's study is an intellectual exercise, a game of numbers. He uses the conceptualization of three dramatic technological revolutions and manipulates his data to show three concomitant bursts in population. It is all too convenient and extremely misleading.

As was mentioned earlier, these technological revolutions did not occur simultaneously throughout but rather within distinct systems across the span of recorded history. Although the Industrial Revolution had its roots in the second half of the 18th century, it is occurring to this day in the Third World nations. Therefore, the only meaningful assessment of technological effects on human populations can be made only within a societal context. Although not documented, it would probably be discovered that ecological expansion of the culture area would have been the major impetus to further population expansion. Also, within this context of societal change, the picture that would evolve would be one of continuous growth of population, approximating the pattern as diagramed in Figure 1, rather than a picture of three dramatic surges. This picture of continuous growth in the world's population would be a mosaic of the population dynamics within the many societal systems in the world and their cycles of technological development, ecological expansion, and population growth and subsequent stabilization at various stages along a continuum of economic development.

The dynamics in "modern"-industrial society, where further ecological expansion is no longer possible except through conquest, has been outlined by Cowgill (53) and is paraphrased as follows by Satin (54, p. 191):

1. Prior to industrialization, population is stabilized at a level commensurate with the carrying capacity of the environment and is characterized by high birth and death rates.
2. As a country industrializes, the techniques of death control are increasingly applied causing a decrease in the death rate. Because techniques of birth control are applied at a later time and less rapidly, during this period, population grows at an accelerating rate.
3. During the process of industrialization, the nuclear family replaces the larger, extended forms.
4. The size of the family is further decreased during industrialization due to falling birth rates.
5. The techniques of death control will, predictably, be applied first in the upper socioeconomic classes. Thus in an era of generally falling death rates, there will be significant differentials in mortality.
6. The same is true for the techniques of birth control when they are finally applied. Therefore, births will show the greatest attenuation in the upper classes prior to a comparable decrease in the general population.

7. During the decline of birth rates, they will decline first in the urban areas.
8. A preindustrial society will be characterized by a young, dominantly male population mostly engaged in agrarian occupations and rural in residence.
9. Industrialized societies will manifest a marked aging trend due to their declining vital rates.
10. This aging population tends to be predominantly female.
11. During industrialization, there is a shift from the extractive to the manufacturing and commercial occupations.
12. With increased industrialization, population tends towards more urban residence.

It is the above pattern of events that was used as the basis for postulating the decreased relative dominance of the population component within "modern"-industrial society (see Figure 5). Within a constricted system, one in which further ecological expansion is not possible, any change precipitated by technology will be felt within the population component.

Almost all arguments on modernization and economic development, via the Western model, stress the necessity for policies aimed at birth control and low rates of natural increase (55; 56). This position has its roots with the trends that have occurred in the Western world through the course of industrialization and which has been dramatically emphasized by the Japanese experience (10). McClelland (55) shows a strong relationship of economic development, in terms of per capita Gross National Product, and low rates of population growth. Such is the basis for the reasoning behind the preconditions of low population growth rates to industrial and economic development. However, this argument could easily be inverted to say that low population growth rates are the result of economic-industrial development. This reformulation places the argument within the societal systems model that was previously outlined and strengthens my contention that the population component has to decrease in relative dominance within a constricted system through increased technological inputs.

It is in the light of arguments for birth control as a precondition to industrial-economic development that Deevey's treatise further falls apart. A technological revolution is occurring within the Third World and a decrease in population growth is deemed a necessity. It cannot be denied that a "burst" in population growth is occurring in the Third World. It is, however, the result of mortality decreases that have little parallel to the Western experience and which have been brought about with no industrial-economic development in many instances. Also, these increases in population that are occurring in the Third World are nowhere near the "assumed" increases that have, supposedly, occurred in history.

The situation in the Third World nations, prior to a push toward industrial-economic development, can be viewed as one of stability of population to subsistence. However, unlike the Western experience, there is no more room for further expansion because of tightly drawn boundaries. Therefore, any technological inputs preclude a decrease in population growth.

Some Examples of Ongoing Processes

Two examples will be used to illustrate the impact of technology on population. These are the Green Revolution as it is occurring in the developing world and the tobacco-growing industry in the United States.

The Green Revolution is a major segment of the industrial-scientific revolution that is occurring in the Third World. The popular conception of the Green Revolution is "miracle" grains, the products of genetic technology, that mean higher grain yields per unit of land (57). And indeed, yields per unit of land have increased dramatically in many countries as the result of the Green Revolution. They have tripled in Mexico and doubled in parts of India, Pakistan, Turkey, and other countries (58).

However, in reality, these "miracle" grains are only a small part of the increased yields. According to Reitz (58) these "miracle" grains are a catalyst to a host of other inputs that provide the basis for obtaining higher yields. These inputs are presented as follows:

1. Increased fertilization or plant food management,
2. Irrigation or better moisture management,
3. Control of pests,
4. Economic incentives, and
5. Selection of responsive genotypes . . .

Staub and Blase (59) show the inputs, in terms of cost, of "miracle" grains as opposed to local varieties for rice and wheat in India for the period 1967-68. They obtained their data from the Planning Commission, Government of India. Table 3 shows these inputs, in rupees per hectare, and the magnitude of change in cost for the various inputs in moving from local to high-yield varieties.

Although the authors fail to provide a measure of yield differences with the two varieties of rice and wheat, the data in Table 3 is, nonetheless, valuable in illustrating the changing character of agriculture as the result of these high-yield varieties. Whereas the agriculture utilizing local varieties is highly labor intensive, the agriculture utilizing high-yield varieties is highly capital intensive. For rice, agriculture involving local varieties had a labor input of approximately 60 percent of the total cost input. Where high-yield varieties are planted, the labor input is approximately 46 percent of the total cost input. For wheat, the change in labor input in moving from local to high-yield varieties was from 48 percent to 32 percent of the total cost input.

If no data were provided on the changing character of other inputs it might be construed that labor costs have gone down. However, it is quite evident that other costs and inputs have significantly increased.

The ramifications of changes from the labor-intensive to the capital-technological-intensive systems of agriculture as a consequence of the Green Revolution are numerous. However, our interests in this paper are the changes wrought by the Green Revolution on the population component within the societal system. The picture that evolves is a dismal and fearful one. It is dismal in the sense that "the food population problem

TABLE 3. CASH INPUT: COST OF HIGH-YIELD VARIETIES AS OPPOSED TO LOCAL VARIETIES OF RICE AND WHEAT, FOR 1967-68, AND THE DIFFERENCE IN COST OF HIGH-YIELD VARIETIES AS OPPOSED TO LOCAL VARIETIES

	Input in Rupees per Hectare					
Crop	Seeds	Ferti- lizer	Labor	Irri- gation	Other	Total
Wheat						
High-yield	69.9	232.8	191.5	58.6	52.6	605.4
Local	4.7	22.0	41.0	12.4	4.9	85.0
Difference (High-yield/local)	14X	10X	4.5X	5X	10X	7X
Rice						
High-yield	30.1	332.8	367.4	27.7	40.5	798.4
Local	8.2	104.3	190.5	13.8	16.8	333.6
Difference (High-yield/local)	4X	3X	1.5X	2X	2.5X	2X

Source: W. J. Staub and M. G. Blase, "Genetic Technology and Agricultural Development," Science, 9 July 1972, p. 121.

of the sixties is becoming the employment population problem of the seventies" (57). Poleman (60) shows that in Ceylon the Green Revolution has resulted in about 83 percent of the youth in the 15-24 age bracket having no job. It is the high rates of unemployment being generated by the Green Revolution that are creating many fears and have spawned speculation on the Green Revolution becoming a "Red Revolution" (61).

Agricultural displacement as well as a high growth in manpower has placed heavy stress on the urban sector of developing nations for it is in the urban sector that the jobless seek employment opportunity. However, as agricultural development has become more capital intensive, so has manufacturing (62). In Latin America, between 1925 and 1960, only 5 million out of 25 million people added to the urban labor force were able to be absorbed in manufacturing (63).

Once a technological breakthrough occurs, it seems to be a springboard for further technological developments. Such change has become a part of everyday life in the United States and is very much taken for granted.

However, each new technological change not only results in a new gadget, a new machine, or added efficiency but also results in the displacement of people from jobs and their replacement with these machines. Stevens (64) documents such technological effects on the working man that have recently occurred in the tobacco belt of Carolina-Virginia. According to Stevens, the tobacco belt was the last big stronghold of the small farmer in this country. But the invention of an automatic harvester is expected to change this by decreasing the need for his services and making him unable to compete against the bigger operators who can afford this harvester. The future is visualized in terms of another wave of farm-to-city and south-to-north migration.

The impact of these automatic harvesters will be substantial. It is estimated that one harvester, operated by one man, will do the amount of work customarily performed by eight workers. In the state of North Carolina alone, this amounts to about 50,000 workers being displaced from their jobs as the result of the harvester.

However, the automatic harvester is only a part of the picture of worker displacement in tobacco farming. Preceding the automatic harvester, and in some cases being necessary prerequisites to its use, were the tractor and automatic planting devices; automatic oil and gas burners that replaced hand-tended wood fires in the curing barns; then chemicals for weed control and "suckering" of plants, tasks that formerly required much hand labor; and finally bulk curing of tobacco leaves. Altogether, it is estimated that these developments will have reduced the human labor requirement by 85 percent.

Some Thoughts on the Future

It is hoped that this paper provided some insight into the interplay of technology and population within society. An attempt was made to discern the dynamics of technological change in history. But moreso, these dynamics were presented utilizing an ecological system model of the interplay of the ecological complex variables of population, organization, environment, and technology within a societal system that is always in a state of flux toward an equilibrium condition of these components to one another and to the total system. Utilization of such a multi-variable model is unique in the analysis of technology and population.

Before an attempt is made to provide a personal view of possible future developments in the course of mankind, let us review some of the major points that were brought out in the discussion. Technology was seen to be the major catalyst for change within the societal system. Technological developments not only affect changes within other system components but also initiate a process of further continual developments in technology.

However, the most crucial elements to understanding changes among variables are the physical concept of society and the process concepts of balance and ecological expansion. These elements not only determine the amount of change possible but also indicate the directions this change can take. Society can be broadly visualized as the culture area of a population--that sometimes well-delineated and most often diffusely defined unit where the subsistence, economic, and social activities of a population occur. When the societal system has room to expand, technological change initiates the expansion of the societal system and expansion of all component variables within the system. But, when the societal system boundaries cannot expand, any technological changes that increase the relative dominance of the technology component within the system will initiate changes that result in the decreased relative dominance of some of the other system components. Historically, technological expansion has resulted in a decrease in dominance of the population and environment components. Any change that occurs within the system places the system in a state of flux and initiates processes toward a new balance of system components.

Since the model outlined is largely conceptual very little data or research exist to substantiate the dynamics outlined. The lack of scientific research in this direction is not a reflection of the inadequacy of the presented model. Rather it is a reflection of the direction research has taken in the past. In terms of population research, studies were largely problem oriented and the framework of analysis was in the direction of cause-effect relationships. Within such a context, analysis is of one problem after another. First food was the problem, now population growth is the problem, and in the future it is visualized as being unemployment. However, attempts to minimize one problem area have maximized problems in another area through such a cause-effect approach. It is felt that a societal system approach would eliminate many of such difficulties through the operationalization of many variables and thereby enable more meaningful examination into all phases of action, interaction, and reaction.

As to future prospects, it all depends on the direction of technological change. The historical trend of increased technological development is expected to continue and is even expected to magnify in scope by both the technocrats (65; 66) and the humanists (67). If such is to be the case then it can be expected that a significantly greater emphasis will be placed on population control in the future because an increased technology will mean decreased emphasis on the human element. The emphasis on population control will be made by governmental agencies in order to avert disaster in the future due to ever-increasing amounts of unemployment that will be generated by technological change.

The above generalizations need further elaboration. Although a decreased value of human effort and an increased value of technological effort is seen for the world as a whole, it will take different forms in the Western world than in the Third World. The difference will stem largely from the form the technological effort will take in each of these large scale socio-economic systems. Ellul (37) distinguishes two forms of technological effort. One is efficiency-oriented, technology used to ease the human effort; the other is automation-oriented, technology being used to replace the human. Although the product of both forms of technology is the same, job displacement, the distinction is made to show that all societies, pre-industrial and industrial, because of the closed nature of their systems and the concomitant stresses on the population component, will face substantial problems of unemployment. The different forms of technology may precipitate different changes in the different societal systems. The trends in the Western world may go in the direction of a welfare state because the changes will not be as stressful due to a smaller population base. However, in the Third World, if trends continue as they are, violent upheaval appears imminent.

But then again, a wave of humanism could change the whole picture. Instead of dealing with questions of yield maximization and capital-intensity of effort, a change would be in attempting to maximize human effort and the human condition. However, such developments appear unlikely.

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