Population and World Economic Development

In a finite world, population growth, before it is finally halted, entails diverse costs.

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"In the long run, the lack of adequate space and resources is logically certain —unless fertility is reduced—to impose a ceiling on rising consumption, then to lower the availability of food per consumer, and ultimately to cause a rise in death rates. These conclusions all follow from the mathematics of geometric increase. . . . At current growth rates, the population of the United States would outweigh the earth in 2500 years" (*1*, pp. 330–31).

The economic development of any particular society is envisaged as entailing changes both in its aggregative economic magnitudes and in its economic composition. Of these changes there are various indicators, not all of which move in wholly parallel paths. For the sake of convenience in exposition, however, use may be made primarily of a single indicator, per capita real income, since the movement of this indicator is highly correlated with the movement of other welfare-oriented indicators, and since changes in it provide a great deal of information respecting the extent to which a community of people has become better or worse off. It is assumed, therefore, that economic development is reflected in the movement of per capita income, and that the role played by population growth in economic development is ultimately expressible in terms of its incidence upon the movement of per capita income.

This article is composed of two main parts: in the first the underlying theory is set down and in the second the prospective incidence of population growth upon the movement of per capita income is examined for each of the main demographic regions of the world. Analysis is restricted to quantitative aspects of the subject under discussion; genetical and most euthenic issues are disregarded. In a final section some implications of the population question are touched upon.

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Economico-Demographic Theory

A complete economico-demographic theory would have to account adequately both for the response of aggregate income to population growth and for the response of population to income growth. In this article, however, major attention is devoted to the former response. The latter response is examined only in so far as it bears on one question: Does population growth respond to slight output changes in the same manner as it responds to large output changes? Relevant theory may therefore be expressed in terms of four principles: (i) changing age composition; (ii) changing factor complementarity; (iii) changing economic homosphere; and (iv) critical minimum economico-demographic stimulus. These principles are described below.

The per capita income in terms of which the course of economic development is plotted is a collection of goods and services, the enjoyment of many of which is contingent upon the availability of sufficient leisure. Increases in the size of this collection tend to be accompanied by increases in its variety and its quality, presumably because the eudemonic property of income depends upon variety as well as upon quantity. This fact is overlooked in much of the popular literature relating to population, in which it is suggested that so long as the food supply, irrespective of its composition, can be made to keep pace with numbers, there is no population problem. Unfortunately, man has taste buds and hence is not disposed to live on algae, or on a 21-cent daily mess of lard, beef liver, orange juice, and soybean meal, or on similar unpalatable minimum-cost diets (*2*). Nor is he content to live on mimimum-cost, nonfood allowances. It is not very relevant, therefore, to ask how many people a given country can support. It is more relevant to ask why population continues to increase in a country after population growth has ceased to confer a *net* advantage upon the country's inhabitants.

Changing Age Composition

Potential productivity per capita depends, *ceteris paribus,* upon the size of the fraction of a country's population that is in the labor force. The size of this fraction, though subject to the influence of socioeconomic conditions, depends upon the age composition of a country's population. Furthermore, though this fraction may be only some 5 to 10 percent higher in developed than in underdeveloped countries, the margin of productivity enjoyed by developed countries will be greater; for around 10 or more percent of the labor force of underdeveloped countries is made up of children under 15, whereas the labor force of advanced countries includes almost no children (*3*).

When a population is growing, its age composition is less favorable than when it is stationary, and when a population's natural rate of growth increases (or decreases), its age composition becomes less (or more) favorable, within limits. More generally, under *ceteris paribus* conditions, the proportion of the population of working age (say 15 to 59 or 20 to 64 years) increases greatly as the gross reproduction rate falls and declines somewhat as life expectancy at birth increases. Model stable populations serve to illustrate this tendency (see Table 1). Suppose we postulate a set of age-specific fertility rates which give us a gross reproduction rate of 3, or a crude birth rate of 43 to 46; then the percentage of the population falling within the age group 15 to 59 will range, in the associated stable populations, between 48.4, if life expectancy at birth is 70.2 years, and 52.5, if life expectancy is only 40 years. Should

this set of age-specific fertility rates be replaced by another set yielding a gross reproduction rate of 1.5 and a crude birth rate of 22 to 23, the percentage of persons aged 15 to 59 would rise one-sixth or more, to between 58 and 62. In short, if fertility declined from levels such as are found in much of Asia, Africa, and Latin America to those found in Europe, the fraction of the population of working age would be something like one-sixth higher under stable-population conditions. This amounts to an increase of one-sixth or more in potential productivity per capita. This theoretical finding is borne out, of course, in the real world; for example, 66.28 percent of the Swedish population but only 56.69 percent of the Brazilian population is aged 15 to 64 years.

High-fertility, underdeveloped countries would derive two advantages from the improvement in age composition that would result if fertility should decline until their populations had become approximately stationary. First, their potential per capita productivity would rise 10 to 15 or more percent; some of this potential productivity would assume the form of income and some the form of leisure. Second, the disposition of parents to put children to work and deny them education would be greatly reduced, and the capacity of the population to educate the children and so make them much more productive would be greatly augmented. Of this we have some evidence in the fact that in the slowly growing populations of developed European countries the ratio of children under, say, 15 to persons of an age (say 15 to 64) to be teachers is only about half as high as in the rapidly growing populations of underdeveloped countries.

Changing Factor Complementarity

Population growth would not affect productivity per capita adversely if output were entirely the product of labor and hence imputable solely to labor. Productivity partly depends, however, upon the number of complementary agents or factors of production (*4*) at the disposal of a population. This number governs the amount of equipment the average worker has to assist him in his occupational assignments. It also governs the rapidity with which technological advances can be given concrete form and the degree to which individuals can be trained and enabled to carry on that basic and applied research which underlies technological progress. Such progress is very important; it seems to have been responsible for some four-fifths of the increase in output per man-hour recently experienced in the United States (*5*). It is because population growth reduces when it does not altogether prevent increase in the number of productive factors available per capita that it tends to depress the rate at which output per capita increases. Population growth has this effect because it entails transformation of a given population, together with its replaceable and irreplaceable environment, into a successor population and environment, with the double result that increases in numbers are achieved at the expense of physical environment and that a portion of this physical environment is permanently dissipated (*6*).

These factors or agents of production are of two sorts: (i) those which are reproducible and augmentable and (ii) those which are nonaugmentable because their aggregate stock is either roughly fixed (for example, potential supply of water power) or depletable (for example, proved and potential oil reserves) and hence subject to the relentless march of economic entropy consequent upon their use (*7*). While the rate at which the stock of agents (i) is increased depends immediately upon the level of income and the average propensity of the community to save, it is affected, as may be the marginal productivity of this stock of capital, by the scarcity of agents (ii). For in so far as agents (ii) are in short supply, this shortage must be made up by agents (i), with the result that average income is somewhat lower than it otherwise would be.

Population growth slows down the rate at which the number of agents (i) available per capita can be increased. Inasmuch as a nation's stock of utilized wealth usually amounts to something like five times its national income (*8*), saving rates of 5 and 10 percent, respectively, are required to keep the wealth-population ratio constant when the population is growing 1 or 2 percent per year. Close association of this ratio and per capita income is prevented by various circumstances, however, among them variation in the composition of wealth, in the wealth-income ratio, in the extent to which increase in wealth is accompanied by technical progress, and in the manner in which wealth and income are measured (*9*). The wealth-income ratio does, however, provide a rough, internationally comparable index of the extent to which population growth absorbs output which might otherwise have been consumed or utilized to increase wealth or capital per head. It may be inferred that, even though the capital output ratio in industry or agriculture is sometimes as low as 3:1 or lower, savings of 8 to 10 or more percent are required in the longer run to offset the population growth rates of 2 or more percent found in many underdeveloped countries. For assets are normally accumulated not only to equip and house people but also for various other reasons which in the longer run bring the ratio of total physical assets to income up to 4 or 5 to 1.

Up to now the nonaugmentable factors have not seriously retarded the growth of output per head, because unused reserves remained, because substitutes were available, because technical progress has reduced the input of these factors per unit of output, and because the use of materials other than minerals and water has grown little more rapidly than population. Furthermore, technical improvements have increased the output of minerals per composite unit input of labor and capital. It is shortage of water and space that bids to restrict expansion here and there. In time, however, population growth, together with rising per capita consumption, will greatly increase the overall use of minerals and water and may even increase the marginal cost of produce, particularly if considerable amounts of cultivable land are diverted to nonagricultural purposes. Consumption of materials originating in nonaugmentable sources has been increasing markedly only since the late 19th century; this increase may not make itself felt in terms of rising costs for some decades, however, and even then the initial impact of such cost increases will be minor. Dearth of suitably situated space is likely to make itself felt, however (*10*).

Changing Homosphere

Man's earthly habitat, or homosphere, is a component of the comparatively invariant biosphere in which living matter flourishes (*11*). The capacity of this homosphere to sustain

human life at a given level is conditioned in some measure by the growth process as such, independently of the operation of the principle of changing complementarity touched upon in the preceding section. The effects of growth may be adverse or favorable. They are adverse when growth permanently dissipates a portion of the environment capable of subserving human life without at the same time replacing it with a suitable substitute.

Illustrative perhaps is erosion consequent upon population pressure, or the dissipation of potential utility associated with increase in economic entropy, noted above. Illustrative also would be the covering of much land by water should continuing population growth so step up man's production of carbon dioxide that the oceans failed to absorb all of it, with the result that the carbon-dioxide content, and hence the temperature, of the atmosphere rose sufficiently to melt the polar icecaps.

Illustrative of the favorable effects are reductions in composite inputs per unit of output made possible, within limits, by economies consequent upon increase in the size of a population and in the apparatus of production. Of minor importance is the resulting fuller use of such indivisible agents as a railroad bed. Of major importance is the increase in organizational, and other, specialization made possible by population growth, together with the tendency of large economies to be more competitive and hence more inclined to make optimum use of factors than are small economies. Much of the restraint to which specialization and competition are subject is attributable, of course, not to smallness of population but to smallness of country or economy. This condition, usually inherited from the 18th century or from earlier centuries, when the optimum-size state was smaller than today, is now being partially rectified through the creation of metastates (*12*).

Population growth, when accompanied by corresponding growth in employment and income, may stimulate both the growth of firms which have not yet expanded to the greatest extent that seems economically desirable and the introduction of equipment and methods superior to those in use. For, so long as an economy is growing and expected to grow, stimulus is given to the disposition to plan and invest for the morrow and to suppose that enhanced output will find market outlets as satisfactory as those currently relied upon. Under these circumstances, also, it is relatively easy for labor and other factors, whether newly employed or situated in nonexpanding industries, to move into expanding industrial sectors. These various potential advantages of population growth, though realizable in a developed country, are not likely to be realized in a heavily populated, underdeveloped country where divers other preconditions for development are lacking. Their role in a developed country may be exaggerated, since in such a country, even if the population is stationary, death and retirement alone permit considerable and rapid readjustment of the labor force, while depreciation and obsolescence permit rapid modification of the composition of capital. Such flexibility is particularly marked when, as in advanced societies, governments are economically powerful enough to support aggregate demand at a level favorable to needed readjustment.

Table 1. Gross reproduction and percentage of population aged 15 to 59 in model stable populations (*23*).

Gross reproduction rate (%)	Life expectancy at birth (yr)					
	40		60.4		70.2	
	Percent aged 15–59	Birth rate (No./1000)	Percent aged 15–59	Birth rate (No./1000)	Percent aged 15–59	Birth rate (No./1000)
3.0	52.5	46.0	49.6	43.8	48.4	42.9
2.0	58.8	31.7	55.8	30.6	54.7	30.1
1.5	61.6	23.1	58.7	22.5	57.7	22.3
1.0	62.6	13.6	59.4	13.3	58.6	13.3

Critical Minimum Economico-Demographic Stimulus

Much of Asia, Africa, and Latin America—perhaps two-thirds of the world's population—is caught in a Malthusian trap, in "a quasi-stable equilibrium system" in which forces making for increase in income evoke counterbalancing income-depressing forces, among them a high rate of population growth.

Escape from this trap or system presupposes a stimulus, or set of continuing stimuli, sufficient to make the income-increasing and the population-growth-retarding effects dominant. This stimulus must operate both to increase income faster than population and to reduce the rate of population growth so that per capita income and expectations respecting the future course of per capita income rise sufficiently. What is called for is heavy investment over a sustained period of time—investment that is oriented not so much toward providing traditional support for a growing population as toward augmenting the stock of income-producing equipment, toward educating and urbanizing the population and rendering it productive and forward-looking, and toward replacing wants that foster population growth by different aspirations (*13*).

What alone is in dispute is the extent to which a people, even when its government is strong and well entrenched, can be induced to extend its time horizon, sacrifice today's simple material pleasures for tomorrow's uncertain returns, and substitute ideals of the sort found among advanced European peoples for those regnant in tradition-bound societies. Puerto Rico's experience demonstrates how very difficult it is to introduce effective family planning.

The significance of the above argument, subscribed to in part already by J. S. Mill, derives from the fact that population growth has been revolutionized in underdeveloped countries by the introduction of modern health measures that increase life expectancy. As a result, numbers increase, or soon will increase, two or three or more times as fast in these countries as they increased in Western Europe when that part of the world was undergoing modernization. The low rate of population growth characteristic of Western Europe (it was generally near or below 1 percent per year) permitted initially low rates of saving to set self-sustaining economic development in motion. Similarly, in Japan, the only non-European country to undergo substantial modernization in the late 19th century, the rate of natural increase long remained close to 1 percent, and savings were relatively high and were put to good use. Even so the agricultural population has remained at the Meiji-era level; moreover, despite considerable modernization and the early adoption of family-limitation

Table 2. Demographic and economic characteristics, by region, about 1950–55 (see *24*). The density and population estimates for A.D. 2000 are based on United Nations "medium" forecasts.

Region	Demographic and economic characteristics									
	Population (in millions)		Persons per km²		Birth rate (No./1000) in 1950	Per capita income (dollars) about 1955	Labor force (%)		Population (%)	
	In 1955	In 2000	In 1955	In 2000			In agriculture	In industry	Aged 15–59	In cities over 100,000
World	2690	6267	20	46	39	50–1864	59	18	56	13
Asia	1490	3870	55	143	46	50–487	73	10	55	8
Africa	216	517	7	17	47	50–284	75	11	54	5
South America	125	394	7	22	25–45	107–391	55	18	54	18
Central America and Caribbean	58	198	21	72	35–50	80–426	62	16	53	12
Rest of world	801	1288	14	23	20–26	150–1864	13–45	30–37	59–62	18–41

practices, Japan's birth rate did not fall sharply until after legal barriers to such limitation were relaxed, in and after 1949 (*14*). The demographic history of Japan suggests that, without strong governmental efforts to augment the rate of capital formation markedly and to stimulate effective control of fertility, underdeveloped countries, especially those which are already heavily populated and less productive of income than was early 19th-century England, are unlikely to escape their Malthusian trap, low incomes and excessive fertility.

Empirical Findings

Having noted ways in which population growth may affect the movement of per capita income and (if we may ignore Pope's dictum: "Fixed to no spot is happiness sincere") "welfare," we may turn to the current demographic situation, a conspectus of which is presented in Table 2. Prospective rates of growth for Asia (exclusive of Japan), Africa, Middle America, and South America (exclusive of its temperate-zone countries) are much higher than for other areas. In these four areas fertility is uncontrolled, natality is high, and the diffusion of effective family limitation practices is retarded by a predominance of rural conditions, often accompanied by a high degree of illiteracy, elimination of which is difficult. While age composition is unfavorable to productivity in all these rapidly growing regions and per capita incomes are generally much lower than in the remainder of the world (that is, in Europe, northern North America, the Soviet Union, Japan, and most of Oceania), where fertility is subject to quite effective control (though this is not always exercised), population density appears to be a powerful depressant of income only in the Far East (where about half the world's population lives) and in Middle America. The low level of income in most of Africa and much of South America is primarily attributable, as are low income levels to some extent in the Far East, to conditions associated with economic underdevelopment as such rather than with population density, a considerable amount of which is compatible with relatively high per capita incomes (for example, population density is approximately 200 individuals per square mile in the northeastern United States and exceeds 300 in much of Europe and 500 in Japan).

Lowness of income is almost invariably associated with a heavy concentration of the labor force in agriculture, a condition found in Asia and Africa and in much of Middle and South America. There results a heavy pressure of agricultural population on the land under cultivation, especially when arable land per head of agricultural population amounts to less than 1 acre, as in Asia, or to about 2, as in Middle America, instead of more than 3, as in Europe and much of Africa and Latin America, or about 20, as in North America (*15*, pp. 474–477). Hence, agricultural income is very low in Asia and is augmentable principally through the reduction of the agricultural population by half or more and the augmentation of the frequently low yields per acre and per man; for, as the data in Table 3 indicate, pasture land is scarce and there is little utilizable forest or potentially productive land to bring into use. In the Near East, to some degree in Middle America, and in South America and much of Africa, the amount of land under cultivation apparently is still significantly augmentable. In all these areas, moreover, as in much of the Far East, output per acre could be greatly increased, given scientific methods of cultivation and a sufficiency of plant nutrients and moisture (*15*, p. 531; *16*). There is little prospect, however, with current population trends, that the peoples of Asia, the Middle East, or Middle America can greatly reduce their excessive dependence on cereals and tubers (*15*, chap. 9).

While the easing of population pressure in agriculture depends in part upon greatly increased investment in agriculture, together with modernization of techniques, it depends largely upon the provision of relatively productive nonagricultural employment for both the excess agricultural population and additions to the labor force resulting from natural increase. Such provision requires not only considerable investment in suitable forms of education but also the formation of capital and the availability of the requisite mineral and other natural resources. Let us consider investment in education and capital formation first. In most underdeveloped countries investment in suitable facilities for education at the secondary and advanced levels is too low, and in many not even a full primary education is provided. In many, savings are barely adequate (if that) to offset population growth, probably averaging less than 10 percent of the national income in the whole of the semi- and nonindustrialized world (*17*). In Asia, with the exception of China, Israel, Japan, and possibly one or two small communities, the rate of capital formation is around 10 percent or less of income, and even in thrifty Japan gross fixed capital formation per capita is only one-ninth of that in the United States and one-third of that in Western Europe (*18*). In Latin America gross investment in fixed capital (some of foreign origin) has been in the neighborhood of 17 percent of the gross

national product, and net investment, around 11 percent of the net national product (*19*). In Africa capital formation has varied greatly, ranging from levels of below 10 percent of national income, through perhaps close to 10 percent in Egypt, to much higher rates in Rhodesia, the Union of South Africa, and other countries (*20*). Much higher rates of savings are required in most of the underdeveloped world, given current population growth, than are presently manifest.

While a number of underdeveloped countries are equipped with the natural resources requisite for economic development, in others the amounts of such resources are small or are offset by heavy population. China's iron-ore reserves (6.7 tons per capita), comparable to Mexico's, are greatly inferior to India's (54.2 tons per capita), which are superior to those of the United States; but India's coal reserves, roughly comparable in per capita terms to those of France, are greatly inferior to China's. Japan, with some coal, lacks iron ore as well as many other minerals. With the exception of these three countries and the partial exception of Korea, no Asian country is able to develop a considerable iron and steel industry and related industries; nor is a comparable industrial base now being provided by other minerals, or, in the long run, by petroleum (most heavily produced in the Near East). In South and Middle America, Brazil, Venezuela, and Cuba are well equipped with iron ore but are short of coal. Most of the coal and iron ore in Africa is in Southern Rhodesia and the Union of South Africa. In sum, a shortage of minerals in relation to population is likely to limit industrial development and the increase of per capita income in Asia, even in the absence of further population growth, and analogous limitation is likely eventually to become operative in much of Latin America and in parts of subsaharan Africa. Only a detailed inventory and study of available resources could disclose when and to what degree such limitation would become evident. Were such a study undertaken now and something like an optimum population determined for subsaharan Africa and South America, policy might be oriented toward reducing the actual and the potential rate of growth (*21*).

Implications

It was suggested above that if a population were stationary instead of growing 2 or 3 percent per year it would have at its disposal, for improving the state of the existing population, current productive power and income amounting, in per capita income terms, to something like 20 to 25 percent of national income under *ceteris paribus* conditions. The precise magnitude of this figure depends upon the economic significance of differences in age composition and upon the relevant wealth-population ratio. It affords a rough measure of the current cost of a 2 to 3 percent yearly rate of population growth. The magnitude of this cost, together with the disadvantages, from the standpoint of education, of an unfavorable age composition, suggests that countries like Brazil which require larger populations for the optimum exploitation of their resources can progress more rapidly if they reduce their annual rates of population growth from the present 2 or 3 percent to, say, 1 percent.

The adverse effects of population growth in heavily populated underdeveloped countries have been well summarized by Coale and Hoover in their study of India. Assuming two postulates, that expectation of life at birth would rise from 32 years in 1951 to 52 years in 1986 and that fertility might either remain unchanged or decline 50 percent by 1986, the decline beginning in 1956 or not until 1966, they examined the economic implications of the population changes that would take place. They found that, if fertility began to decline at once, to be halved by 1986, income per consumer by the 1980's would be rising nearly four times as fast as would have been the case had fertility not declined at all. Moreover, the population, though still increasing 0.9 percent per year, would be approaching a stationary state, whereas, if fertility had not declined, the population would be increasing 2.6 percent per year and escape from the Malthusian trap would be even more difficult than it had been 30 years earlier (*1*, pp. 38, 273, 280). Analogous results were yielded by a similar inquiry in Mexico, where population has been growing faster than in India and where per capita income is two or three times that in India. Given a 50-percent decline in fertility, income per consumer would, as in India, be about 41 percent higher at the end of 30 years than it would have been in the absence of any decline in fertility (*1*, pp. 280, 305–306). Reduction in fertility, in short, makes possible higher and much more rapidly growing average incomes.

Because of the geometrical character of population growth and the fact that numbers rarely decline, the problem now confronting India or Mexico may eventually confront Europe or the United States or any other region where population is not yet so dense as it is in Europe, or where it is growing less rapidly than in, say, Latin America. It is sometimes supposed that maintenance (as in the United States) of two- to four-child families—that is, of a three-child-family average—would constitute a sufficient degree of control. Yet, under the conditions that exist in the United States, maintenance of a level

Table 3. Amount of land, per capita and by use, 1955 (*25*).

Region	Agricultural area				Forest land (millions of hectares)	Unused but potentially productive land (millions of hectares)
	Arable land and land under tree crops		Permanent meadows and pastures			
	Total (millions of hectares)	Per capita (hectares)	Total (millions of hectares)	Per capita (hectares)		
U.S.S.R.	220	1.10	267	1.33	743	161
Europe	150	0.37	85	0.21	136	8
Northern North America*	228	1.26	278	1.54	668	79
Rest of North America†	27	0.47	78	1.34	71	17
South America	69	0.56	313	2.52	887	53
Oceania	24	1.71	376	24.00	87	6
Far East	355	0.25	271	0.19	475	60
Near East	78	0.56	295	2.11	145	116
Africa	219	1.29	502	2.95	652	76

* "Northern North America" includes Alaska, Canada, and the U.S.; † "Rest of North America" includes the balance of North and Central America.

of three children per family would result in an increase of population of about 1.3 percent per year, and this rate could easily be raised to 1.5 percent, approximately the rate at which the American population has been growing since 1950 (*22*). With an annual rate of increase of 1.5 percent, a population doubles every 47 years. In a mere 200 years, therefore, at this rate of increase the population of the United States would rise from a current 179 million to about 3.5 billion, or nearly 1200 persons per square mile, a density roughly double that presently found in Massachusetts and New Jersey.

In most of the world, persisting population growth constitutes the most serious of the long-run threats to the continuing improvement of man's material lot. Because of the existence of limitational factors, if only that of suitably situated space, there is a limit to the extent to which populations can grow, in any country or in the world as a whole. It is sometimes argued that fertility will never endanger man's standard of life, since men, having acquired a standard, are unwilling to surrender it, whether to population growth or to other income depressants. This argument overlooks a more fundamental ethical and eudemonic issue posed by population growth, however. It ignores the fact that resources currently used to support the costs of population growth might otherwise serve to augment welfare per capita. It fails to ask to what degree maximum welfare per capita would be more nearly realized if those preferring population growth, whether in the United States or elsewhere, were required to support more of its costs than at present. It neglects the fact that in much of the world living standards already are desperately low and will prove hard to raise even if the stork's wings are clipped.

References and Notes

1. A. J. Coale and E. M. Hoover, *Population Growth and Economic Development in Low-Income Countries* (Princeton Univ. Press, Princeton, N.J., 1958).
2. See *Time* **74**, 84 (7 Dec. 1959). The mess described, reportedly the cheapest capable of supplying man with his minimum daily requirement of nutrients, was rejected even by the laboratory dog. Linear programming and related methods have indicated, however, ways in which the housewife can provide an adequate and reasonably palatable diet at minimum cost. See R. Dorfman, P. A. Samuelson, R. M. Solow, *Linear Programming and Economic Analysis* (McGraw-Hill, New York, 1958), p. 9 ff.
3. *The World's Working Population* (International Labour Office, Geneva, Switzerland, 1956); J. D. Durand, "Population Structure as a Factor in Manpower and Dependency Problems of Under-Developed Countries," *Population Bull. of the United Nations No. 3* (Oct. 1953), pp. 1–16.
4. P. A. Samuelson has urged that the expression "factor of production" be avoided entirely. I have, however, retained it, in part because the discussion does not call for a precise, empirical, quantitative definition of the term. See *Foundations of Economic Analysis* (Harvard Univ. Press, Cambridge, Mass., 1947), pp. 84–85.
5. For example, see R. M. Solow, *Rev. Economics and Statistics* **39**, 320 (1957), where seven-eighths of the increase in gross output per man-hour in 1909–49 is attributed to "technical change."
6. I have ignored the waste in resources resulting from high child mortality, since it does not, at worst, much exceed 2 percent of national income. See T. K. Ruprecht, "The cost of child mortality in developed and underdeveloped countries," *Proc. Conf. Western Economic Assoc. 33rd Conf.* (1958), pp. 21–25.
7. See J. J. Spengler, *Southern Econ. J.* **14**, 238 (1948); *Kyklos* **7**, 227 (1954).
8. See S. Kuznets, *Econ. Develop. and Cultural Change* **7**, No. 3, pt. 2, app. B (1959).
9. See ———, *ibid.* **7**, No. 3, pt. 2, 63, 65, 68 (1959).
10. For data on resources, see President's Materials Policy Commission, *Resources for Freedom* (Government Printing Office, Washington, D.C., 1952); *Univ. Maryland Studies in Business and Economics 12, No. 1* (June 1958); E. A. Ackerman, *Water Resources in the United States* (Resources for the Future, Washington, D.C., 1958).
11. See W. I. Vernadsky, *Am. Scientist* **33**, 1 (1945). Living matter, some complementary and some antagonistic to man, constitutes an insignificant (about 0.0025 percent) and essentially unchanging fraction of the biosphere.
12. For example, see S. Kuznets, "Economic growth of small nations," in A. Bonne, Ed., *The Challenge of Development* (Hebrew Univ., Jerusalem, 1958); F. Gehrels and B. F. Johnston, *J. Polit. Econ.* **63**, 275 (1955).
13. The argument set forth in this paragraph has been admirably developed by H. Leibenstein in *Economic Backwardness and Economic Growth* (Wiley, New York, 1957). See also R. R. Nelson, *Am. Econ. Rev.* **46**, 894 (1956) and J. J. Spengler, *Econ. Develop. and Cultural Change* **4**, 321 (1956). For a critique of the above argument, → H. S. Ellis, *Quart. J. Econ.* **72**, 485 (1958).
14. See I. B. Taeuber, *The Population of Japan* (Princeton Univ. Press, Princeton, N.J., 1958). Compare R. Hill *et al.*, *The Family and Population Control: A Puerto Rican Experiment in Social Change* (Univ. of North Carolina Press, Chapel Hill, 1959).
15. See W. S. Woytinsky and E. S. Woytinsky, *World Population and Production* (Twentieth Century Fund, New York, 1953).
16. In Europe and America, yields per acre are more than double those reported for Africa and are higher by a fifth or more than those reported for Asia; see W. S. Woytinsky and E. S. Woytinsky, *World Population and Production*, p. 531, and also yield figures for most crops reported periodically in *U.S. Dept. Agr. Foreign Crops and Markets*. Output per capita of agricultural population is only about one-fourth as high in Asia as in Europe; it is only about half as high in Africa as in Asia.
17. The Netherlands Economic Institute estimates at about 5 and 7 percent, respectively, the over-all domestic rates of saving in non-industrialized and semi-industrialized countries [cited in *Bull. from the European Community No. 37* (Aug.–Sept. 1959), p. 2]. These rates seem to be too low.
18. *Economic Survey of Asia and the Far East, 1958* (United Nations, Bangkok, Thailand, 1959), pp. 91–93, and *Econ. Bull. for Asia and the Far East* **9**, No. 3, 19, 25 (1958). That gross investment has formed 22 to 23 percent of the gross national product in mainland China and only 13 to 14 percent in India is indicated by W. Malenbaum's estimates in *Am. Econ. Rev.* **49**, 285 (1959). Investment in China is more efficient also [*ibid.* **49**, 299 (1959)]. In 1955, 986 million of Asia's population of 1490 million were in China and India.
19. For example, see *Economic Survey of Latin America, 1956* (United Nations, New York, 1957), pp. 6–7, and *Analyses and Projections of Economic Development* (United Nations, New York, 1955), p. 11. In 1956 about 9 percent of gross investment in Latin America was of foreign origin.
20. See F. Harbison and I. A. Ibrahim, *Human Resources for Egyptian Enterprise* (McGraw-Hill, New York, 1958), p. 33; *Structure and Growth of Selected African Economies* (United Nations, New York, 1958), pp. 32–34, 121–122, 149.
21. On resources in Asia see *Econ. Bull. for Asia and the Far East* **9**, 38 (1958); also the following UN surveys. *World Iron Ore Resources and Their Utilization* (1950); *Survey of World Iron Ore Resources* (1955); *Nonferrous Metals in Under-developed Countries* (1955); *New Sources of Energy and Economic Development* (1957); *La Energia En America Latina* (1957). See also W. S. Woytinsky and E. S. Woytinsky, *World Population and Production*, chaps. 21-25, and E. A. Ackerman, *Japan's Natural Resources and Their Relations to Japan's Economic Future* (Univ. of Chicago Press, Chicago, 1953).
22. See R. Freedman, P. K. Whelpton, A. A. Campbell, *Family Planning, Sterility and Population Growth* (McGraw-Hill, New York, 1959), pp. 372, 376–385.
23. Data given in Table 1 are based on *The Aging of Populations and its Economic and Social Implications* (United Nations, New York, 1956), Table 16, p. 27.
24. This conspectus is based upon the following publications: *The Future Growth of World Population* (United Nations, New York, 1958); *The World's Working Population* (International Labour Office, Geneva, Switzerland), p. 503; K. Davis and H. Hertz, "The world distribution of urbanization," reprinted in J. J. Spengler and O. D. Duncan, *Demographic Analysis: Selected Readings* (Free Press, Glencoe, Ill., 1956), pp. 325–326; *Demographic Yearbook, 1956* (United Nations, New York, 1956), chap. 1; P. Studenski, *The Income of Nations* (New York Univ. Press, New York, 1958), pp. 228–233.
25. Data given in Table 3 are from *Food and Agr. Organization UN Yearbook of Food and Agr. Statistics* (1957), vol. 10, pt. 1, pp. 3–9, 15. Estimates of the amount of cultivable land in the world range from 2.6 to around 5 billion acres. The FAO reported, for 1956, 1.37 billion hectares in land and tree crops; 2.466 billion in permanent meadow and pasture; 3.864 billion in forest; and about 0.6 billion unused but potentially productive. According to R. M. Salter, of the 1.3 billion acres that might still be developed, only 100 million in islands south of Asia lie near areas of population concentration on that continent; 300 million are in northern North America and Eurasia; and 900 million are in Africa and South America. The yield of these acres, Salter estimates, might double pre-1939 world food production.