POPULATION AND ECONOMIC GROWTH

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1. INTRODUCTION

MODERN economic growth, as revealed by the experience of the developed countries since the late eighteenth or early nineteenth century, reflects a continuing capacity to supply a growing population with an increased volume of commodities and services per capita. The increase in both population and per capita product is not the unique feature of recent growth: even in pre-modern times the population of several countries grew and enjoyed a rising per capita product. The distinctive features of modern economic growth are the extremely high rates of increase—at least five times as high for population and at least ten times as high for per capita product as in the observable past.[1] Both high rates of increase imply rapid shifts in the structure of production and patterns of life, suggested by the terms industrialization and urbanization. Underlying these high aggregate rates and rapid structural shifts is the extended application to problems of health and economic production of a vast and rapidly growing stock of tested knowledge and inventions. The knowledge, which relates not only to natural conditions of the universe in which we live but also to the characteristics of social groups, affects the values and beliefs of the societies that possess and apply it; and the inventions contribute to the advance not only of material technology but also of social institutions.

That modern economic growth meant a strikingly accelerated rise not only in product per capita but also in population does not imply that the latter was a necessary condition for the former. To be sure, until the 1930's there was a broad positive association: population grew more rapidly in the developed countries than in the underdeveloped rest of the world[2]; and in some

[1] The approximate orders of magnitudes can be suggested. For the area of European settlement (Europe, the Americas, and Oceania, the last omitted before 1750), which includes all the economically developed countries except Japan but also several less-developed units, population grew 9.5 per cent per decade between 1750 and 1960 and only 1.4 per cent per decade from the year 1000 to 1750. If we put the dividing line at 1850 (for comparison with per capita product), the recent and pre-modern rates of population growth for the area become 11.1 and 2.1 per cent per decade, respectively.

Professor Durand's estimates in this volume carry only the totals for world population back before 1750. The rate of growth in the latter was 0.8 per cent per decade from A.D. 1 to 1850 (using the "medium" estimate of 300 million for the earlier date); and 6.7 per cent per decade from 1850 to 1950 (the rates here and in footnote 2 are based on e^x derived from the initial and terminal values of the series, e denoting the base of natural logarithms and x the number of decades in the period). The relative range in the rates is wider than in the comparison above because the initial date is earlier here and the range reflects the lower rates of population growth between years 1 and 1000.

Long-term series on national product per capita for several developed countries suggest a decadal rate of increase ranging at the lower levels from about 15 to 20 per cent. Rough extrapolation of present levels by the geometric mean of the two, somewhat less than 17.5 per cent per decade, suggests that the per capita product at the beginning of modern economic growth was $200 or more in 1958 prices in almost all developed countries except Japan. If we set the date of initiation of modern economic growth about 1850 (which is too early for some countries and too late for others), and assign a minimum per capita product in 1958 prices of $50 to the year 1000, the implicit rate of increase in per capita product between 1000 and 1850 is about 1.6 per cent per decade. Clearly, this result could be modified by shifting the initial date of the period for which we measure pre-modern growth; and the longer the period, the lower the rate. Yet the economic history of Europe suggests a minimum in the late ninth or early tenth century, before recovery from the Dark Ages that preceded Medieval urbanization.

These calculations, based on standard sources, are derived from a convenient summary in my *Modern Economic Growth* (Yale University Press, 1966), tables 2.1, 2.2, and 2.5, pp. 35, 38, and 64–65.

[2] As Professor Durand suggests, it would be an oversimplification to attribute higher rates of population growth largely to economic growth. Yet the estimates he gives (with the 1930 figures interpolated and the 1960 figures extrapolated on the basis of the source cited in footnote 1) show that until 1930 population grew more rapidly in the area of European settlement, dominated by the more developed countries, than in the rest of the world

countries, particularly the European offshoots overseas, a substantial population increase seemed to be indispensable for the rapid growth in per capita product. But the association was quite loose: in some countries high rates of growth in per capita product were accompanied by high rates of population increase, and in others by low rates. Besides, historical association is a treacherous guide to invariant relations. Clearly, in this case the rise in the knowledge and technological power of human societies meant greater control over health and economic production problems and resulted in an accelerated growth of both population and per capita product. But today and in areas with conditions quite different from those that characterized the presently developed countries in their past, rapid population growth may be an obstacle to, rather than a condition of, an adequate rise in per capita product.

Indeed, the question that we wish to examine is that emphasized in the widespread discussion of the current population "explosion." To what extent does a high rate of population growth impede the growth of per capita product? This question is explored here in general terms; yet such general treatment is required if we are to avoid *ad hoc* empiricism and plausible but casual inferences from currently pressing problems that may, in fact, incorrectly identify the causes of observed low and stagnant levels of economic performance in many parts of the world.

2. THE LIMITS TO RISING PRODUCTIVITY—NATURAL RESOURCES

The central question may be put sharply by asking why, if it is man who was the architect of economic and social growth in the past and responsible for the vast contributions to knowledge and technological and social power, a larger number of human beings need result in a lower rate of increase in per capita product. More population means more creators and producers, both of goods along established production patterns and of new knowledge and inventions. Why shouldn't the larger numbers achieve what the smaller numbers accomplished in the modern past—raise total output to provide not only for the current population increase but also for a rapidly rising supply per capita?

The usual answers indicate limits to the productive power of a larger population, limits that either did not operate or were less restrictive with smaller numbers, and that prevent the attainment of the high rate of increase in per capita product that would otherwise be possible. We examine these limits briefly, distinguishing between those related to scarcity of natural, non-reproducible resources—to be discussed here—and those represented by greater requirements of capital investment for the sustained or increased productivity of the larger population and labor force—to be discussed in the next section.

The fixed supply of natural resources, especially land, which limits the productivity of a larger labor force and per capita supplies of a larger population, was the major theme of Malthus, particularly in the first edition of his *Essay on Population* in 1798. In subsequent editions, second and third thoughts shaded the stark confrontation of the geometric rate of growth of population endowed with "fixed passions" with the arithmetic rate at which the limited natural resources kept the increase in necessary subsistence. And the theme has persisted, with varying intensity, ever since—with the focus of scarcity shifting from land to other natural, non-reproducible resources such as depletable minerals, to water, and finally to space on our planet. Implied in the theme was the assumption that discovery and innovation, and their extended application, could not significantly remove or raise the limits—except at heavy material costs that would necessarily reduce or stop the rate of growth of per capita product or indeed bring it down to a point where the Malthusian positive checks would operate.

The one and three-quarters centuries since the publication of the first edition of Malthus' *Essay* have seen the assumption of the inability of human knowledge and technology to cope with the constraints imposed by the scarcity of natural re-

(the rates below are percentages per decade based upon the "medium" estimates).

	1750–1850	1850–1930	1930–1960
Latin America included in area of European settlement			
1. A. E. S.	6.3	10.1	10.3
2. Rest of world	4.1	4.2	13.7
Latin America included in rest of world			
3. A. E. S.	6.0	9.6	7.7
4. Rest of world	4.3	4.8	14.3

For comparison of developed with underdeveloped parts of the world, lines 3 and 4 are more relevant than lines 1 and 2. The higher rate of population growth in the developed parts of the world for the period before 1930 and the striking reversal thereafter are clearly indicated.

sources proven wrong—despite a rate of population growth that by the mid-twentieth century was more than double that of Malthus' time. And the same fate befell several other long-term prognoses made by the Classical and Marxian schools of economics from a model in which the keystones were scarcity of land and diminishing returns as an historical tendency: the iron law of wages, the falling rate of profit and increasing exploitation, the "immiseration" and proletarianization of the masses, the increasing violence of economic crises. Furthermore, for the developed part of the world, which accounted for a rising share of world population, the disparity between the reality of rapid growth of population and per capita product and the vision of the Malthusian threat has become progressively wider.

But the important question relates to the present situation, to the limits that scarce natural resources impose upon current and prospective rises in productivity, given current and prospective population numbers. Rather than attempt to answer this question myself, let me quote two summary statements by Professor Joseph J. Spengler, who recently reviewed the field.

The first statement was made in a Presidential Address to the American Economic Association in December, 1965, and describes the present thinking of economists as follows:

> Perhaps the greatest reversal of opinion in the period 1930–65 is that relating to the role played by land and other natural resources in economic development and the disenthralling of populations from Malthusian traps. The importance of this role has been played down for a variety of reasons. First, investment in scientific discovery, applied technology, and education has been found to account for a major fraction of the increase in output in advanced countries, although recently the need to complement this type of investment with physical capital has again begun to be emphasized. Second, input of the services of land and natural resources per unit of GNP has greatly decreased in advanced countries. . . . Third, discovery and technological change, together with substitution at producer and consumer levels, have greatly augmented both the visible and the immediately potential stock of fuel, mineral, and related sources of natural-resource services. Man, it is supposed, is confronted by chains of natural-resource substitutes which modern molecular engineering and alchemy can subvert to his purposes, replacing links that weaken and elevating inferior sources (e.g., taconite rock) as well as substituting less expensive for more expensive sources of particular natural-resource service needs. For example, energy should prove producible in large amounts through fission assisted by breeder reactors, and in almost unlimited amounts should fusion prove technologically and economically feasible.[3]

Professor Spengler qualifies this consensus of economists as overly influenced by the favorable experience of advanced countries and insufficiently cognizant of the difficulties of underdeveloped countries and of the depressing effects of population growth on the amenities of life. However, in a summary paper on population and natural resources for the United Nations World Population Conference in the fall of 1965, he suggests that, given skills, capital, and effective use of technology, scarcity of natural resources does not impose serious constraints on population growth, present and presumably in the discernible future. The following quotations support this conclusion.[4]

On agricultural production: "Because it is becoming increasingly difficult to increase arable land, especially in the more densely populated regions, emphasis will be placed almost exclusively upon increasing yields per acre, though some acreage may be shifted to the production of output with a high protein yield per acre (e.g., cereal instead of meat) . . ." (p. 29); and "Food production in most underdeveloped countries could eventually be trebled or quadrupled, given good fertilization, together with improved seed, cultivation, and control of pests and diseases" (p. 30).

On mineral and other depletable resources: "Supplies of many non-fuel minerals will be depleted within a century or two, and it will become increasingly necessary to resort to substitutes or to synthetic production. Fossil fuel reserves may be used up in two centuries or less though the use of fuel cells could extend this period. Improvement in fission procedures and enlargement of sources of fission materials could meet energy needs for several millennia, while the development of feasible, economic ways for using fusion materials would virtually remove limits imposed by shortage of energy. Given adequate supplies of energy, exploitation of sources of heavy-volume minerals, or of substitute materials, which abound in the surface of the earth (iron, aluminum, crushed rock, etc.) would be economically feasible and the costs of desalinization and transportation of sea water would be reduced" (p. 31).

As Professor Spengler indicates, judgments like

[3] See "The Economist and the Population Question," *American Economic Review* **56**, 1 (1966): p. 9.

[4] See "Population and Natural Resources," mimeographed and listed as prepared on behalf of the United Nations, Background paper /B.10/6/E/447.

these are necessarily approximate and partly conjectural. Nor is it clear how such judgments, even if made by technical authorities, are best combined into a reliable consensus with firm quantitative results. But it seems warranted to assume that such a consensus, even if put in moderate terms and shorn of exuberant claims for technology, affirms the feasibility in the proximate future of substantial population growth without such pressure on scarce natural resources as would prevent a substantial rise in per capita product. And "warranted" means that the consensus carries far more weight in its appraisal of possibilities than dogmatic *obiter dicta* of the Malthusian type.

The content of the consensus should not be misinterpreted. The judgments tell us that it would be technologically feasible to triple or quadruple food production in most underdeveloped countries, presumably within a limited time horizon; in other words, that the capital and skill requirements are not beyond reach of these countries. And if we accept these judgments, doubling of the population of less-developed areas in the world between 1965 and 2000, indicated in the medium projection of the United Nations,[5] would still leave a substantial margin for a rise in food production per capita. But the statement does not mean that the technologically feasible will necessarily be realized, even though capital and skill requirements are not excessive. And, although population growth is feasible at the rate projected, we have no assurance that the rate of growth in food supply or total product per capita will be as high as it might be with a lower rate of population growth.

Even in this sense, and disregarding for the moment other conditions necessary for the realization of technological potentials (to be discussed below), the feasibility of continued population growth should not be accepted without examining several possible qualifications. First there is the question of the time horizon. The reference above to the next three to four decades was by design; and even that period may be too long. It is only for a limited span ahead that we can evaluate current but not yet fully applied discovery and invention and gauge their contribution to increased productivity (offsetting scarcity of resources); and also suggest plausible population growth rates. As the time span is extended, it becomes increasingly difficult to assess the cumulative interaction of additions to knowledge and technology, some of which are still to be made; far more difficult, in fact, than to extrapolate further into the future the geometric rates of increase in population. If, in facing the complexity of the long-term projection of technological capacity, we retain some obvious limits—e.g., the limits of our planet, refusing to consider the science-fiction possibilities of extra-planetary existence of mankind—then we must admit that at some future time population growth will have to slow down and eventually come to a standstill. This eventuality is sufficiently plausible (if we disregard atomic holocausts and other calamities), for all countries and the world at large, to warrant imaginative exploration of social devices for channeling individual passions and choices into demographically desirable patterns of population constancy in a world society for which a range of significant variants would have to be projected. But it qualifies our conclusions only by limiting the consensus on technological potentials to a restricted time span ahead. Extension of the span suggests tasks, in exploration either of long-range technological progress or of social adjustment to unchanging population numbers, that are beyond the scope of the discussion here.

The second possible qualification is that in some countries, particularly among the underdeveloped, the relative scarcity of natural resources may be so acute that the pressures of further population growth may be too costly to be borne even by advanced technology. For example, a high rate of increase in the number of Eskimos in the Arctic

[5] See United Nations, *World Population Prospects, as Assessed in 1963* (New York, 1966), table A3.2, p. 134.

In connection with its Freedom from Hunger Campaign, the Food and Agriculture Organization explored the problem in its Basic Study no. 10, *Possibilities of Increasing World Food Production* (Rome, 1963). The food requirements that constituted the target allowed not only for the population increase as projected to year 2000, but also for rises in per capita food consumption in the underdeveloped countries above their 1958 level—by 67 per cent in Asia and the Far East, 28 per cent in Africa, 17 per cent in the Near East, and 5 per cent in Latin America (see table 2, pp. 24–25). The conclusion of the exploration was that not only for the developed countries, but also for Latin America, Africa, and the Near East, meeting the food requirements was technologically feasible. Only for the Far East "the balance between future food needs and known potentialities for production may well prove to be delicate" (pp. 222–223). But even in the Far East a substantial increase, if not 67 per cent, in per capita food supplies was also presumably technologically feasible.

Like most evaluations of this kind, this one assumes that growth in food production will not be at the expense of adequate growth in per capita supplies of other economic goods (see pp. 7–8).

wilderness, or of nomads in the Sahara Desert, may prohibit a rise in per capita product that might be possible otherwise. And because many underdeveloped countries, particularly in Asia, are densely populated, relative scarcity of natural resources may seem to be the typical condition—suggesting that the Malthusian limit should be raised for developed countries only. But the scarcity of natural resources in the underdeveloped countries is primarily a function of underdevelopment; underdevelopment is not a function of scarce natural resources. Although the natural resources of Japan and Switzerland are limited compared with those of Indonesia, Nigeria, and the Congo, the former managed to attain high levels of economic performance and growth. Many underdeveloped countries are unaware of their wealth of natural resources since such knowledge is itself a function of economic development. These countries may possess more resources than they realize; practically all of them have sometime in their history enjoyed comparative advantage with respect to some commodity in world demand; and the population density of many of them is in itself evidence that the natural conditions are not drastically unfavorable—as they are in the Arctic or in the desert, where population is thinly spread out. Moreover, the expansion of the international trade network to the whole world has made each country less dependent upon its own specific range of natural resources. It seems legitimate to assume that the supply of natural resources relative to population in most underdeveloped countries is sufficient for technologically feasible advanced methods to provide a larger population with higher per capita product—an assumption that warrants the use of the term "underdeveloped," i.e., below the feasible potential, rather than "undevelopable."

The last possible qualification, a variant of the one just discussed, is formulated explicitly since it bears directly upon the limits represented by greater capital investment requirements associated with increased population. As already indicated, effective use of technology calls for material capital and a new range of skills, as well as the more important institutional adjustments that will be stressed below. As far as capital investment is concerned, whether in material capital or in skills, the conclusion of the discussion of the second qualification in the paragraph above may be taken to read that the removal of limitations of natural resources by the use of advanced technology will require relative inputs of investment into material capital or human skills no greater than those that have occurred in the presently developed countries in the course of their growth. In the course of the growth of the presently developed countries the increasing pressure of population on natural resources was also lifted to permit substantial rises in both population and per capita product, and their incremental capital-output ratios can be considered relevant to further growth—either in the developed or in the underdeveloped countries. Indeed, as will be suggested below, there may be grounds for arguing that in the underdeveloped countries, the late-comers on the scene of industrialization, the wider choice of available technological alternatives may permit, despite the apparent scarcity of resources under *traditional* technology, a lower capital input, i.e., a lower investment in capital (whether material or in skills) per unit of additional output deliverable by *modern* technology, lower than was needed in the earlier phases of growth of the presently developed countries.

3. LIMITS TO RISING PRODUCTIVITY—CAPITAL REQUIREMENTS

Larger population and labor force mean, in the first instance, additional workers who must be equipped with material capital if their productivity is not to fall below that of those already equipped and engaged. Hence, whatever our assumptions concerning desirable net rises in productivity per worker (and per capita), the higher the rate of increase in population and labor force, the greater the requirement for material capital to equip the additional workers. Thus, if in one case, population and labor force grow 1 per cent per year, while in another they grow 3 per cent per year, and the incremental capital-output ratio, i.e., the ratio of additions to material reproducible capital stock needed to produce an additional unit of output (say net domestic product), is 3.0, the proportion of product that has to be devoted to net capital formation or investment is 3×0.01, or 3 per cent in the first case, and 3×0.03, or 9 per cent in the second case—if the per worker and per capita product in the case of higher population growth is not to fall below the per capita product in the case of lower population growth. And unless the share of government consumption in total product is reduced, this means that current consumption by households would, with the higher share of capital formation, drop by 6 per cent of

total product (and a larger percentage of household consumption proper).

This is the rationale for lines 1–5 of the Illustrative Calculation 1, a demonstration of the effects of the rate of population growth on capital and other requirements, and hence on household consumption per unit. Case A assumes a population growth rate of 1 per cent and Case B, a rate of 3 per cent. Within A and B, A-1 and B-1 assume an annual growth in per capita product of 2 per cent whereas A-2 and B-2 assume only 0.1 per cent.

Greater material capital requirements, in terms of a higher share of total product to be devoted to net capital formation, is only one effect of a higher rate of population increase. The second is the consequence for the age structure *if* population growth is due exclusively to natural increase, i.e., balance of births over deaths, and not at all to immigration; and it is with the rate of natural

ILLUSTRATIVE CALCULATION 1

EFFECTS OF RISE IN RATE OF POPULATION GROWTH ON CAPITAL REQUIREMENTS AND PER CAPITA CONSUMPTION

	A-1 (1)	B-1 (2)	A-2 (3)	B-2 (4)
1. Assumed rate of growth of population, % per year	1.0	3.0	1.0	3.0
2. Assumed rate of growth of per capita product, % per year	2.0	2.0	0.1	0.1
3. Rate of growth of total net product, % per year (from lines 1 and 2)	3.02	5.06	1.101	3.103
4. Net capital investment required as % of net product (Incremental net capital–output ratio, ICOR, assumed to be 3.0)	9.06	15.18	3.303	9.309
5. Government consumption as % of net product (assumed)	10.0	10.0	10.0	10.0
6. Private consumer expenditures as % of net product (100 minus lines 4 and 5)	80.94	74.82	86.70	80.69
Age Structure of Population (based on UN selected data) *Total population = 100*				
7. 0–14 years old	26	40	26	40
8. 15–64 years old	64	56	64	56
9. 65 and over	10	4	10	4
10. Equivalent consumer units (lines 7 and 9 weighted by 0.6; line 8 by 1.0)	85.6	82.4	85.6	82.4
11. Private consumer expenditures, % of total net product percentile of equivalent consumer units (line 6 ÷ line 10)	0.946	0.908	1.013	0.979
12. Total net product (assuming output of 100 per worker, i.e., per member of line 8)	6,400	5,600	6,400	5,600
13. Consumption per equivalent unit (line 11 × line 12 ÷ 100)	60.54	50.85	64.83	54.82

The ICOR in line 4 (3.0) is the figure customarily used in economic analysis of capital-output ratios. The entries in lines 7–9 are the only other empirical coefficients and their derivation is indicated here.

In general, given a rate of natural increase of population and a set of age-sex-specific death rates, the birth rate and the age structure can be derived. For recent years, we have the age structure for a number of countries, with differing rates of population growth over an immediately preceding long period (of say 15 years); and that structure appears to be dominated, at least for the wide age brackets used here, by the population growth rate. This is shown in a recent study of the total dependency ratio (defined as the ratio of population under 20 and 65 and over to one between 19 and 65, a ratio dominated by the younger age brackets) by David R. Kamerschen, "The Total Dependency Ratio Approach to Overpopulation," *Social and Economic Studies* 13, 4 (1964) : pp. 488–501.

From the recent *Demographic Yearbooks* we derived both the shares of population under 15 in a recent year (usually 1960 or later) and the rate of population increase for the preceding 15 years for several countries not much affected by international migration. Several examples, covering the range of population growth from low to high, with the first figure indicating the rate of growth and the second the share of the group under 15 are: Costa Rica—3.88 and 47.6; Chile—2.25 and 39.8; the Netherlands—1.44 and 30.7; Sweden—0.80 and 22.0. The figures in our calculations are derived from this association, and are similar to those given in Jan L. Sadie, "Demographic Aspects of Labour Supply and Employment," prepared for the 1965 World Population Conference (No. A.5/19/E/484), where for industrialized countries, with a birth rate (BR) of 20 and life expectation at birth (E_o) of 70, the shares of the three successive age groups are 27, 63, and 10; whereas for the agricultural countries (BR—38; E_o—46) they are 39, 57, and 4 (see table 1, p. 4).

increase of a closed population that we are concerned here. The effect on the age structure of the population, under these conditions, of differences in the growth rates assumed (i.e., between 1 and 3 per cent per year) is shown in lines 7–9 of the exhibit, which we derived by relating the age distribution to population growth rates over the preceding 15 years, in countries for which international migration was negligible. A country with a high population growth rate had a higher proportion of population under 15 than a low growth country—40 per cent compared with 26; a somewhat lower proportion of population of working ages, i.e., 15 through 64—56 per cent compared with 64; and a much lower proportion of older population, 65 years old and older—4 per cent compared with 10.

This shift in age structure, associated with the rate of natural increase of the population, is a long-term result; and Cases A and B represent two patterns of population growth, each persisting long enough to reveal its eventual consequences. Three aspects of such a shift in age structure must be noted. First, the proportion of the population in the working ages is distinctly lower in the case with the higher rate of population growth. Hence, if total populations in the two cases are equal (which we assume to simplify the illustration), total output should be lower in Case B, with a higher rate of population growth and a lower proportion in the working ages, than in Case A, which has more workers. On the assumption that per worker product is the same in both cases, total product (and product per capita) is lower in Case B than in Case A in the proportion of the working age shares in population in the two cases.

Second, the higher growth rate, which makes for a higher share of population under 15 in Case B, also means a higher share of younger age groups *within* the total span of working ages. In other words, the labor force is more youthful in Case B than in Case A. The effect of this greater youthfulness on productivity cannot be measured without further specification of the productive processes involved and of the precise age structure of the labor force. Thus, greater emphasis on mobility, on recent education, etc., would favor the more youthful labor force; greater emphasis on experience, acquirable only with practice and age, would favor the older labor force. But I do not feel competent to deal with this question; nor is the answer likely to have major quantitative effects under the simple conditions of the illustration. This aspect of the shift in age structure associated with a higher rate of population growth is therefore neglected.

Third, the greater proportion of population in ages under 15 in Case B means a greater burden of dependency, but this is partly offset by the lower consumer requirements per head of the young. The reduction to equivalent consumer units would therefore be proportionately greater in Case B than in Case A. Neglecting the complex question of consumer equivalence by age and sex, we assigned a weight of 0.6 to the dependent population, i.e., ages under 15 and over 65, and a weight of 1.0 to the population in the working ages.[6] We then calculated the total of equivalent consumer units in all cases, and arrived at the ultimate result—per consuming unit supply of total product which remains after the requirements for material capital and the changing proportions of working-age population have been satisfied.

We may now list, seriatim, the conclusions that the calculation suggests concerning the effects of higher population growth rates on capital and other requirements, and on consumption per equivalent consumer unit.

First, a 3 per cent rate of population growth, compared with a 1 per cent rate, raises capital requirements; and, all other conditions being equal, reduces per unit consumption. With government consumption set at 10 per cent of total product in

[6] These weights were derived from data in Ansley J. Coale and Edgar M. Hoover, *Population Growth and Economic Development in Low-Income Countries* (Princeton University Press, 1958). For India "the number of males over ten is multiplied by 1, the number of females over ten is multiplied by 0.9, and the number of children under ten by 0.5" (see footnote 1, p. 238). This calculation was based essentially upon scales of dietary requirements discussed in *ibid.*, pp. 88 ff.; and implies a weight for children under 10 of 0.5 divided by roughly 0.95 for people over 10, or 0.53 to 1.0.

We used these estimates since we had in mind an underdeveloped country; raised the fraction to 0.6, to allow for extension of age to 15 and for non-food consumption; and applied it also to ages of 65 and over, since per head consumption in these ages is also probably lower than for the working population. Assigning the full consuming weight to ages 65 and over would only strengthen the conclusion suggested by the illustrative calculation, *viz.* the limited reduction in consumption per consumer unit, under the conditions stated, necessitated by a higher rate of population growth.

Our calculation is similar to that in Chapter XVII of the Coale-Hoover volume but uses illustrative figures rather than realistic projections for a specific country.

all cases, and with an incremental net capital-output ratio of 3.0, the residual for consumption is reduced 7.56 per cent in Cases A-1 and B-1, with annual growth in per capita product of 2.0 per cent, and 6.93 per cent in Cases A-2 and B-2, with annual growth in per capita product of 0.1 per cent (line 6).

Second, the lower proportion of working-age population to total in Case B, resulting from the higher rate of natural increase in total population, means under the simple assumptions used here a corresponding reduction in total product and in total consumption. This amounts to a drop from 64 to 56, or 12.5 per cent—in both pairs of cases (line 8).

Third, the shift in age structure reduces the number of consumer equivalent units more when population growth is high than when it is low. In our illustration equivalent consumer units drop from 85.6 in Case A to 82.4 in Case B, or 3.74 per cent (line 10).

Fourth, the effect on consumption per equivalent consuming unit is the cumulative result of the two reductions in total product flowing to consumers referred to above, and the one rise represented by the smaller number of equivalent consumer units. Thus for the A-1, B-1 pair the difference in consumption per consuming unit is $100 - [(100 - 7.56) \times (100 - 12.5) \div (100 - 3.74)]$, which works out to a decline of 16.0 per cent, and is equal to the percentage drop from 60.54 to 50.85 (higher figure as base) in line 13, columns 1 and 2. For the second pair of cases (A-2 and B-2) the difference is $100 - [(100 - 6.93) \times (100 - 12.5) \div (100 - 3.74)]$, which works out to a decline of 15.4 per cent, and is equal to the fall from 64.83 to 54.84 (higher figure as base) in columns 3 and 4.

Fifth, the percentage reduction in per consuming unit supply of consumer goods, caused by a higher rate of population growth, is roughly the same whether the annual rate of increase in per capita product is 2.0 or 0.1 per cent—which means that results would be similar for a wide range of rates of growth of per capita product.

Finally, attempts to accommodate both a higher rate of population growth and a higher rate of increase in per capita product would not reduce per unit consumption much more. Thus if we compare Case A-2 (population growing at 1.0 per cent; per capita product at 0.1 per cent) with Case B-1 (population growing at 3.0 per cent; per capita product at 2.0 per cent), the difference in per consumer unit supply is between 64.83 and 50.85, or 21.6 per cent of the higher figure.

These calculations suggest that raising the rate of population growth from 1 to 3 per cent per year can presumably be accommodated by a reduction of about a seventh in consumption per unit; and that a few more percentage points taken from ultimate consumption would permit a much higher rate of growth of per capita product. Before we ask what such reduction in consumption would mean, and how revealing this kind of analysis is, let me note that the analysis follows the traditional lines of the economic discipline—even if in a crude form (using capital-output ratios and simple assumptions concerning labor inputs, rather than linear production functions, whose use, however, would not change the results significantly). The results could easily be modified within a limited range either by raising or lowering the fractions of consumption that would have to be foregone as a result of accelerated population growth. Consumption would be reduced more if *gross* capital-output ratios were used, provided that the rates of increase of *gross* product per capita are the same; or if some part of the government consumption fraction were assumed to be related either to capital investment required or to population, so that a higher rate of population growth would call for a larger fraction for government consumption (a point to which we shall return below). On the other hand, the net incremental capital-output ratio of 3.0 used here may be too high: in the early phases of growth distinctly lower ratios prevailed in several countries.[7] If we set it at 2.0, and apply the full

[7] The ratio (NDCF/NDP) for Japan from the late 1890's to World War I was 1.6; for Denmark, from 1870 to 1914—2.4; for Sweden from 1861 to 1911–20—2.6. See "Quantitative Aspects of the Economic Growth of Nations: VI. Long-Term Trends in Capital Formation Proportions," *Economic Development and Cultural Change* 9, 4, Part II (1961): table 5, pp. 17–18.

The choice between the gross and net capital-output ratios depends upon our judgment of the extent to which capital consumption charges represent an absolute reduction in the productive capacity of the fixed capital goods. Consumption charges that represent physical deterioration or greater maintenance costs, and thus a reduction in absolute productivity, ought to be subtracted and capital-output ratios net of these charges should be used in our analysis. Charges representing obsolescence due to changes in taste (e.g., in residential housing), almost inevitably associated with rising per capita income and a growing economy, should be similarly treated. But most of the consumption charges for durable capital goods in the hands of producers, at least in a modern economy, do not represent deterioration in absolute pro-

weight of 1.0 to the numbers in age groups of 65 and over, the entries in line 13 for consumption per equivalent unit would be, in the order of columns 1–4, 59.97, 53.25, 62.71, and 55.86. In this case a rise in population growth rates from 1 to 3 per cent per year can be accommodated by a decline in per unit consumption of about 11 per cent; and even with the additional shift from low to high growth rates in per capita product (i.e., cols. 2 and 3, consumption per unit would have to be reduced only 15 per cent.

If the orders of magnitude derived in the illustrative calculation are acceptable, and there is no reason to reject them outright, the puzzling results cast doubt upon the adequacy of the underlying analytical structure. That the results are puzzling need hardly be stressed. They suggest that with a growth in per capita product of 2.0 per cent per year a rise in the rate of population growth as large as that from 1 to 3 per cent per year can be met by a reduction in consumption of about 16 per cent—which means that the sacrifice of half of the long-term increase of 2 per cent in per unit consumption for about a decade and a half would bring the country to the high level of per capita product that it would have achieved with only one-third of the population growth rate—and thereafter the growth in per capita product would continue at 2.0 per cent. Likewise, with a given population growth rate, raising the rate of increase in per capita product from 0.1 to 2.0 per cent apparently reduces per unit consumption only about 7 per cent—which would be made up in about three years. One may ask why, if this is a realistic model of economic growth, so few countries have become developed, for surely the sacrifice of a small fraction of rapidly growing consumption would hardly tax the energies or social capacity of the least-developed economies and societies.

The analysis is clearly deficient because it assumes that material capital is the sole agent of increases in per capita product, and that the input of labor is proportional to numbers in the labor force. Since material capital formation is a small fraction of total output, major changes in the former mean minor changes in a large component of output like consumption, and these minor changes can consequently work seeming miracles in the way of producing economic growth. Since limitations of natural resources have also been translated into reproducible capital requirements, without materially raising their share in product (at least for purposes of present analysis, and reasonably so in view of the experience of the developed countries), the dominant role of material capital in the simple model served to remove all limitations to rising productivity and growing population. Consequently a wholly unrealistic picture of the possibilities, and of the problems associated with population and economic growth, is presented.

While the effort cannot lead to firm conclusions at the present stage of our knowledge, we must attempt to repair the omissions in the above analysis by re-examining the nature of capital and other requirements.

4. CAPITAL AND OTHER REQUIREMENTS RE-EXAMINED

The realization that material reproducible capital and labor input unadjusted for quality differentials explain little of the rise in total product and much less of the rise in productivity has led, within recent years, to an attempt to identify and quantify the other factors involved. One direction followed in economic research has been to specify more explicitly various qualities of labor and different aspects of the organization of input into production. This approach is exemplified by Edward F. Denison's study, in which the effects of education of the labor force, length of workday, sex of workers, economies of scale, spread of knowledge, etc. were estimated in an attempt to allocate *fully* the growth of product in the United States among the relevant factors.[8] The other

ductivity but rather technical obsolescence, i.e., loss in relative earning power due to technical progress that brings constantly new and more productive producer goods into being; so that even zero net capital formation represents a *rise* in productive capacity (about equal to the average rate of technical progress). In this case, gross rather than net capital-output ratios should be used in our analysis. (For further discussion of this problem, particularly in application to pre-modern times, see my *Capital Formation in Modern Economic Growth (and Some Implications for the Past)*, presented at the Third International Economic History Conference in August, 1965 (to be published in the proceedings in early 1967).

With gross capital-output ratios between 4 and 5.5, compared with net ratios between 2.4 and 3.3 (see the source in the first paragraph of this footnote), the relevant ratios might perhaps be closer to 4 than to 3 (used in the illustrative calculation), but the use of the 4.0 ratio would modify the results only slightly.

[8] See "The Sources of Economic Growth in the United States and the Alternatives Before Us," Committee on

direction emphasizes the extension of the concept of capital beyond material stocks, reproducible or not, to investment in human beings in the form of education—formal or training on the job—as a major growth-promoting factor omitted in the conventional analysis of economic growth. The effort to measure investment in education has been pioneered by Theodore W. Schultz, and followed by Gary Becker and Jacob Mincer among others.[9]

The element common to and prominent in both approaches is the emphasis on investment in knowledge and in the quality of human beings as an integral component of capital formation, i.e., the part of current product diverted from ultimate consumption for the purpose of contributing immediately, or with some time lag, to the increase in output and productivity. We consider this element first in connection with the analysis in the illustrative calculation above—if only to see whether extension of the capital concept effectively repairs the obvious omissions and inadequacies of that analysis.

Undoubtedly both government and household consumption, as defined and measured in current national accounting, contain numerous elements that should be viewed as capital formation rather than government overhead services or ultimate consumption. Such capital-like uses of product range from obvious cases like research and development services (now *not* included under capital formation unless embodied in material capital goods), education and training activities, and services contributing to health, whether curative or recreational, to the more doubtful items of supplies of various commodities over and above a minimum viewed as indispensable for existence, which may contribute to better quality and hence higher productivity of persons engaged in economic production.[10] Needless to say, problems arise in drawing the line between these capital-like components and the pure consumption items; and these will be briefly examined below. But any component of government or household consumption that we do identify as a capital item must be transferred to capital formation.

Such transfers, which clearly add to capital formation and capital stock, also affect the definition and scope of net and gross product; and these effects should be indicated. If some items of what is now classified as government consumption or private consumer expenditures are classified as capital, the current expenditures on these items represent capital formation—presumably gross. Hence, for net product, one would have to *subtract* the proportion of such expenditures that represents replacement of currently consumed capital (whether it is stock of education, of consumer durables, etc.) and *add* the net returns on the stock of items newly classified as capital. For gross product the procedure is less complicated: one would only have to add the net returns on the items newly classified as capital stock. Thus, if, for illustration, we assume that the result of the reclassification is a doubling of the gross capital formation proportion and of the net capital returns before reclassification, and if gross capital formation and net capital returns were each 20 per cent of GNP before reclassification, an original gross capital-output ratio of 5 to 1 becomes 10 to 1.2, or 8.5.

To demonstrate how the rise in the incremental capital-output ratio modifies the effects of a rise in the rate of growth of either population or per capita product on the supply of consumer goods per consumer unit, we prepared Illustrative Calcu-

Economic Development, *Supplementary Paper no. 13* (New York, 1962).

[9] See Theodore W. Schultz, "Capital Formation by Education," *Journal of Political Economy* **68**, 6 (1960); *The Economic Value of Education* (Columbia University Press, New York, 1963); and the collection of papers by Schultz, Becker, Mincer, and others under the title "Investment in Human Beings," which appeared as a supplement to *Journal of Political Economy* **70**, 5, Part 2 (1962).

[10] The activities in question are to be treated as capital whether performed by government and now included under government consumption, or by households and quasi-households and now included under private consumer expenditures.

Consumers' durable commodities—furniture, other house-furnishings and equipment, passenger cars, and the like—warrant specific mention, to avoid confusion. These could be considered capital goods, as residential housing is at present, and their purchases classified as capital investment rather than as consumer expenditures. But if this procedure were followed the household would be treated as a business unit producing consumer-good services, just as it is now treated as a business unit producing services of owner-occupied residences; and the definition of total product would be changed to include only the net income from consumers' durables, not the gross value of purchases.

In order to avoid complications, we retain the current concept of product and prefer the gross product and capital formation totals to the net (as indicated in the text discussion below). And since we retain the current concept of product, we do *not* classify all consumers' durable commodities, other than residential housing, as capital. Some of them will be so classified, in accordance with our text discussion, if they are seen as contributing to greater product, as product is now defined.

ILLUSTRATIVE CALCULATION 2

EFFECTS OF RISE IN RATE OF POPULATION GROWTH, OR OF GROWTH IN PER CAPITA PRODUCT ON PER UNIT CONSUMPTION, DIFFERENT VALUES OF CAPITAL–OUTPUT RATIO

Assumptions: (1) income per capita = 100; (2) government consumption (excl. all implicit capital) = 5% of total product

	Values of incremental C/O ratio				
	2.5 (1)	5.0 (2)	10.0 (3)	15.0 (4)	20.0 (5)
Consumption per equivalent consumer unit					
Growth of per capita product = 2.0%					
1. Population growth = 1% (Case A-1)	65.38	59.74	48.45–	37.16	25.87
2. Population growth = 3% (Case B-1)	55.97	47.37	30.17	12.98	−4.21
Growth of per capita product = 0.1%					
3. Population growth = 1% (Case A-2)	68.97	66.91	62.80	58.68	54.56
4. Population growth = 3% (Case B-2)	59.29	54.02	43.47	32.93	22.39
% reduction in consumption per consumer unit associated with rise in population rate of growth					
5. Growth in per capita product = 2% (lines 1 and 2)	14.4	20.7	37.7	65.1	116.3
6. Growth in per capita product = 0.1% (lines 3 and 4)	14.0	19.3	30.8	43.9	59.0
% reduction in consumption per consumer unit associated with rise in per capita product rate of growth					
7. Population growth = 1% (lines 1 and 3)	5.2	10.7	22.9	36.7	52.6
8. Population growth = 3% (lines 2 and 4)	5.6	12.3	30.6	60.6	118.8
% reduction in consumption per consumer unit associated with rise in population and in per capita product rates of growth					
9. Lines 2 and 3	18.8	29.2	52.0	77.9	107.7

lation 2. The ICOR ranges from 2.5 to 20.0; and, by design, we do not specify whether it is a net or gross capital-output ratio, a decision that depends largely upon whether it facilitates further analysis.

Of course, as the capital-output ratio rises, the reduction in the supply of consumer goods per consumer unit due to any rise in the growth rate of population (or of per capita product) becomes more marked. And this reduction is rapidly magnified as the capital-output ratio reaches the higher values. With the population growth tripling, and the ICOR doubling from 2.5 to 5.0, the reduction in per unit consumption increases from 14.0 or 14.4 per cent to about 20 per cent, i.e., by less than half (lines 5 and 6, cols. 1 and 2); with the next doubling, from 5.0 to 10.0, the reduction widens to 38 or 31 per cent, respectively, i.e., by more than a half (lines 5 and 6, col. 3); with the next doubling, from 10.0 to 20.0, the reduction widens to 116 or 59 per cent, i.e., tripling or doubling (lines 5 and 6, col. 4)—and indeed shows negative consumption in line 5. The point relevant to our analysis is that when the ICOR is high, say over 10, any acceleration of the growth rate of either population or of per capita product is severely limited; and, in fact, at those ICOR levels where consumption is reduced to negative values or to values close to 0, the rates of growth of product involved are impossible (e.g., a population growth rate of 3.0 per cent and a per capita product growth rate of 2.0 per cent for an ICOR of 20.0; see line 2, col. 5).

Three major problems are involved in identifying capital items, i.e., those contributing to the increase in output and productivity. First, an activity or product may serve both to increase output and to satisfy basic consumption or related needs. In commonly recognized capital goods, such as machinery, the element of consumption (e.g., vanity of the producer) is usually viewed as minor and is neglected. But in the case of education or health, the question as to how much is a consumption good and how much a production tool is complex. Second, there is the decision between gross and net, i.e., whether to try to establish the uses of product that contribute both to replacement of existing capital stock (however capital is defined) and to net additions, or only to the latter. As footnote 7 indicated, this decision is difficult even for the narrowly defined capital goods; and it becomes even more so when we deal with investment in knowledge and human beings. Third, there is the problem of the period elapsing between the time of the capital investment and the time at which it can be reasonably expected to

contribute to product and productivity. In our calculations we disregarded this lag, and it is relatively short for material capital; but it may be far longer for investments in knowledge like basic research, or education and training.

We propose to simplify the analysis by neglecting the time lag between capital investment and its effect on output and by dealing with gross capital formation. Empirical evidence on the lag is scanty; and it would complicate analysis unduly to try to take account of it. Furthermore, the major results sought here are not likely to be affected, however important this question may be in policy decisions concerning investment priorities. The choice of a gross capital and product basis is largely governed by the desire to keep the present product concept, and utilize the available empirical knowledge concerning its rate of growth. As already indicated, if we were to use net capital and net product, outlays for education, if education is classified as capital, would be gross; and we would have to estimate the current consumption of the stock of education to derive net capital formation, and subtract it from the present product total to obtain net product. The difference between gross and net product is slight when we limit capital to reproducible material stock, and capital consumption to current charges against this capital—so that at present the two product totals differ by 6 to 8 per cent, and their growth rates are similar. An allowance for current consumption of the capital stock of education, health, basic research, etc., might amount to a substantial fraction of gross product as now defined; and net product, after subtraction of such consumption, might be appreciably smaller than the present net product, and might move at rates appreciably different from those of gross product. In short, we propose to view the capital-output ratios in Illustrative Calculation 2 as gross ratios, with capital investment acting instantaneously, and then ask what the plausible orders of magnitude would be, given a reasonable interpretation of the scope of capital formation.

The answer to this question, uncertain as it will be, can be sought in an examination of the structure of government and household consumption, in both developed and underdeveloped countries. This might suggest the extent to which the capital-output ratio would be raised by the inclusion in capital of some items now classified as consumption. We could then ask whether the capital-output ratios, based on the experience of the developed countries, are fully relevant to the underdeveloped countries.

Summary data on the structure of government and household consumption in recent years in the developed countries show that of the 14 per cent share of government consumption in GNP, 6 percentage points may be allocated to direct services to consumers, in the way of educational, curative, recreational, and similar services—and should be added to private consumer expenditures to form total consumption.[11] Of the latter total, the components (expressed as percentages of GNP) are: food, beverages, and tobacco—24 per cent; clothing—8 per cent; household, including rent, water, light, fuel, domestic services, furniture and furnishings—16 per cent; and the remaining services—health and personal care, education, recreation, transportation and communication, etc. —23 per cent. The total is 71 per cent of GNP, with the residual accounted for by gross capital formation (21 per cent) and the remainder of government consumption, essentially intermediate services (8 per cent). In the case of the underdeveloped countries, consumption, including direct services of government, is roughly 78 per cent of GNP, with 14 per cent allocated to gross capital formation, and 8 per cent to government intermediate product. The structure of consumption is, however, distinctly different: food, beverages, and tobacco account for 42 per cent of GNP; clothing for 8; the household and its furnishings for 14; and the residual services—of education, health, transportation, etc.—for 14 per cent. Perhaps more important than the differences in structure is the much larger per capita consumption in the developed than in the underdeveloped countries, ranging, in a rather conventional translation to U. S. dollars, from 5 to 1 for food to 22 to 1 for recreation and amusement, or 16 to 1 for all the services. Granted that the inadequate conversion exaggerates the difference, the effective disparity in consumption per capita, absolute and relative, must be large for all categories.

[11] These and other data in the paragraph are from my "Quantitative Aspects of the Economic Growth of Nations: VII. The Share and Structure of Consumption," *Economic Development and Cultural Change* **10**, 2, Part II (1962): table 6, p. 12 and table 10, p. 24.

The discussion here deals only with use of current product, and disregards the "income foregone" component in the usual calculation of investment in education. In order to include the latter we would have to consider the changing relation of labor force to total population, a relation that we treat as constant in order to simplify the analysis.

How much of the much greater consumption in developed countries of all items, not merely those that contain large capital elements, facilitates and induces further growth of output and production? In attempting an answer, we could adopt one of two approaches. In one we would argue that a larger per capita consumption of *any* commodity or service, except those classed as pernicious and illegal (such as narcotics), may have an element of capital, i.e., output-increasing capacity, within a wide range of per capita volume; but that this capital-content of consumption changes markedly with changes in per capita use of the goods in question, as well as with the requirements of the productive structure of the economy. Thus an increase in daily calorie consumption per capita from 1,800 to 2,200 may have a marked positive effect on the productivity of the labor force, and in that sense additional food consumption is a capital item; but the effect would be less marked with a rise from 2,500 to 3,100 calories per day, and might prove negative with a rise to more than 3,500 calories. (The figures are illustrative, and no knowledge of nutrition is claimed.) At some early stage in an economy's development a greater input into education may fail to contribute to increased output because the productive structure, even though developing, is not advanced enough to accommodate the higher skills involved; whereas at a later stage of development the demand for the products of more education may be great, and the incremental capital-output ratio of this type of use may be quite high. This approach would emphasize not only the capital element in all uses now classified as ultimate consumption, but also the variability, in the course of growth and of changes in absolute levels of consumption and product, in the proportion of such capital elements in the various categories of what are now viewed as consumer goods. The second approach, a crude variant of the first, would, in application to developed countries, begin by assuming that the capital element in most consumer commodities and services is close to zero, given the high levels of per capita consumption and no significant decline in them; and would then identify and estimate the capital elements in a few important consumption categories, e.g., research, education, and possibly health care.

Unfortunately, we cannot assign any values, even orders of magnitude, to incremental capital-output ratios that include indispensable growth-promoting uses, other than material capital formation. Indeed, such estimates would require extensive study of aspects of economic growth still barely known—and for a wide range of phases of economic performance. As the preceding discussion indicates, we would also need to know the net yield to be imputed to the items newly classified as capital stock, since it would have obvious effects on the capital-output ratio. However, two conclusions pertinent to our problem of relating population to economic growth immediately follow.

First, at any level of economic growth and at any time, material capital stock is not the only use of product indispensable for an increase in output and productivity; some elements in consumption are capital items in that sense; and hence the effective incremental capital-output ratio is significantly greater than that in which material capital formation is the numerator. In other words, material capital stock effectively increases output and productivity only if it is supplemented by some uses of product now classified as consumption; and, even then, other conditions may be essential—a point to which we shall return below. But if we consider for the moment uses of economic product alone, when we calculate the effects of a higher rate of population growth, this higher effective incremental capital-output ratio means much larger reductions in consumer goods per unit (as a proportion of per capita product)—whether from an attained or from a potential high level.

Second, the identity of the capital elements within the conventional classification of consumption shifts with changes in per capita consumption and in the productive structure of the economy. At one phase and level of economic growth the growth-promoting capital element may lie in consumption of food or in health services above a minimum; at another phase, it may lie in research and higher education. Consequently, in considering the effects of higher population growth, these capital-like items in consumption must be identified; otherwise the attempt to reduce consumption might have the undesirable effect of stifling growth. Thus, as with material capital formation, choices must be made regarding the particular types of investment to favor for growth to be maximized, so that those consumption items that contribute to increase of output and productivity should hopefully rise and those that will be reduced, absolutely or relatively, should have the least restricting effect on further growth.

In view of these conclusions the conventional

capital-output experience of the developed countries is only a limited guide in the study of the effects of population increase on economic growth —in the developed countries and particularly in the underdeveloped. Not only material capital formation but also other uses of product must be examined to observe their relation to population increase and to growth in per capita product; and the higher relevant capital-output ratios have a numerator whose changing identity is important. Consequently the raising of the growth rate of total product intended to accommodate the combination of a higher rate of population increase and the same growth rate of per capita product involves more substantial and more selective reductions in the proportion of product flowing into "pure" consumption.

One other aspect of the relevance of even the expanded capital-output ratios to the analysis must be explicitly noted before we are ready to ask what all this means for the population growth problems of either underdeveloped or developed countries in the world today. The material capital-output ratios, for which we have a fair amount of long-term data for the developed countries and some for recent years for the underdeveloped countries, differ even among developed countries, and have changed over time (disregarding short-term fluctuations). For the developed countries the gross ratios ranged from less than 3 to more than 7, for the long period before World War I; and from more than 4 to more than 7 for the half-century since the beginning of the twentieth century (see the paper cited in footnote 7, table 5, p. 177). Nor is there any reason to expect these ICOR's to be the same for the different countries, or constant in the course of a country's economic growth. There is no *technological* basis for a fixed relation between additions to material capital and increase in output, except in the sense, hardly relevant to economic experience, that without some low minimum capital addition a sustained rise in output and productivity is impossible —in a given specific field. A railroad cannot operate without track and rolling stock; mechanical spindles and looms are essential to the efficient production of cotton textiles. But a track can be two streaks of rust in the desert, or heavily ballasted high-speed rails cutting through mountains; and rolling stock or textile machinery can be new and expensive or secondhand and cheap. And if one has a choice among means of transport (railroads or trucks) or textile materials (cotton or synthetic fabrics), even greater variability is introduced into the material capital-output ratio. Most important, a capital stock can be run 24 hours a day, with high intensity of utilization, or on an 8-hour day—with obvious effects on the average and incremental material capital-output ratios. Furthermore, conditions existing in economic and social institutions vary and may affect differently the long-term capital-output ratios of individual countries: in general, the material capital-output ratios tend to rise over time, perhaps because a greater supply of capital permits a less intensive rate of utilization and an increase in the proportion of long-lived capital, or because the opportunities for strategic use of the stock of innovations available in the early phases of growth to follower countries (and all but one developed country are followers) are reduced.

These statements concerning the narrower capital-output ratios probably apply also to the extended ratios, since decisions regarding the items of use now classified under consumption but with significant capital elements, are unlikely to eliminate differences among countries in the increases in total or per capita output that they attain with the same inputs of a given additional capital total, including both conventional and nonconventional components; or to cancel the significant trends over time observed in the material capital-output ratios. Differences in efficiency caused by differences in economic and social institutions would persist, as would those related to effects of low absolute levels of economic performance and degrees of backwardness; and the trends associated with economic growth and changes in the structure of both material capital and other uses of product would hardly be affected.

Given the variability even of the extended capital-output ratios, the values to be used in measuring the effects of a high rate of population growth, or of a desired higher rate of growth of per capita product—for a given country at a given time—cannot be determined mechanically. No matter how approximate the result will be, it necessitates the examination of all the conditions affecting the economic efficiency of a given country and of any other, apparently relevant countries over their relevant past. And obviously these conditions encompass economic and social factors, complementary to, but not identical with the determinants embodied even in the wider definition of capital, in its relation to output—factors that should not

be neglected, and yet are outside the conventional limits of the economics discipline.

5. BEARING UPON UNDERDEVELOPED COUNTRIES

The above discussion can be summarized briefly. First, economic analysis which uses the conventional definitions of material capital and of labor uncomplicated by quality differentials, is inadequate for the exploration of the relations between population increase and economic growth, and, in effect, leads to unwarrantedly easy and optimistic conclusions. Second, while these limitations have been recognized for some time, and attempts have been made to expand the concept of capital either by including non-conventional capital inputs or taking account directly of qualities of labor and of some aspects of economic organization, the empirical evidence is still scanty.[12] Moreover, the difficult problems in distinguishing between capital formation, defined broadly, and pure consumption, and between gross and net value of non-conventional capital inputs, are still to be resolved. Third, while this conclusion is tentative, pending further study of additional capital-like uses of product and of qualities of labor, even with the extension of the concepts in any economic analysis of the relations between input and output, effective treatment of the bearing of such relations upon the interaction between population increase and economic growth would probably still involve broader economic, social, and technical conditions, in the given country and elsewhere—conditions that cannot be classified and measured under economic inputs.

With such a prognosis, intellectual caution and modesty should compel one to stop right here—with this confession that economic analysis alone is inadequate in dealing with such a fundamental aspect of economic growth as its relation to population increase. One could, of course, list the economic arguments for and against population increase as an instrument in raising per capita product; or describe past conditions of the presently developed countries where a high rate of population growth seemed indispensable for the achievement of high rates of growth in per capita product (as evident in much of the nineteenth- and early twentieth-century economic growth of this country and other European offshoots overseas, and possibly also of France); or where, on the contrary, a lower rate of population growth might have meant a higher rate of growth in per capita product than was attained (as might have been the case in the Netherlands). However, the history of economic growth, past and current, suggests strongly the importance of non-economic factors not amenable to economic analysis—the broader social, political, and international decisions that set the conditions for the purely economic decisions and factors. Consequently, in dealing with the relation of population to economic growth, whether in underdeveloped or developed countries, we must note, in addition to the familiar economic factors, some of the broader aspects of social organization, national and international. Since these lie outside the discipline with which I am familiar, my judgments may be superficial; but they should, at least, suggest the important variables, other than the economic factors, since the latter, if not qualified, would be misleading, and if qualified, may prove to cover the least part of the problem.

In turning now to the underdeveloped countries, we find that the definition affects the size of the group, its economic characteristics, and its diversity. Thus, if per capita product is taken as the most relevant criterion (even if we omit such exceptional cases as the Arab sheikdoms, where high product may be due to an unusual endowment having little to do with the native economy) and the line is drawn at the low level of $100 GDP per capita, in 1958 the countries with per capita product below $100 accounted for 1,530 million of the world population of 2,887 million, somewhat over a half.[13] The non-Communist developed countries (North America, Europe, Australia and New Zealand, and Japan) had a population of about 550 million and a per capita product of about $1,400 in that year. And nine-tenths of the population of the underdeveloped countries live in Asia and account for most of the population of Asia, excluding Japan and Asiatic U.S.S.R.; most of the remainder live in Africa and account for some 60 per cent of the population of that con-

[12] Our discussion has been in terms of the concept of capital, but it could as well have been in terms of the quality of labor input.

[13] The data are largely from the United Nations, *Yearbook of National Accounts Statistics* for gross domestic product (at factor cost) and the *Demographic Yearbook* for population, both for recent years. A convenient summary is provided in my *Modern Economic Growth*, tables 7.1 and 7.2, pp. 360–364 and 368–369. In Chapter 7, I discuss the problems of converting per capita product to comparable units, for countries that differ greatly in level and structure of economic performance.

tinent (excluding South Africa and the regions assigned to the Middle East). If we raise the limit to $200, the population total for underdeveloped areas rises to 1,800 million, or about six-tenths of world population; and it covers almost all of Asia and Africa, about 60 per cent of the population of the Middle East, and about half of the population of Latin America.

It seems advisable to accept a dividing line of $200 per head or thereabout, in order to include the areas in which relatively low per capita income is associated, in recent years, with high rates of population growth. The underdeveloped group, in that case, includes the population of almost all of Asia, Africa, the Middle East, and most of Latin America (with the usual exclusions of Japan, South Africa, and Israel), but practically none of Europe, North America, or Oceania (where population outside Australia and New Zealand is quite small). The per capita product of this group, which accounts for almost two-thirds of world population, still shows a range from 1 to 3 (i.e., from less than $100 to more than $200); and the distribution is skewed in the sense that the bulk of the population, dominated by the populous countries of Asia, has a per capita product below $100.

Several economic characteristics of the underdeveloped countries bear closely on the question of population growth as a possible obstacle to a rise in per capita product. First, per capita product is low, relative to that of the developed countries; and at the lower end of the range it is apparently significantly lower than the per capita product of the presently developed countries (with the exception of Japan) on the eve of their industrialization (i.e., the late eighteenth to the mid-nineteenth century) which, as suggested in footnote 1, may have been about $200. Second, the present low per capita product of underdeveloped countries is *not* the result of a recent decline from some higher level in the past. On the contrary, the little available long-term evidence suggests that, at worst, their per capita income was constant (as appears to have been true of Egypt from the early nineteenth century until recently), but that it probably rose, appreciably in some countries in Latin America and Africa (e.g., Ghana) and significantly even in India, although the rates of growth were much lower than in the developed countries. Third, the low per capita product in the underdeveloped countries is not due to a lower ratio of labor force to total population, i.e., a higher dependency ratio of the type shown in our illustrative calculations. The orders of difference between the underdeveloped and the developed countries with respect to per capita product are far too great to be explained by the limited fractional disparities that emerge in the ratio of labor force to total population due to differences in rate of natural increase, and even to differences in social practices with respect to use of labor. Fourth, in both underdeveloped and developed countries, product per worker in the A sector (agriculture, forestry, and fisheries) is distinctly lower than product per worker in the I sector (broadly defined to include mining, manufacturing, construction, light and power, etc., and transport and communication); but the relative differences in product per worker between the A and I sectors are greater in the underdeveloped than in the developed countries. Hence, the backwardness of the underdeveloped countries, if measured by per worker product, is appreciably greater when we compare product per worker in the A sector than when we compare product per worker in the I sector—partly because more modern technology has been introduced into the industry sector of the underdeveloped countries than into their agriculture. Finally, since per worker and per capita product are low, the structure of domestic demand favors foods and other prime necessities, primarily products of the A sector; and these would have to be produced at home rather than imported, except in the few underdeveloped countries that may have some valuable natural resource exportable in quantities that are large relative to the population. But with a high proportion of domestic demand for products of the A sector and low per worker productivity in the A sector, the share of the A sector in the total product and especially in the total labor force will be much larger in the underdeveloped countries than in the developed. Indeed, the share of the A sector in labor force in the low-income, underdeveloped countries may be as high as 60 to 70 per cent, whereas it is less than 10 per cent in the developed countries; and yet some of the latter (e.g., the United States) have a surplus of agricultural production over and above wasteful standards of domestic consumption. Obviously, the economic backwardness of the underdeveloped countries is due partly to lower productivity per worker within both the A and the I sectors, and partly to the greater weight of the A sector, with product per worker in both sets of countries lower than the

countrywide average. It follows that in the course of growth per capita and per worker product rises partly because of growth in intra-sectoral productivity, and partly because of shifts in labor force (and other resources) from lower to higher productivity sectors. Such inter-sectoral shifts usually accompany and are indispensable for a sustained and significant rise in per capita product.

The low per capita and per worker output in the underdeveloped countries is due to the failure to apply modern technology, to exploit the productivity potential available in the stock of knowledge used by the developed countries. It is not due to scarcity of natural resources, climatic constraints, or deficiencies in genetic endowments, which would either bar the use of modern technology or result in a low product *despite* it. This proposition, which was advanced in part in our earlier discussion of natural resource limits, cannot be elaborated further here and must be accepted. It is fundamental to all our discussion: if it is rejected, the economic growth problems of underdeveloped countries cannot be solved with presently existing technology; and must await some major innovational developments in the uncertain future.

The proposition is fundamental also in that it points to the advantages of economic backwardness that the underdeveloped countries possess. If their low productivity is due to failure to exploit modern technology effectively, the accessibility of most modern knowledge and technical know-how means a large stock of tested technology, material and social, available for future exploitation. In other words, all other conditions being equal, the incremental capital-output ratios, however capital is defined, in the underdeveloped countries should be much lower than either the current or past ratios in the developed countries, as long as production goals in the underdeveloped areas are similar to those of the developed at similar phases or levels of growth. In an economically advanced country, a large proportion of the expansion in output is in new directions and reflects recent innovations rather than the old, tried and true; and the costs of innovations in the early phases of their development are reflected in greater input of material capital, new types of education and training, and wider experimentation with new organizational and social devices. This proportion of the relatively new and untried tends to raise the proportion of capital investment, defined broadly, to new output; and the effect on the capital-output ratio is the greater, the more advanced the country. An underdeveloped country, on the other hand, has at its disposal a variety of what for the developed countries is the old technology; and it should be able to attain the increased output that it desires with a relative input of material and other capital that is far smaller than was required in the developed countries in the past when the product or the technology in question was new, and smaller, too, than the capital requirements of the developed countries today, since, as already stated, the latter devote a large proportion of their resources to recent innovations.

The magnitude of this advantage of economic backwardness in relatively low capital-output ratios for the underdeveloped countries cannot be gauged. Given the marked rise in efficiency, i.e., the marked reduction of real inputs per unit of output, accomplished by modern technology in the developed countries since the early phases of the technological innovations, the required incremental capital-output ratios for the underdeveloped countries must be substantially lower, *if* they do not try to emulate developed countries in the pursuit of new and untried technological goals. To put it differently, the purely economic requirements for increasing output significantly—the relative requirements, even when capital is defined broadly to include investment in man—are comparatively moderate. Since the per capita product in underdeveloped countries has been growing in the past, even though slowly in most countries, they should be able to generate enough savings, diverting product to uses other than "pure" consumption, to permit high and sustained rates of growth of total and per capita product.

Yet neither in the long-term past, when population in the underdeveloped countries grew at distinctly lower rates than in the developed areas, nor in recent decades, has the growth rate of the underdeveloped countries exceeded that of the developed. If any underdeveloped country had attained a greater rate of growth of product, particularly on a per capita basis, and had sustained it over a fairly long period, it would have joined the ranks of the developed countries, as Japan did. The historical fact that since the mid-nineteenth century only a few countries were added to the small group of already developed (e.g., the United Kingdom, the United States, France, and Germany, to name the larger units), and only one of these was outside Europe and its offshoots overseas, suggests that the economic provisions for

exploiting the advantages of economic backwardness, while necessary, are far from sufficient. The social and organizational requirements for channeling economic activity to allow for some minimum efficiency must have been, and must still be, unsatisfied; and this lack was enough to offset the economic advantages of backwardness and keep the underdeveloped countries at an economic standstill or permit only a slight growth in per capita product, which meant a marked loss in position relative to the developed areas.

Three social concomitants of economic backwardness seem crucial in any consideration of the economic growth problems of underdeveloped countries, whatever the role assigned to population increase. First, the main economic activity of these countries, particularly in agriculture, has been following long-established patterns, only slightly modified by contact with the rest of the world and by the emergence of export-oriented sectors of a more modern type. This long persistence of old patterns of agricultural and related production typical of the large populations of Asia, most of Africa, and of the indigenous Indian populations in much of Latin America means an entrenched heritage of economic, political, and social institutions adapted to these patterns of economic activity; and the reduced potential for additional productivity caused by population growth means greater population pressure *within* the framework of old, traditional technology. Therefore the advantages of backwardness—reduced economic requirements for the application of modern technology—can be realized only if changes are introduced into the old institutional framework to accommodate the new technology—whether in land distribution and tenure, control over financing of agriculture, provisions for storage and marketing, or in the institutions governing the use of labor in and out of agriculture to provide productive employment to persons displaced with a rise in agricultural productivity.

Since the old technology has failed, the new techniques must be used and they require inputs not only of economic capital but also of social capital, if one may use the term to designate efforts and costs involved in modifying old established social institutions to provide the indispensable legal, political, and social conditions for the new technology.[14] Unless these changes are made, only a few of the more venturesome entrepreneurs, in agriculture or elsewhere, will attempt to apply modern technology because the risks are excessive; and others will direct their efforts into uses that are easier and safer but least productive in terms of socially desirable economic growth. The channeling of savings into hoards of gold and precious ornaments, into layering of property rights over agricultural land, and into high-rent urban real estate, are illustrations of the latter that easily come to mind.

Second, many of the presently underdeveloped countries with a vast majority of world population have, in the past century or longer, either been colonies governed by a distant metropolitan country; or, if sovereign states, have been handicapped by governments either too weak to withstand the aggressive pressures of more developed countries or insufficiently responsive to the country's growth needs in dealing with the interests and pressures of groups inimical to economic modernization. Consequently, the development of a viable political structure that would provide adequate auspices for modern economic growth has been slow. Evolution of a political consensus of the population, or of an effectively trained and committed bureaucracy, has been far too limited for modern economic growth, which requires a modern state able to resolve conflicts usually generated by growth and to provide the necessary economic and social overhead capital. Even in the presently industrialized countries the political requirements of economic growth were often taxing, and many conflicts that growth generated (between agricultural and non-agricultural population, between workers and proprietors, between creditors and debtors, among regions, etc.) could not be resolved by a peaceful consensus of representative central governmental institutions. The Civil War in the United States and the efforts, often laborious and painful, to adjust political sovereignty to underlying community of feeling—illustrated by the separation of Belgium from the Netherlands, and of Norway from Sweden, or by the unification of Germany and of Italy—are partial evidence that political viability sufficient to assure the proper decisions relating to a country's economic growth and to its conditions is not easily attained. The current political turmoil and frequent break-

[14] This need to shift the whole basis of technology and avoid the error of assuming that gradual adjustments within the traditional technology could provide an effective basis for economic growth, in agriculture and hence elsewhere, is the major point made by T. W. Schultz in *Transforming Traditional Agriculture* (New Haven and London, Yale University Press, 1964).

downs into internal conflicts in so much of the underdeveloped world may be exaggerated by us —since all such events are likely to over-impress the contemporaries. But the minimum political stability and efficiency needed for sustained economic growth seem to be lacking in most underdeveloped countries—from the most populous in Asia to those with apparently greater natural resources per capita in Africa and in Latin America. Political instability, governments too weak to provide the economic and social overhead, divisive tendencies within the population among races, tribes, regions, castes, etc.—are all conditions that sharply reduce the economic growth capacity of a country.

Third, the persisting patterns of economic activity and of the social and political institutions of a country are reflected in the general outlook and the scales of values of the population—if only in the sense that all these aspects of human life must be generally consistent. An institution like the caste presumably affects the views of the people involved on the relation of man to man; and the views on which the power of a government rests are different in a traditional land-empire like premodern China from those held in a modern developed country with a democratic constitution. A high rate of modern economic growth is compatible with some sets of values and views, and not with others. It is incompatible, in the long run, with significant downgrading of the material welfare of the population; with severe restrictions on the search for and application of new knowledge and technology; with limited freedom to match the capacity of the population, afforded adequate and equitable life and learning, with the productive tasks of society. It is hardly surprising that the general outlook and the scales of values of populations acquired through centuries of traditional organization in the presently underdeveloped areas differ significantly from those associated with and required for a high level of economic performance; and while some small groups in these countries have acquired modern views and have thus become "westernized," they are only a very small minority of the population. Hence, if we gauge economic growth, as we do and must, by the criteria of a modern economic society, and in estimating the national product of India, for example, do not assign any positive values to the psychic income presumably gained from unproductive cattle, or from preservation of monkeys and destructive pests, while deducting the values of the crops that they destroy, traditional views *must* reduce the economic growth potential, as such growth is currently defined and measured.

We can easily add to these social concomitants of economic backwardness, to accentuate the obstacles which they create. Thus, the recent achievement of political sovereignty by so many underdeveloped countries has brought with it not only the responsibility for internal growth, which in the long run is all to the good, but also the responsibility for national security, which involves problems aggravated by the partitions forced through when independence was attained, and by the artificial character of some of the political boundaries drawn. The resulting international frictions have certainly consumed a substantial volume of resources that would otherwise have been available for economic advance. In the present international situation, the danger of backwardness, as well as the increasing contact with the rest of the world, may have made claims upon the government and raised the expectation of significant groups within the population that inhibit the pursuit of an efficient, long-term economic policy, and the maintenance of internal and external peace. Moreover, the exploitation of modern technology requires a sustained conversion of domestic resources and institutions to new uses, and that is not easy. Even on the technical level, it is a matter not only of borrowing and copying but also of modifying and adjusting the prototype to fit the specific structure of domestic resources and needs.

To be sure, the social and political obstacles to economic growth in the underdeveloped countries can be exaggerated, particularly since we cannot estimate the growth that could have taken place if they had been removed. Almost all underdeveloped countries have enjoyed substantial growth in recent years. But in making a broad judgment concerning the major focus of the growth problems in underdeveloped countries—taken as a group and allowing for a range within them—the preceding discussion can be summarized as follows. The underdeveloped countries possess a large potential for economic growth: modern technology provides the needed devices and tools (subject to feasible modifications and innovations to be made by the technicians of the underdeveloped countries themselves); and their economic resources permit absolutely modest but relatively large diversions from current product into capital (broadly defined) that are adequate

for substantial growth, given low capital-output ratios as the typical advantage of economic backwardness. The core of the problem seems to lie in the inadequate internal social and political institutions, including some with a dominant economic content, which fail to provide the auspices for effective, sustained exploitation of the advantages of economic backwardness, and which are not easily modified. This difficulty is naturally compounded by international turbulence, partly arising from the recency of the achievement of sovereign status by such a large proportion of the currently underdeveloped areas.

This view bears directly on the question regarding population increase in the underdeveloped countries as an obstacle to a rise in per capita product. Obviously the high rates of population increase, and a rapid acceleration like that of the recent decade or two, resulting from continuing high or even slightly rising birth rates and sharply declining death rates, aggravate the already difficult problems of growth. Channeling more resources into capital formation, broadly defined, is an additional organizational task that would increase the burden of the already overtaxed machinery of the existing economic, political, and social institutions in underdeveloped areas. In particular, since the greatest pressure may be felt in agriculture, the traditional sector and the one most difficult to transform, additional constraints due to rapid population growth may not be easy to bear. And yet, if the preceding discussion correctly describes the balance of factors with respect to the *aggregate* supply of goods per capita, a higher rate of population increase, although an *additional* problem, would probably not be as great an obstacle as the failure to exploit the potential due to delays in adjusting social and political institutions. Given some favorable development within the latter, additional population could be accommodated, even if possibly at the cost of a smaller rise in per capita income than might otherwise occur. Given less favorable development, even if population growth slows down, misery will continue—even though it might be aggravated by population increase. Thus, one could hardly argue that in much of sub-Sahara Africa, Latin America, and even Asia, a reduction of population growth to say a tenth of a per cent from the current annual rate of 2 or more per cent would significantly alleviate the acute growth problems. Indeed, in view of the essential institutional and what might be called the "ideological" framework, the high fertility rates that cause the high rate of population increase may be less important for their direct effects—greater capital requirements, etc.—than as evidence of the population's lack of confidence in, or indifference to, the value of investment in its children by education and training. This lack of confidence or indifference is a reflection of the failure of the existing society to convince the population of the long-term wisdom of restricting the size of the family for the future benefit of its younger members.

The implications of this position for the evaluation of population policies should not be misunderstood. Unquestionably, strenuous efforts at reducing the birth rate in the underdeveloped countries are fully warranted, if they do not constitute a large drain upon economic and organizational resources that would otherwise be used advantageously to raise per capita product and indirectly induce a more rational long-term family planning process in a different and farther-going fashion. After all, even the partial reduction of additions to what is otherwise a heavy burden is all to the good. But other inferences may put policies aimed at direct population control within a better perspective and prevent placing undue hopes on their effects. First, even a reasonably successful population-control policy will not solve the major economic growth problems of the underdeveloped areas: these will remain with a lower rate of population growth or even with no increase in population (and they may be replaced by other problems if population actually declines rapidly). Second, the short-term effects of current reduction in birth rates are quite limited, short-term in this case meaning a period of one to two decades, which is fairly long when we consider strains of economic backwardness. Fewer births for a number of years mean only a reduction in the proportional numbers in the younger age groups, whose consumption per head is relatively low and whose effects on the distribution of product between consumption and capital formation are moderate.[15] Since the growth problems of the underdeveloped

[15] In the calculations in the Coale-Hoover volume, a 50 per cent reduction in the birth rate from 1956 to 1981 leads to a rise in per consumer income of less than 3 per cent in the first 10 years, i.e., to 1966; of less than 7 per cent in the first 15 years, i.e., to 1971; of less than 15 per cent in the first 20 years, i.e., by 1976 (see Projection 1, table 38, p. 272). A *minor* change in the capital-output ratios could either aggravate or more than offset these effects.

countries are far too acute to permit a delay of two to three decades for their resolution, control of population growth, important as it may be for the longer range future, offers little hope for the immediate present. Third, this implies that the choice between population control and no population control means only moderate differences in current per capita product, not a change from bare sustenance to surfeit. Fourth, a set of policies directed at the economic, political, and social institutions of the underdeveloped countries is required for the solution of their growth problems, i.e., to increase significantly their capacity to take advantage of their economic backwardness. But this set of policies, if successful, would also indirectly spread population control far enough to make it really effective in the long run. The changes in social and economic structure (and in the international situation) would provide reasonable assurance to future parents that their children will profit from fewer siblings, both in terms of survival and in terms of the effective return on their better education, training, and health. Without these changes, parents see no reason to limit the size of the family but may have many children in the expectation that some will survive and fight their way, on the basis of genetic and other non-investment endowments, to a fruitful life. Pursuit of a family-planning policy that limits the birth rate and envisages a trained and educated younger generation, most productive in terms of desirable goals of economic growth, would result in a sufficiently moderate rate of population growth, but it requires changes much the same as those required in traditional economic, political, and social institutions to optimize rapid rates of economic growth.

6. CONCLUDING COMMENTS

Our discussion, in the main, emphasized that purely technological and economic factors allow sufficient margins, in most underdeveloped countries, to permit substantial and sustained economic growth, even with a significant rise in population —at least for the proximate future of two to three decades. The difficulties and the problems lie in the limited capacity of the institutions of the underdeveloped countries—political, legal, cultural, and economic—to channel activity so as to exploit the advantages of economic backwardness, in the way of low incremental capital-output ratios, capital being broadly conceived to include economic inputs into education and other human investment.

This conclusion cannot be tested for lack of empirical data on social institutions and organization. However, some interesting statistical associations of growth rates, although of limited value, are revealed by the available statistics for the post-World War II years. The sample in the reference table is limited to non-Communist countries, is affected by the brevity of the period, and is distorted by continuing effects of postwar recovery. But it is the major body of evidence upon which we can draw easily; and the sixty-three countries cover a wide range of economic development and a wide variety of economic and social institutions.

Three relevant points are suggested by the data. First, the average rate of growth of total product for the entire sample is close to 5 per cent per year; and even if corrected for the inflation due to the inclusion of postwar reconstruction years, it would be well above not only the average but even the higher population growth rates. There is thus capacity for *product* growth at rates significantly higher than population growth; and the rate of increase in *per capita* product of most countries covered in the table is high, even in the recent periods of accelerated growth in population.

Second, for the sample as a whole, correlation between population growth and growth in per capita product is negative (line 19); and the association is statistically significant, although not at demanding levels (which call for an index at least three times its standard deviation). But this negative correlation is due to the difference between the developed and the underdeveloped countries (compare lines 1–18, particularly line 6 for the developed group as a whole, with lines 12 and 18 for Asia-Africa and for Latin America). The question then arises whether a high rate of growth in per capita product is a result or a function of a high level of economic development rather than of a low rate of population growth—in the sense that it is the high level of economic development that yields both the high rate of growth in per capita product and the low rate of population growth, and that the latter are independent of each other.

Third, this last suggestion is denied, at first glance, by the negative association between the rates of growth of population and of per capita product *within* the group of developed countries (line 20) which, if significant, would indicate that even in the developed countries higher rates of population growth impede growth in per capita

product. But the negative correlation is due entirely to the contrast between the overseas offshoots of Europe (listed in line 21) whose population grew more rapidly than that of Europe and Japan (partly because of immigration) but whose per capita product grew at lower rates unassociated with population movements. Exclusion of these four countries reduces the association for the developed countries to insignificant levels. Nor is the association significant for the Asia-Africa group (line 22), for Latin America (line 23), or for all forty underdeveloped countries on these three continents (line 24). The implication is that the rate of population growth among the underdeveloped countries has no uniform effect on growth in per capita product—a denial of the hypotheses discussed above that assumed that high rates of population growth would be particularly limiting on the growth of per capita product in the underdeveloped countries, with their lower reserves and increased pressure of population on economic resources.

The lack of significant association between population growth and growth of per capita product would only be confirmed if we were to widen our sample to include the Communist countries, or extend our review to the long-term trends in the developed countries back to the mid-nineteenth century (or earlier). Statistical associations do not help us to discriminate clearly among determining factors, but they should at least serve to

REFERENCE TABLE

ANNUAL RATES OF GROWTH OF POPULATION AND TOTAL AND PER CAPITA PRODUCT (GROSS DOMESTIC AT FACTOR COST OR MARKET PRICES), NON-COMMUNIST COUNTRIES, POST-WORLD WAR II PERIOD (Mostly from the early 1950's to 1964)

I. *Average Rates for Groups of Countries Arrayed in Increasing Order of Rates of Growth of Population* (%)

Groups	Population (1)	Per capita product (2)	Total product (3)
A. Developed Countries (Including Japan)			
1. 1–4	0.29	3.66	3.96
2. 5–8	0.65	3.60	4.28
3. 9–13	0.94	5.07	6.05
4. 14–17	1.46	3.49	5.00
5. 18–21	2.19	2.02	4.25
6. Average, 21 countries	1.10	3.64	4.77
B. Asia and Africa (Excluding Israel and South Africa)			
7. 1–4	1.81	2.17	4.02
8. 5–8	2.25	2.91	5.23
9. 9–13	2.76	1.28	4.07
10. 14–17	3.05	2.34	5.46
11. 18–21	3.43	2.67	6.19
12. Average, 21 countries	2.66	2.23	4.95
C. Latin America			
13. 1–4	1.56	2.51	4.12
14. 5–8	2.30	0.94	3.26
15. 9–12	2.84	3.24	6.17
16. 12–15	3.05	1.60	4.70
17. 16–19	3.40	2.66	6.15
18. Average, 19 countries	2.61	2.20	4.86

II. *Spearman Indexes of Rank Correlation Between Rates of Growth of Population and of Per Capita Product*

Groups	Number of countries (1)	Index of rank correlation (2)	Standard deviation (3)	Ratio, col. 2 to col. 3 (4)
19. All countries (incl. Israel and South Africa)	63	−0.309	0.1270	2.43
20. Developed countries	21	−0.434	0.2236	1.94
21. Developed countries excl. overseas (Canada, U.S.A., Australia, New Zealand)	17	0.061	0.2500	0.24
22. Asia and Africa (excl. Israel and South Africa)	21	0.079	0.2236	0.35
23. Latin America	19	0.246	0.2357	1.04
24. All underdeveloped (lines 22 and 23)	40	0.111	0.1601	0.69

The underlying data are from United Nations, *Yearbook of National Accounts Statistics, 1965* (New York, 1966), tables 4A and 4B, pp. 467–473. The rates for total gross domestic product and product per capita, shown for two periods before and after 1960, were combined with due allowance for the difference in duration. The population growth rates were calculated from these.

The averages in lines 1–18 are unweighted arithmetic means of the growth rates for the countries in the group.

The developed countries are largely in Western Europe (including Greece) and the overseas countries listed in line 21. Asia and Africa include the major populous countries, although Indonesia, Nigeria, and Egypt are omitted for lack of data. The coverage of Latin America is fairly complete.

The formulas for the Spearman index and the standard deviation (for an n of about 20 or more) can be found in Maurice G. Kendall, *Rank Correlation Methods* (2nd ed., London, Charles Griffin & Co. Ltd., 1955), paragraphs 1.14, pp. 8–9, and 4.13 and 4.14, pp. 58–59 (equation 4.7).

exclude claims to primacy for single factors whose effects do not prove dominant in the empirical data.

Two sets of qualifications apply to our discussion of the effects of population increase on economic growth; and these must be explicitly stated in order to place the analysis in proper perspective. The first set stems from the fact that we confined our view of economic growth to one index—aggregate output per capita. We limited our review to the effects on this index alone of the technological, economic, and social constraints on the proper response of an economy to higher rates of population growth. Obviously there are other important and desirable aspects of economic growth. Adequate employment opportunities, minimum equity and stability in the distribution of the product, and, above all, an optimal combination of individual freedom and social responsibility are goals that we would wish economic growth to attain, or at least not contravene. Even if we grant that a high rate of population growth is technologically and economically feasible, conditions are such in many underdeveloped countries that the attempt to divert even the moderate proportion of consumption into the capital formation required by a higher rate of population increase might involve tighter, centralized political controls that would sharply limit individual freedom and adjustment and adversely affect the long-run evolution of a society and economy responsive to the changing needs of its members. Even if growth in per capita product were not impeded by a higher rate of population increase, the latter might create other serious problems of adjustment, e.g., in providing employment for an increasing number of entrants into the labor force, over and above that automatically provided by the increased capital formation assumed to sustain per capita output and its growth. In short, with the several minimum goals that acceptable economic growth should satisfy, a high rate of population increase, while not necessarily having a major and direct effect on the increase in per capita product, may obstruct adequate employment, income equity, individual freedom, and other desiderata in the economic modernization of societies.

The second set of qualifications stems from the fact that we limited the analysis to the *aggregative* aspects of population increase and economic growth, and did not consider the *differential* aspects, i.e., the differences in the rate of population increase among various economic groups within a country. Even if group differentials in the rate of increase in numbers were not *systematically* related to economic and social status a higher rate of population increase, proportionately the same for all economic and social groups, would be far more serious, and adjustment far more difficult, for the poorer than for the richer groups. Even a moderate proportionate reduction in consumption, required in adjusting to a higher rate of population increase, would be far more difficult for the lower income groups; and if the incomes of both the poor and the rich were reduced (or their gains withheld) by the same fraction, the welfare burdens of income inequality would become heavier.

But population growth and income differentials are *systematically* and *negatively* associated. In many societies and over long periods, fertility and the rate of natural increase have been greater for the poorer and lower social status groups than for the richer and higher social status groups. The evidence is abundant for the developed countries. Birth and fertility rates have differed and still differ, substantially, among various groups within the population of developed countries—among groups distinguished by economic position, occupational status, type of residence (e.g., rural versus urban), and a variety of other social characteristics, including the biological (race) to which social distinctions have been attached.[16] The major problems generated by population increase in the developed countries stemmed from the persistent and far from accidental circumstance that the higher birth and fertility rates characterized those groups whose economic position (and often social status) was lower—the rural rather than the urban; within the urban population, the poorer rather than the richer; the manual workers with little schooling rather than the white-collar workers with professional education; among the races discriminated against, such as non-whites in this country, rather than among the dominant ones. Since these higher birth rates were offset only partly by slightly higher death rates, the rates of natural increase among the economically and socially less favored also tended to be much higher

[16] For a summary discussion see Gwendolyn Z. Johnson, "Differential Fertility in European Countries," and Clyde V. Kiser, "Differential Fertility in the United States," in Ansley J. Coale, ed., *Demographic and Economic Change in Developed Countries* (Universities—National Bureau of Economic Research Committee, Princeton University Press, 1960).

than those of the economically and socially more favored.

The evidence for underdeveloped countries, although scantier, also points to greater fertility, and implicitly to higher rates of natural increase, among the rural, and hence lower-income, groups than among the urban, and hence higher-income, groups. Sample studies show a distinctly negative correlation between fertility and income for families classified by size of income.[17] Since the fertility differentials are too large to be offset by plausible mortality differentials, we may reasonably assume a higher rate of natural increase for the lower income and social status groups than for the higher groups within the underdeveloped countries also.

This negative correlation between birth rates and rates of natural increase, on the one hand, and economic status and per capita economic performance, on the other, raises problems with respect to the economic advance of the poor and generally less favored groups within any society—not only in keeping economic and social inequality from widening because of the greater growth in numbers among the poor and in trying to reduce that inequality as a concomitant of economic advance, but also in providing a sufficient upward economic flow of potential human talent from the surplus at the low economic levels. In the course of growth, the presently developed countries have met these problems by a variety of institutional changes, ranging from provision of free education and other social services to a revolution in the system of matching people to economic jobs to permit relatively free mobility. But even in the developed countries the problems may be accentuated when a rise in the over-all rate of population growth means a greater differential between the lower and upper economic and social groups, and acceleration in the growth of the former; or when technological changes, requiring more education and investment in human capital, may impede upward economic and social mobility that in the long run is indispensable to the efficiency of the economic society—if it is to function as a unified and coherent unit rather than as a shaky coalition of two or more "subnations" in continuous conflict with each other.

The problems created by a greater rate of population increase among the lower than among the higher income groups are far more acute in the underdeveloped countries—with their lower over-all per capita income and smaller economic reserves. If a high rate of population increase would bring about an even wider income inequality than now exists in the underdeveloped countries, the consequences in the way of misery, failure of unity, and loss of political viability might indeed be dire. For an adequate analysis of these problems our discussion of the relations between higher rates of population increase, capital requirements, dependency ratios, and the like, would have to be extended to cover significantly different economic and social groups *within* the underdeveloped countries, and coupled with the assumption that the higher rate of population increase means particularly high rates for lower income and social groups. The new parameters might show that large groups within these societies could not make the assumed adjustment to a high rate of population increase. And what seemed feasible in aggregative terms might cease to be feasible when the analysis distinguishes the lower economic groups—unless we further assume that drastic changes are made in the social and political structure to prevent what might otherwise be a breakdown resulting from wider economic inequality.

Both the effects of population increase on aspects of economic growth other than aggregate income per capita and the differential impact of population growth on distinct economic groups within a country obviously merit further analysis. Such analysis is essential if we are to approximate the *weights* of the effects of the type only hinted at in the few preceding paragraphs. But at this juncture, we can only note these aspects of the relation between population increase and economic growth as qualifications, with weights to be determined by further exploration, of the narrower analysis articulated more fully in this paper. The latter, by design, concentrated on the aggregative aspects and on per capita product—an approach generally followed in the current, neo-Malthusian, literature which seemed to require a critical examination.

[17] For a summary of rural-urban fertility differentials for a range of countries, from industrial to agricultural, see United Nations, *Demographic Yearbook, 1952* (New York, 1953), table F, p. 17, and the discussion on pp. 16–17. Recent evidence on fertility, including economic and social differentials in underdeveloped countries, is given in George W. Roberts, "Fertility," a background paper prepared on behalf of the United Nations, for the 1965 World Population Conference (mimeo.).