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ABSTRACT

This paper compares population growth and affluence in developed nations in which per capita income and consumption have been relatively high, and in developing nations in which per capita income and consumption have been relatively low. The paper is one in a series of occasional publications intended to increase understanding of the interrelationships between population growth and socioeconomic and cultural patterns throughout the world, and to communicate this understanding to scholars and policy makers. In this publication, the author uses the consumption of energy and steel between 1950 and 1970 as primary indicators because of the obvious implications of the growth of such parameters upon the environment and the world resource base. Graphs and tables are provided. (Author/RM)

Caltech Population Program Occasional Papers

Caltech Population Program

The Caltech Population Program was founded in 1970 to study the factors influencing population growth and movement. Its goal is to increase our understanding of the interrelationships between population growth and socioeconomic and cultural patterns throughout the world, and to communicate this understanding to scholars and policy makers.

This series of Occasional Papers, which is published at irregular intervals and distributed to interested scholars, is intended as one link in the process of communicating the research results more broadly. The Papers deal primarily with problems of population growth, including perceptions and policies influencing it, and the interaction of population change with other variables such as resources, food supply, environment, urbanization, employment, economic development, and shifting social and cultural values.

The views expressed in this monograph are those of the author, and do not necessarily represent those of CIT or the Caltech Population Program, its directors, or staff.

POPULATION GROWTH AND AFFLUENCE:

THE FISSIONING OF HUMAN SOCIETY

Harrison Brown*

From the time when industrialization based upon steampower became firmly rooted in human culture there have existed "rich" nations, in which per capita income and consumption have been relatively high, and "poor" nations, in which per capita income and consumption have been relatively low. For the most part, levels of per capita income and consumption in the poorest countries have been characteristic of those in traditional peasant-village societies. For the greater part of the history of modern industrial civilization the distribution of income and consumption among the world's people appears to have been a continuum with most persons being very poor, a few being very rich, and the rest, numbering more than the rich but fewer than the poor, being somewhere in between. Since World War II, however, a striking pattern has evolved amounting to no less than a fissioning of human society into two quite separate and distinct cultures-- the culture of the rich and the culture of the poor, with very few people living in between these two extremes.

The evolution of this pattern is dramatically illustrated by the changing patterns of per capita energy consumption and per capita steel consumption between 1950 and 1970. Figure 1 shows the numbers of people living at various levels of energy consumption in 1950, 1960 and 1970. The data are drawn from the *Statistical Yearbook*[1] and the *Demographic Yearbook*[2] of the United Nations. The *Statistical Yearbook* gives the energy consumption of those countries (where figures are available) expressed in kilograms of coal equivalent per capita.[3] The levels of energy consumption are shown on a logarithmic scale, in which each step increases by a factor of two.

Figure 1 shows a general spread of levels of per capita energy consumption in 1950, the emergence of a bimodal distribution by 1960 and the evolution of a very clear bimodal distribution by 1970. No reasonably authoritative data are available for the People's Republic of China prior to 1970.[4]

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*I am indebted to Ms. Elizabeth Krieg for her help in collecting the data presented in this paper.

A condensed version of this paper appeared in the *Quarterly Journal of Economics*, Volume 89, May 1975, pp. 236-246.

FIGURE 1. PER CAPITA ENERGY CONSUMPTION

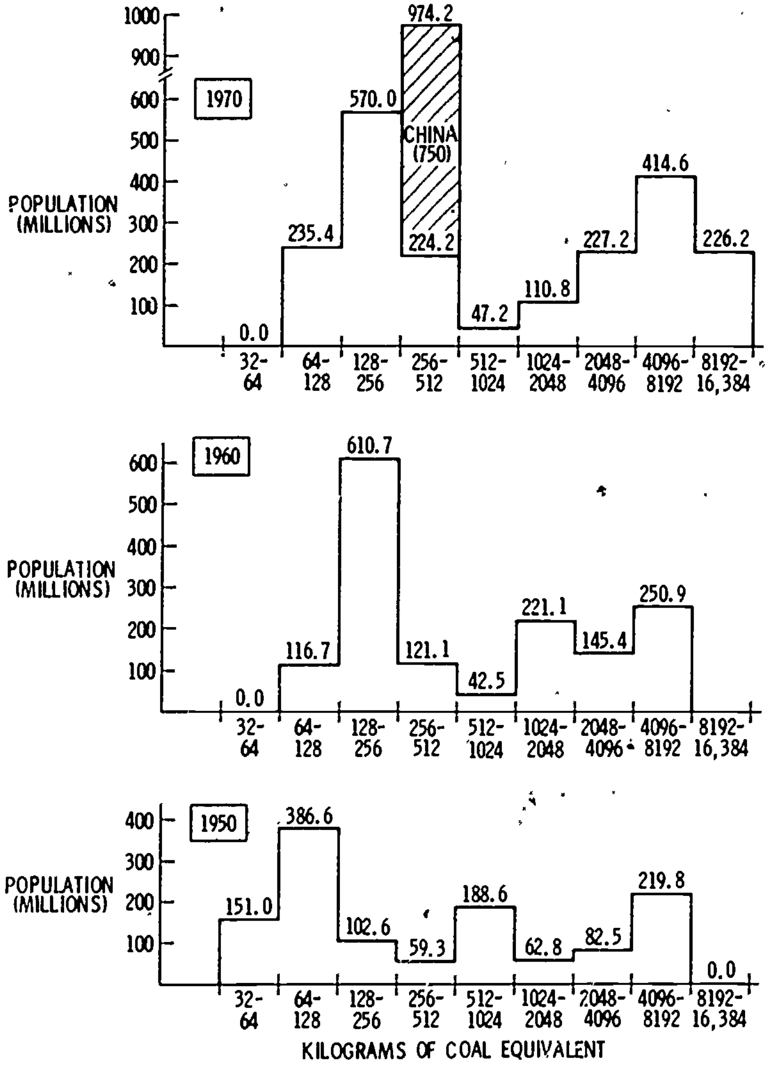


Figure 2 shows the numbers of people living at various levels of steel consumption in 1950, 1960 and 1970. These data also are drawn from United Nations statistics.[5] As in the case of energy consumption, figure 2 shows a general spread of levels of per capita steel consumption in 1950 and the emergence of a bimodal distribution in 1960.

FIGURE 2. PER CAPITA STEEL CONSUMPTION

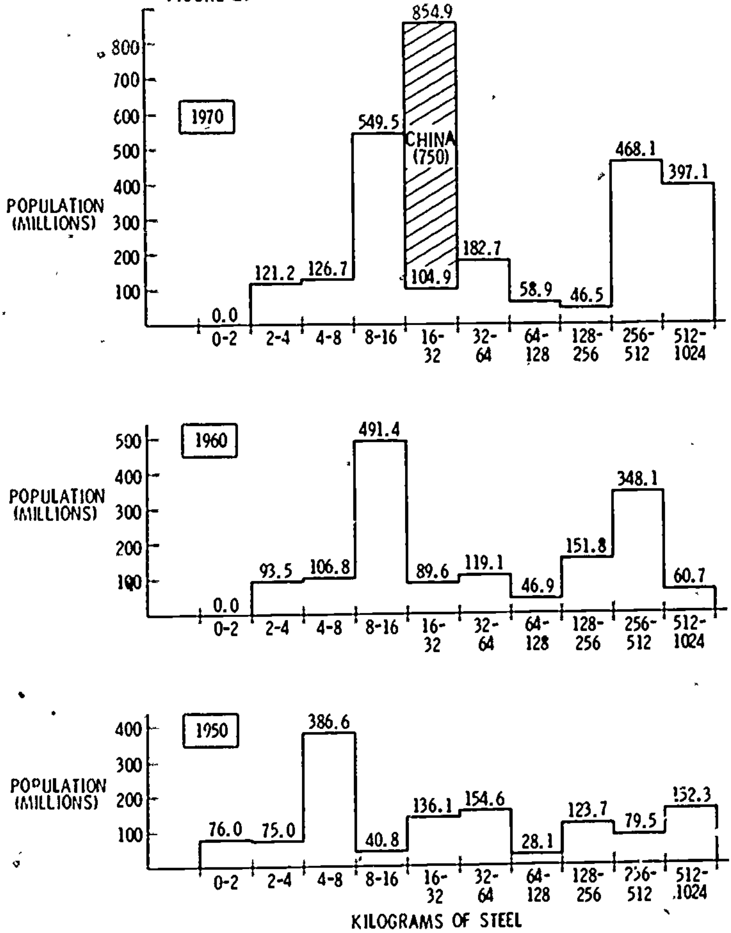


Figure 3 shows the countries which fall within each of the levels of per capita energy and steel consumption. As might be expected there is a general correspondence between the two indices.

Consumption of energy and steel are used as primary indicators in this discussion because of the obvious implications of the growth of such parameters upon the environment and the world resource base. It is interesting, however, to compare the distribution of these indicators with the distribution of the per capita gross national products. This is shown in figure 4 for all UN members and all geopolitical entities with a population larger than 200,000 for the year 1973.[6] Again we see a bimodal distribution. Significantly, nations which contribute to the low and high peaks of

FIGURE 3. ENERGY
CONSUMPTION PER CAPITA
(1970)

Kilograms of coal equivalent	
32-64	
64-128	Pakistan, Indonesia
128-256	Tunisia, Morocco, India, Ceylon
256-512	China, Turkey, Philippines, Malaysia, Egypt, Brazil, Algeria
512-1024	Uruguay, Rhodesia, Peru, Colombia
1024-2048	Yugoslavia, Mexico, Cuba, Chile, Argentina
2048-4096	Switzerland, New Zealand, Japan, Italy, Israel, France, Austria
4096-8192	W. Germany, USSR, UK, Sweden, Norway, Netherlands, Finland, Denmark, Belgium, Australia
8192-16,324	USA, Canada

KILOGRAMS OF COAL EQUIVALENT

STEEL
CONSUMPTION PER CAPITA
(1970)

Kilograms of steel	
2-4	Indonesia
4-8	Pakistan, Ceylon
8-16	Uruguay, Rhodesia, India
16-32	China, Turkey, Morocco, Egypt, Colombia
32-64	Tunisia, Philippines, Peru, Malaysia, Cuba, Brazil, Algeria
64-128	Mexico, Chile
128-256	Yugoslavia, Israel, Argentina
256-512	UK, USSR, Switzerland, Norway, New Zealand, Netherlands, Italy, France, Finland, Denmark, Belgium, Austria, Australia
512-1024	USA, Sweden, Japan, W. Germany, Canada

KILOGRAMS OF STEEL

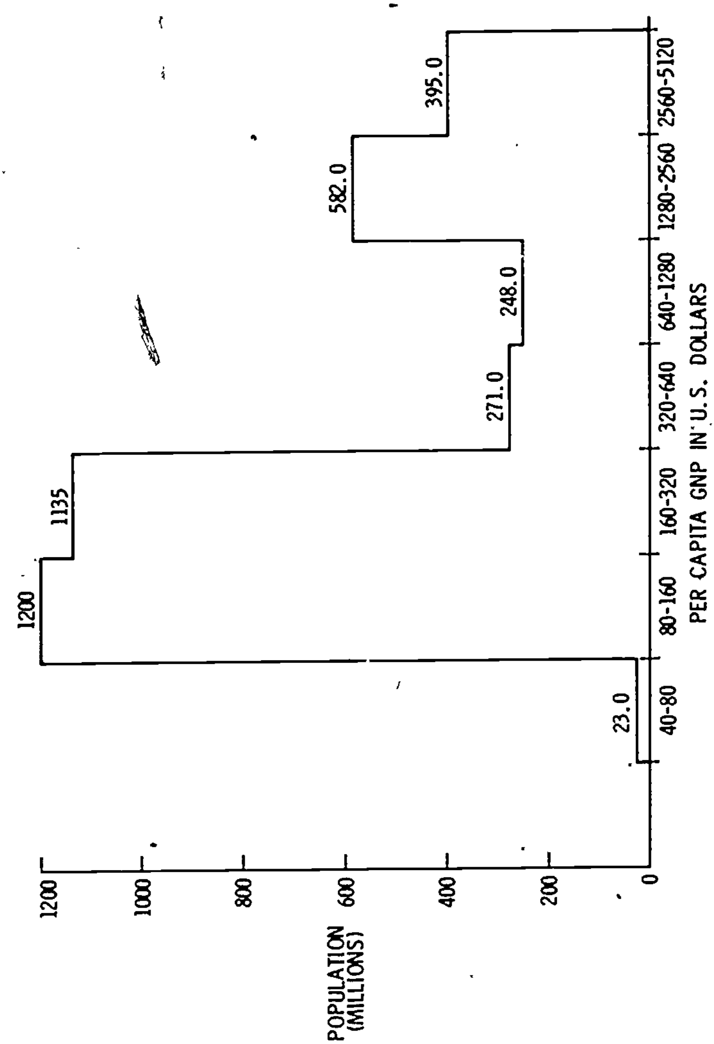


FIGURE 4. 1973 PER CAPITA GNP

Table 1. Classification of Nations

	Per Capita Energy Consumption (kg. c.e.) (1970)*	*Per Capita Steel Consumption (kg.) (1970)*	*Per Capita GNP (1973) (U.S. Dollars)*	*Population (1973) (Millions)*
Rich Nations	2048-16324	256-1024	1280-5120	977 (25.4%)
Intermediate Nations	1024-2048	64-256	640-1280	248 (6.4%)
Poor Nations	64-1024	2-64	40-640	2629 (68.2%)

*kilograms of coal equivalent

energy and steel consumption also contribute to the corresponding peaks of per capita GNP.

The peaks provide a convenient division of nations into "rich" and "poor" categories. A group of nations possessing per capita GNPs lying between $640-$1280 are listed as intermediate. The classifications and the population in each class are shown in table 1.

It is of interest to calculate the average per capita energy and steel consumption for those rich and poor nations for which data are available as well as the average for those few nations which lie in between the two extremes.[7] The averages for total energy consumption and per capita energy consumption (*not* including China) are shown in figures 5 and 6 respectively. It will be seen that with respect to total energy consumption, the ratio between the rich and the poor countries remains fairly constant between 1960 and 1970. As a result of rapid population growth in the poor countries, however, the curves showing the changes in per capita energy consumption have been diverging at an appreciable rate. In 1960 the average person in a rich country consumed 18.5 times as much energy as a person in a poor country. By 1970 this ratio had grown to 20.8.

The averages for total steel consumption and per capita steel consumption (again, not including China) are shown in figures 7 and 8 respectively. Again, the ratio of total steel consumption between the rich and poor countries remains fairly constant between 1960 and 1970. On a per capita basis, however, the two curves diverge at an appreciable rate. In 1960 the average person in a rich country consumed 21.4 times as much steel as did one in a poor country. By 1970 this ratio had grown to 25.2.

The averages of the quantities thus far discussed for the year 1970 are shown in table 2.

FIGURE 5. TOTAL ENERGY CONSUMPTION

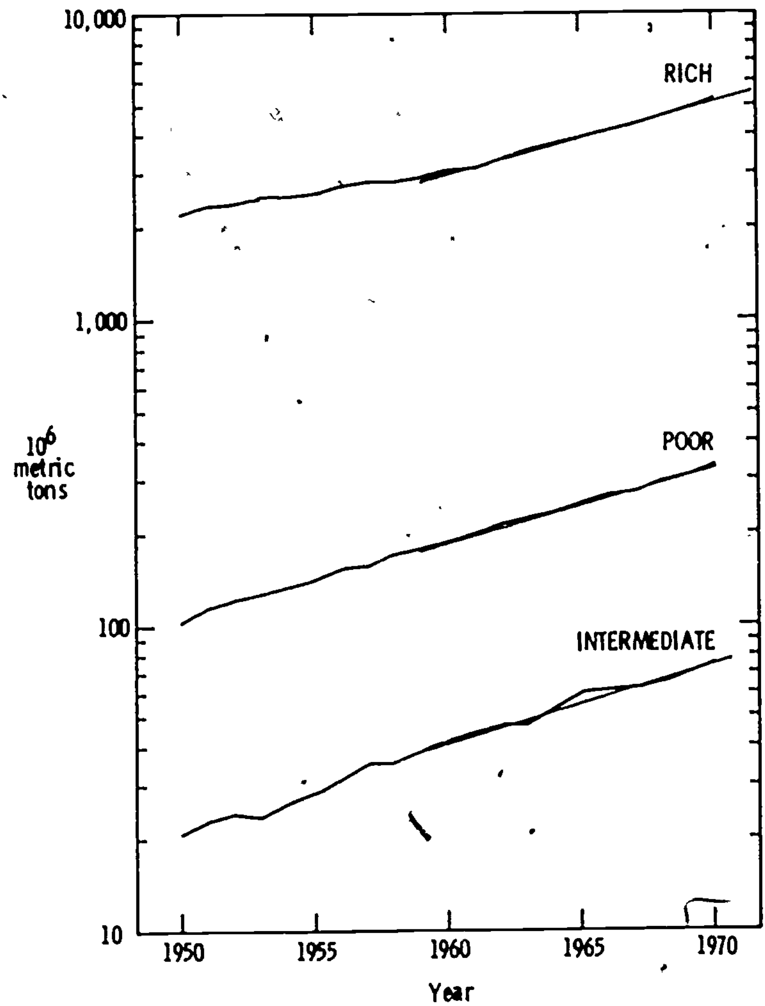


FIGURE 6. PER CAPITA ENERGY CONSUMPTION

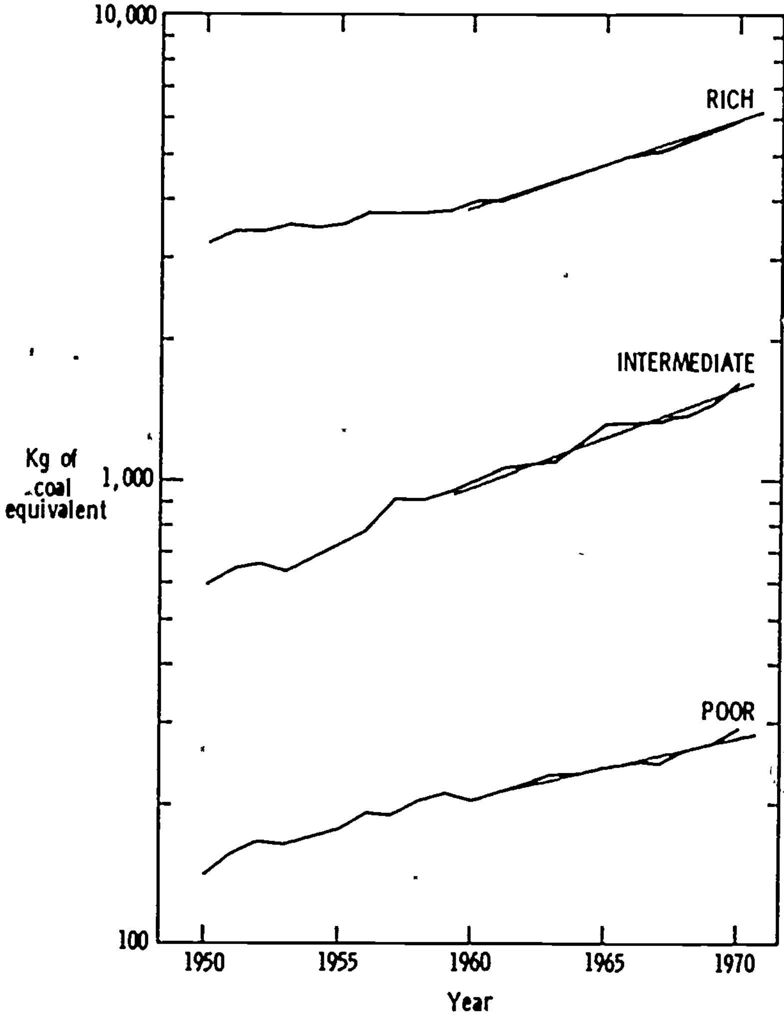


FIGURE 7. TOTAL STEEL CONSUMPTION

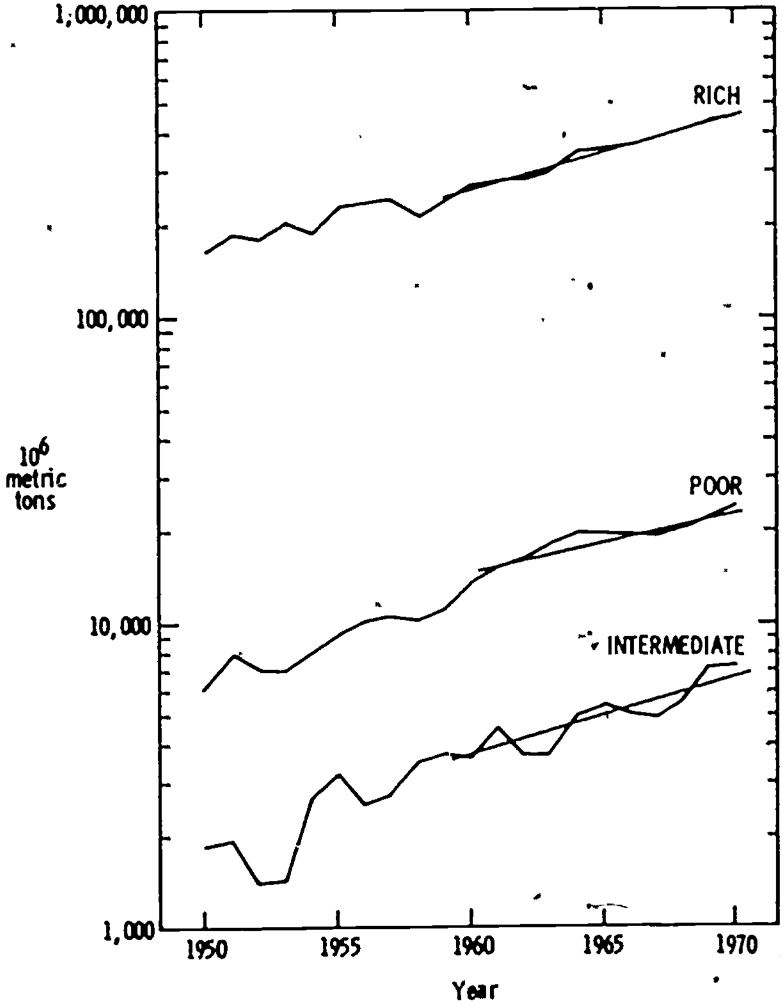


FIGURE 8. PER CAPITA STEEL CONSUMPTION

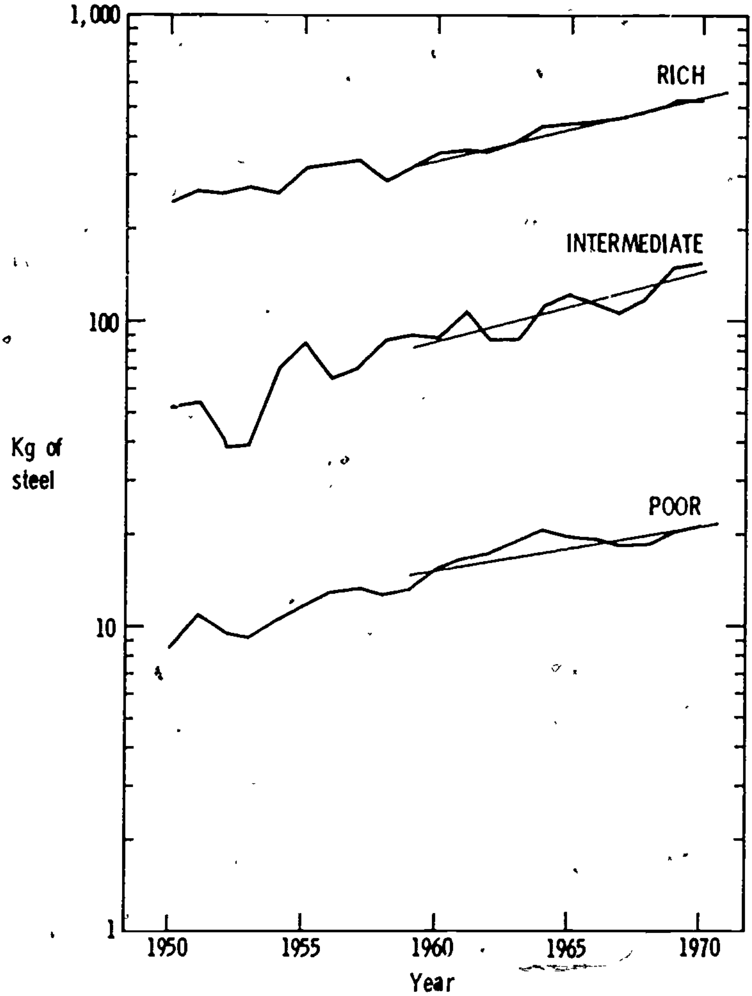


Table 2. Average Population and Consumption Levels for Energy and Steel in 1970

	Rich Nations	Intermediates	Poor Nations
Population (millions)	954	234	2440
Energy (10^6 m.t.c.e.*)	5680	384	717
Steel (10^6 metric tons)	507	38	51
Per Capita Energy (kg. c.e./person)	6010	1610	293
Per Capita Steel (kilograms/person)	537	158	21
Per Capita GNP (U.S. dollars 1973)	2720	846	169

*metric tons of coal equivalent

It is useful to examine the growth in the consumption of energy and steel on a regional basis. The trends in per capita consumption of energy and steel are shown in figures 9 and 10 respectively.[8] Table 3 shows the average rates of growth of the quantities with which we are concerned during the period 1959-1970.

It is significant that the U.S.S.R. has already overtaken Western Europe with respect to per capita energy and steel consumption, but neither is converging very rapidly with the rising per capita energy consumption in North America. Japan is approaching the per capita energy consumption of Europe. With respect to per capita steel consumption, North America, Western and Eastern Europe, and Japan appear to be converging. Although the trend in North America since 1959 has been upward there has actually been very little overall increase since 1950.

When we consider the rates of population growth listed in *The World Population Data Sheet* for 1973, the average current annual rates of population growth for the three classes of nations are determined to be:

Rich Nations	0.008
Intermediates	0.019
Poor Nations	0.025

Coupling these rates with the observed rates of growth of energy and

FIGURE 9. PER CAPITA ENERGY CONSUMPTION

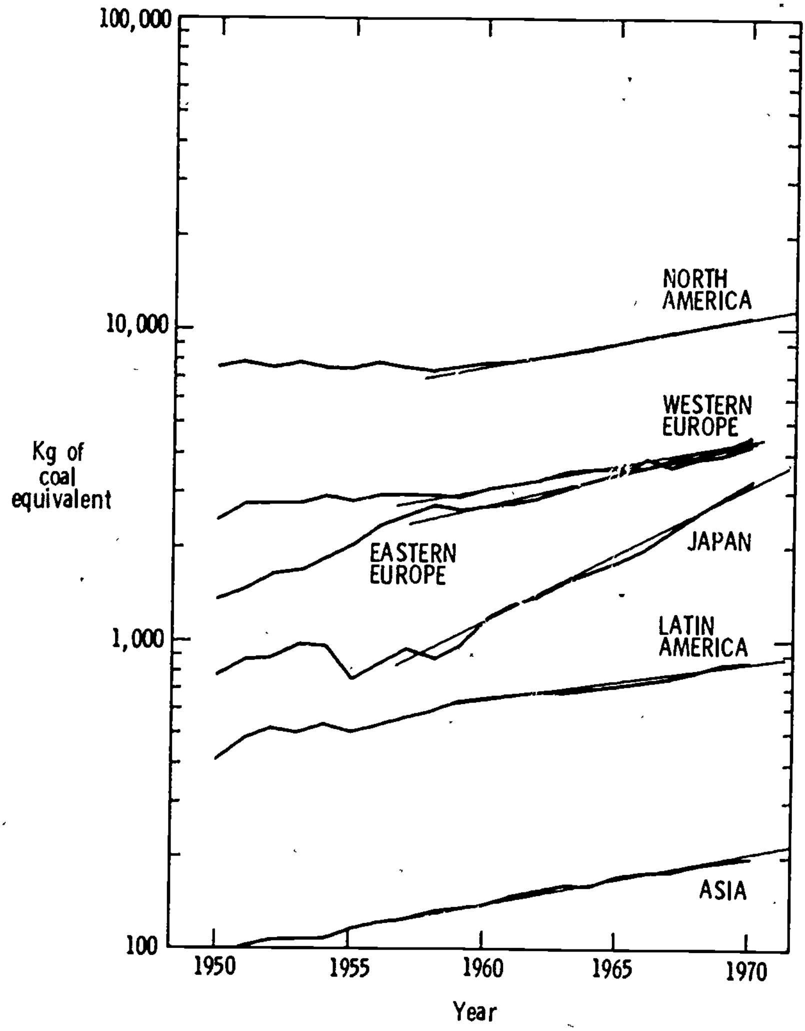


FIGURE 10. PER CAPITA STEEL CONSUMPTION

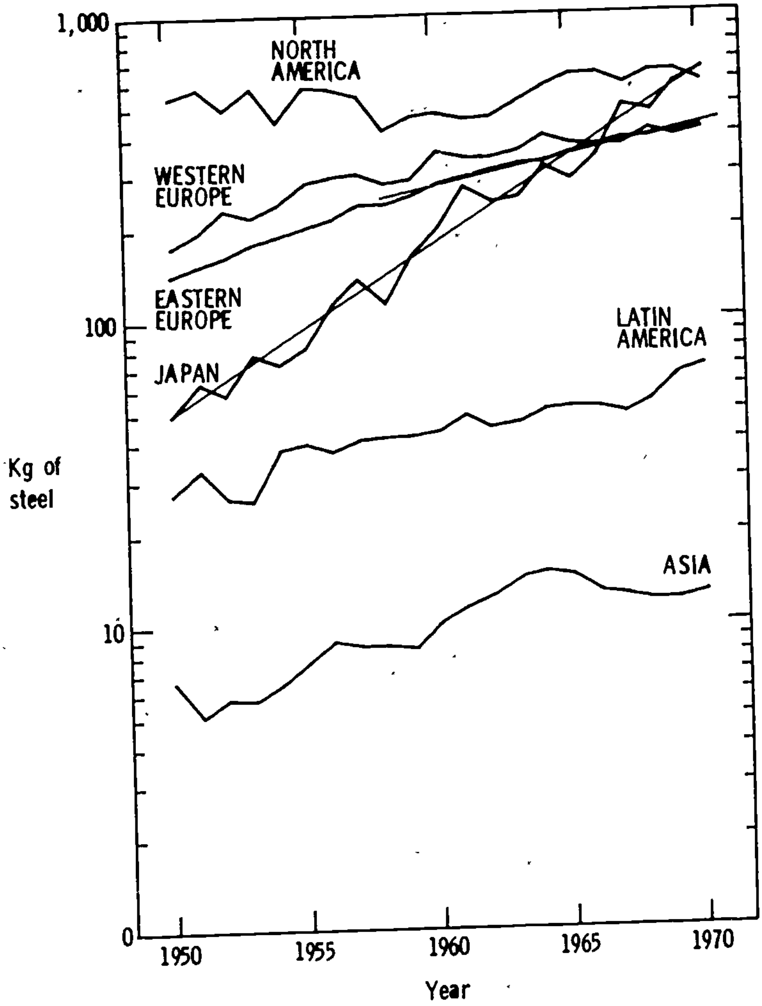


Table 3. Average Rates of Growth During Period 1959-1970
(best fit to equation $y = y_0 e^{\lambda t}$)

	*Population**	*Total Energy*	*Total Steel*	*Per Capita Energy*	*Per Capita Steel*
Rich	0.0114	0.0522	0.0579	0.0407	0.0464
Intermediate	0.0131	0.0579	0.0600	0.0447	0.0469
Poor	0.0269	0.0556	0.0571	0.0286	0.0302
North America	0.0134	0.0481	0.0486	0.0347	0.0352
West Europe	0.0089	0.0444	0.0341	0.0355	0.0252
East Europe	0.0125	0.0579	0.0570	0.0454	0.0445
Japan	0.0100	0.1116	0.1285	0.1016	0.1185
Latin America	0.0292	0.0556	0.0695	0.0264	0.0403
Asia	0.0254	0.0578	0.0458	0.0324	0.0204

*Population data was used only for those nations for which adequate data for energy and steel consumption was available.

steel consumption in the period 1959-70, we can extrapolate into the future in order to determine the effects of a continuation of the present rates.

Were the current rates to continue for 50 years beyond 1970 (which is no further in the future than 1920 was in the past), per capita consumption of energy in coal equivalents would rise to 54 tons in the rich countries and to 1.4 tons in the poor. Per capita consumption of steel would grow to 6.4 tons in the rich countries and to 0.10 tons in the poor ones. By that time the population of the world would be 10.5 billion, some 1.4 billion of whom would be rich and 8.5 billion of whom would be poor. Consumption of energy and steel in the poor countries alone would rise to levels considerably higher than total consumption in the world today, while world consumption of energy would approach the equivalent of 100 billion tons of coal annually and that of steel would exceed 10 billion tons annually.

Although one can imagine complex technological arrangements which might conceivably make such levels of consumption possible, there is little question that the resource base would be sorely pressed and the effects upon the environment would be substantial. Almost certainly the greater part of the energy produced in most areas of the world would be nuclear. The potential instabilities in a system composed of an affluent minority coexisting with a crowded, hungry and discontented majority which has access to nuclear fuels are awesome to contemplate.

The problems of feeding 10.5 billion persons in such a world would be enormous, particularly if growing affluence in the rich countries would mean growing per capita meat consumption. Figure 11 shows the per capita cereal consumption in several parts of the world between 1950 and 1970. In India, where there has been virtually no change since 1960, almost all of the cereal is consumed directly by people. In the United States, where there has also been little change in per capita consumption in the two decades, most of the cereal is fed to animals. As Japan and Western Europe have become more affluent, as their per capita consumption of energy and steel increased, their per capita consumption of animal products has increased as well. As a result, per capita cereal consumption is increasing in those areas and is perhaps destined eventually to converge with that of the United States. Thus, increasing affluence coupled with increasing population will give rise to greatly increased world demands for cereals.

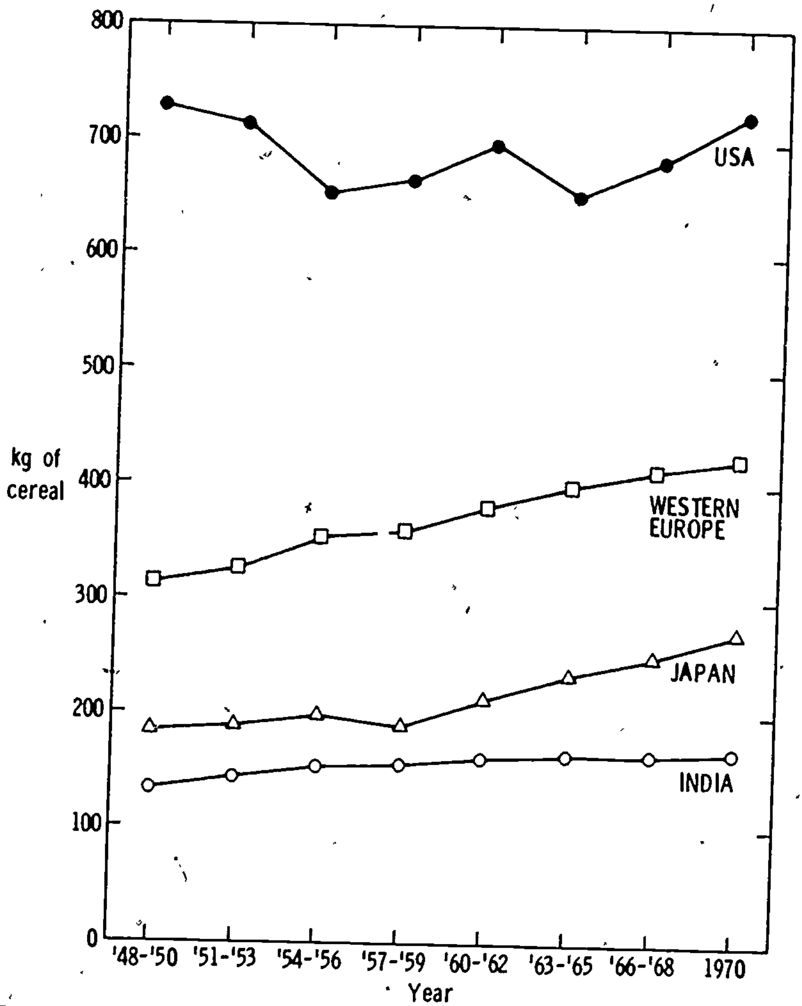
When we consider only the obvious implications of continued growth during the next fifty years along the pattern established during the past twenty years it seems clear that we are confronted by what amounts to an impossible situation. Current growth rates will almost certainly decrease, but when and under what circumstances?

First, rates of population growth are destined to decrease. In the rich countries they are already low and decreasing. In the poor countries where growth rates are high, three factors seem destined to cause them to lessen: 1) the spread of family planning programs, 2) increased mortality resulting directly and indirectly from the limited availability of food, and 3) environmental effects.

Rates of growth of consumption of energy and metals also seem destined to decrease, particularly in the rich countries, in part because of limitations of resources and in part because of the effects of increased energy consumption upon the environment.

In view of these prospects it is of interest to examine what the consumption levels would be in 2020 were we to assume rather dramatic extremes in the growth rates which might prevail after 1970. Table 4 gives estimates of the population, energy consumption and per capita energy consumption of the rich countries and the poor countries in 2020 based upon the

FIGURE 11. PER CAPITA CEREAL CONSUMPTION



following extreme assumptions:

1) no growth,
2) continued growth at present rates,
3) continued growth at present rates, except that energy consumption ceases to expand in the rich countries,
4) all population growth ceases, energy consumption ceases to expand in the rich countries, and energy consumption continues to expand at the present rate in the poor countries.

Because a greatly expanded rate of increase of energy consumption in the poor countries seems unlikely, that possibility has not been considered.

Inspection of table 4 shows that even were we extremely optimistic concerning the behavior of people and governments, the world is destined, in the absence of catastrophe, to remain divided into two cultures for a very long time in the future. Even were population growth to cease growing immediately and were consumption in the rich countries also to cease growing immediately (obviously an impossibility) more than fifty years would be required to bridge the gap.

Nevertheless the "energy crisis" which came upon the rich countries in 1973, the environmental concerns which mushroomed even earlier and the decreasing birth rates in such areas as Taiwan, Korea and Jamaica seem to foreshadow significant decreases in rates of growth. Thus the conclusions based upon assumption 2 are probably extreme. Even so, we must recognize that in the absence of disaster the cultures of the rich and the poor are destined to coexist for at least another century and perhaps for longer. The implications of this fact upon efforts to create "global models"[9] are obvious.

Table 4. Population, Energy Consumption and Per Capita Energy Consumption in 2020 Based upon Assumptions as to Prevailing Growth Rates from 1970

	Assumption as to Growth Rates *Population*		*Energy*		*Population (millions)*		*Energy Consumption* (10^6 m.t.c.e.*)		*Per Capita Energy Consumption* (*m.t.c.e.**)		
	rich	*poor*	*rich*	*poor*	*rich*	*poor*	*rich*	*poor*	*rich*	*poor*	*ratio*
1)	0	0	0	0	950	2,440	5,680	720	5.95	0.29	20.5
2)	0.008	0.025	0.052	0.056	1,400	8,500	77,100	11,600	54.2	1.36	39.9
3)	0.008	0.025	0	0.056	1,400	8,500	5,680	11,600	4.06	1.36	3.0
4)	0	0	0	0.056	950	2,440	5,680	11,600	5.95	4.75	1.25

*metric tons of coal equivalent

Notes

1. United Nations, *Statistical Yearbook, 1971* (New York: United Nations Publishing Service, 1972). Also see previous issues.
2. United Nations, *Demographic Yearbook, 1970* (New York: United Nations Publishing Service, 1971). Also see previous issues.
3. Consumption data are based on the apparent consumption of coal, lignite, petroleum products, natural gas and hydro and nuclear electricity. Comparison between coal and other sources of energy is based on calorific values; factors for conversion to coal equivalent are given in the Appendix of the United Nations *Statistical Yearbook, 1971*, page 814.
4. What appear to be reasonable estimates of energy and steel consumption and of population in the People's Republic of China for 1970 were given the author when he was in Peking in May 1973.
5. The consumption figures given are for apparent consumption, defined as production plus imports minus exports.
6. *World Population Data Sheet* (Washington, D.C.: Population Reference Bureau, 1973).
7. The following nations were classified as "intermediate" on the basis of the 1970 energy and steel data: Argentina, Israel and Yugoslavia.
8. "Eastern Europe" includes only the U.S.S.R. and Yugoslavia as data for the other countries are either not available or are not consistent over the twenty-year period. "Latin America" includes South and Central America plus Mexico. "Asia" does not include either the People's Republic of China or Japan but does include other populous countries such as India, Pakistan (including Bangladesh), Indonesia, Ceylon (Sri Lanka) and the Philippines. "Africa" is not shown because the levels for most of tropical Africa are not well known.
9. For example, Donella H. Meadows, et al., *The Limits to Growth* (New York: Universe Books, 1972).

The Author

Harrison Brown received his B.S. in chemistry at the University of California at Berkeley in 1938 and his Ph.D. in chemistry at Johns Hopkins University in 1941. In 1942 he joined G.T. Seaborg at the Metallurgical Laboratories at the University of Chicago to work on the chemistry of plutonium and in 1943 moved to the newly created Clinton Laboratories at Oak Ridge, Tennessee as Assistant Director of Chemistry. In 1946 he joined the staff of the Institute for Nuclear Studies at the University of Chicago and there started his work in geochemistry and cosmochemistry. In 1951 he became a Professor of Geochemistry at the California Institute of Technology and Professor of Science and Government in 1967. From 1962 to 1974 he served as Foreign Secretary of the National Academy of Sciences and is now the President of the International Council of Scientific Unions.