The World Economy of the Year 2000

Author(s): Wassily W. Leontief

Source: *Scientific American* , Vol. 243, No. 3 (September 1980), pp. 206-231
Published by: Scientific American, a division of Nature America, Inc.
Stable URL: https://www.jstor.org/stable/10.2307/24966419

The World Economy of the Year 2000

The first input-output model of the world economy suggests how a system of international economic relations that features a partial disarmament could narrow the gap between the rich and the poor

by Wassily W. Leontief

The term "world economy" (*Weltwirtschaft*) first appeared in Germany on the eve of World War I, when Kaiser Wilhelm II was preparing to challenge the political and economic domination of the British Empire. It was at about the same time that the German economist Bernhard Harms, with the backing of Germany's newly created steel and heavy-chemical industries, founded the Institute for World Economics in Kiel, the first large institution devoted to economic research on a global scale. These two signs of impending change proved to be reliable. Over the next 60 years Germany would lose two wars, Britain would lose its empire and the notion of a world composed of self-sufficient, autonomous national economies would recede into the realm of conventional abstractions.

A dramatic demonstration of the degree of global interdependence that exists today is provided by the current "oil crisis," whose direct and indirect effects are felt in the farthest corners of five continents. The world economy has become a tangible reality, and at the present time its dominant feature is the gap in income (and thus standard of living) between the poorer, less developed countries of the world and the richer, highly industrialized ones. In this article I shall discuss the prospects for accelerating the rate of growth of the less developed countries of the world under some of the most frequently proposed scenarios for world economic development.

In 1973, to provide a quantitative basis for such an investigation, the United Nations, with special financial support from the Netherlands, commissioned the construction of a general-purpose model of the world economy. To transform the vast collection of microeconomic facts that describe the world economy into an organized system from which macroeconomic projections of future growth could be made the model was to rely on the method of input-output, or interindustry, analysis. The input-output method depicts the structure of an economy in terms of the flows among its producing and consuming sectors, real transfers of goods and services. Such transfers can be displayed in a statistical input-output table for the economy. This table in turn gives rise to a set of structural equations whose simultaneous solution provides a numerical picture of a possible future state of the economy. In order to generate such a projection from the input-output model it is necessary to make a certain number of assumptions about some of the factors that will determine the pace and the shape of the economy's future growth, that is, some of the variables in the set of equations must be fixed. Hence by trying different assumptions it is possible to project a series of alternative paths for the development of the economy. In this way input-output analysis provides a means of taking the quantitative measure of hopes and plans for the future.

In the nearly 50 years since the input-output method was first introduced its practical applications have proliferated, and it has become a standard tool for investigating the economic structure of countries and of smaller systems such as states, cities and even corporations. The compilation of national input-output tables has become part of the official statistical program of all the developed countries and many of the less developed ones. By 1973, when the construction of the world model was begun, there were input-output tables for more than 60 countries, several of which (including the U.S., Japan and Norway) were publishing their own tables at regular intervals.

A national input-output table describes the web of technologically determined interindustry relations that constitute the economic fabric of a country. Naturally many of the threads of the fabric (the quantities of goods produced or the services provided) cross geographic borders and are woven into the fabric of another country, but until recently such threads had always been left hanging loose. No attempt was made to tie the various national tables together, an omission that not only prevented the systematic application of the input-output method to investigating the structure of international economic relations but also introduced an element of uncertainty into the study of national economics. This problem is solved in the input-output model of the world economy in a simple way: the world is visualized as consisting of 15 distinct geographic regions, each one described by an individual input-output table, and these tables are then linked by a network of interregional commodity flows.

Even though the overall design of this multiregional model—the first input-output model of the world economy—is simple, constructing it was complex. To begin with, the results of information-gathering efforts throughout the world had to be combined to create a detailed picture of the input-output structure of each regional economy in 1970 (the model's designated base year). The re-

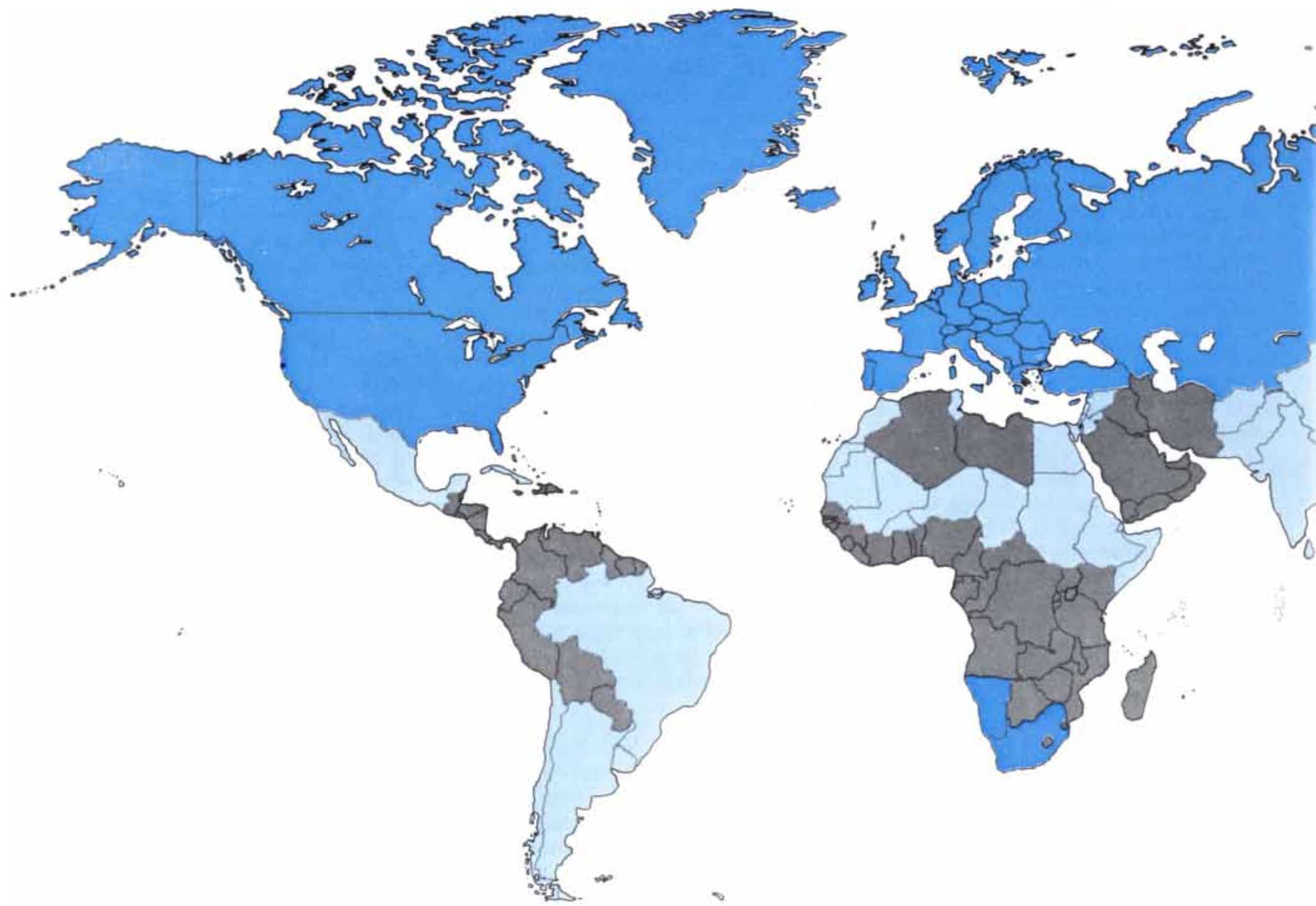
TECHNOLOGICAL INNOVATION plays a key role in the economic development of nations by creating what are essentially new resources. An example is the reclaimed arable land visible as a pattern of hexagonally close-packed red dots in the false-color Landsat image on the opposite page, which shows a desert area near the Oases of Kufra in Libya. Dots are circular fields of crops grown under center-pivot irrigation. Each dot is almost a mile in diameter.

sulting arrays then had to be arranged in a single vast data bank and stored in a computer. (Some national input-output tables are so large that they cannot be printed out.) Finally, complex computer programs had to be written to implement the model, that is, the structural information contained in the data bank had to be transformed into an appropriate system of equations and then the equations had to be solved simultaneously in order to obtain projections of future development.

In 1978 a set of detailed projections made using the multiregional input-output model appeared under the title *The Future of the World Economy.* These projections, all of which begin with the base year 1970, provide comprehensive descriptions of the state of each of the 15 regions in the world model and the relations among them for the benchmark years 1980, 1990 and 2000. The division of the world into 15 geographic regions with a reasonable degree of economic homogeneity was achieved by first ranking all the countries of the world in decreasing order of their average annual per capita income and then grouping those that seemed to be at about the same stage of economic development and to have a comparable endowment of natural resources.

For the purpose of presenting and interpreting the results of global economic projections carried out in regional detail it was convenient to further group the 15 regions into three main categories: the developed regions, the resource-rich less developed regions and the resource-poor less developed regions. In 1970 the developed regions of the world, including (in decreasing order of their average annual per capita income) North America, Oceania (mainly Australia and New Zealand), Western Europe, Japan, the U.S.S.R., Eastern Europe (other than the U.S.S.R.), South Africa and Mediterranean Europe, had a total population of 1.108 billion and an average per capita income of $2,534. The resource-rich less developed regions, including low-income Latin America and the oil-producing states of the Middle East and tropical Africa, had a total population of 358 million and an average income of $278. The resource-poor less developed regions, including medium-income Latin America, arid Africa, the centrally planned nations of Asia and low-income Asia, had a total population of 2.154 billion and an average income of $186 [*see illustration below*].

What are the objective possibilities of closing the gap between the income that can be expected in a developed country and the income that can be expected in a less developed country poor in natural resources? Can such growth be achieved under the current policies regulating credit and trade balances among nations? Could a radical revision of those policies serve to accelerate the growth of the poorer less developed nations? And what effect could an international agreement to limit military spending have on the income gap? The multiregional input-output model, whose pro-

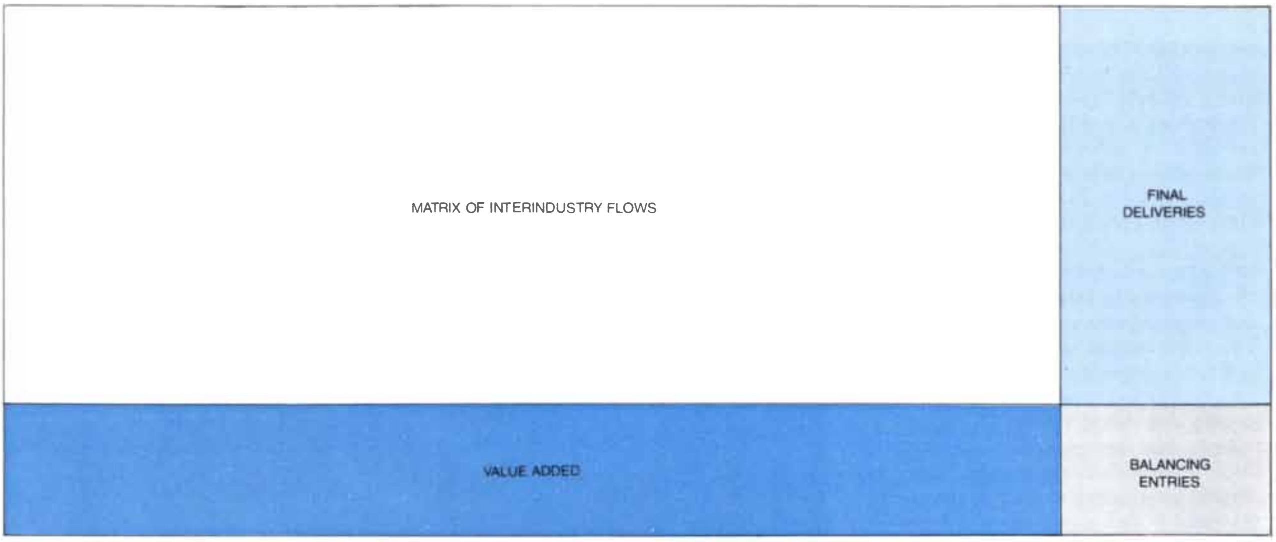


WORLD MAP shows how the nations of the world can be divided into three economic categories: developed (*dark color*), resource-rich less developed (*gray*) and resource-poor less developed (*light color*). For the purpose of projecting future economic development the input-output model of the world economy analyzes 15 homogeneous regions that make up these categories. In 1970, the model's base year, the eight regions classified as developed, with 31 percent of the world population, had an average annual per capita income of $2,534. Three resource-rich less developed regions, with 10 percent of the population, had an average income of $278. Four resource-

jections are grounded in the real data of the world economy, provides a reliable means of exploring these questions (and many others). To understand how the projections are made it is necessary to consider the structure and workings of the model in more detail, and so I shall explain how input-output analysis is applied to an economic system.

The input-output method analyzes an economy in terms of its production and consumption of goods and services. The total output of each of the goods and services produced and consumed in a particular national economy is divided among the "final users," such as consumers and governments (which consume commodities directly), and the various producing sectors of the economy (which consume commodities indirectly, as inputs to their respective industrial or agricultural processes). The total dollar value of all the goods and services delivered to final users is the gross national product. The magnitude

poor less developed regions, with 59 percent of population, had average income of $186. In the model each region is described by an input-output table, and tables are linked by a network of interregional commodity flows.



Industry number	Industry	Livestock and livestock products 1	Agricultural crops 2	Forestry and fishery products 3	Agricultural, forestry and fishery services 4	Iron and ferroalloy ores mining 5	Total interindustry use	Personal consumption expenditures 80	Gross private fixed capital formation 81	Exports 82	Imports 83	Federal Government purchases 84	State and local government purchases 85	Total final demand	Total industry output
1	Livestock and livestock products	11,316	870		188		41,958	1,454		111	−259	4	71	1,381	43,339
2	Agricultural crops	10,088	1,129		52		27,160	4,580		4,763	−630	−982	189	7,920	35,080
3	Forestry and fishery products			9	11		2,696	848		105	−1,152	−533	7	−725	1,971
4	Agricultural, forestry and fishery services	1.222	1,289	49	106		3,361	125		19	−2	14	49	205	3,566
5	Iron and ferroalloy ores mining					24	1,775			102	−619	−25		−542	1,233
6	Nonferrous metal ores mining					3	2,466		199	32	−414	−7		−190	2,276
7	Coal mining		1			4	4,749	125		496	−1	48	22	690	5,439
8	Crude petroleum and natural gas						19,439		53	1	−2,763			−2,709	16,730
9	Stone and clay mining and quarrying	1	88		1	6	3,046	5		90	−179	−2	−49	−135	2,911
10	Chemical and fertilizer mineral mining		46				459	3		79	−96	−2	49	33	492
11	Maintenance and repair construction	224	304		55	33	26,995			6		2,079	7,337	9,422	36,417
12	Ordnance and accessories				*		399	457	80	325	−81	5,742	16	6,539	6,938
13	Food and kindred products	5,324	1	46	26	*	46,802	73,276		2,862	−4,857	310	2,229	73,820	120,622
14	Tobacco manufacturers	*	*	*	*	*	2,377	6,087		839	−71		−1	6,854	9,231
15	Broad and narrow fabrics, yarn and thread mills		10				16,950	639		432	−895	26	58	260	17,210
16	Miscellaneous textile goods and floor coverings	13	54	52	43		4,391	1,513	606	156	−586	16	3	1,708	6,099
17	Apparel						9,767	22,563		260	−2,638	131	82	20,398	30,165
18	Miscellaneous fabricated textile products		19	23	13		2,824	2,775		103	−134	145	49	2,938	5,762
19	Lumber and wood products except containers	6	3			3	22,424	384	5	850	−2,073	30	27	−777	21,647
20	Wood containers	1	121		17		446			3	−4	13		12	458
I	Total intermediate inputs	33,776	15,480	704	1,833	721									
VA	Total value added	9,563	19,600	1,267	1,733	511									1,182,766
EC	Compensation of employees	1,854	2,556	395	1,249	247									717,663
BT	Indirect business taxes	794	701	59	108	60									110,981
PTI	Property-type income	6,914	16,343	813	375	204									354,122
T	Total	43,339	35,080	1,971	3,566	1,233		738,072	181,931	72,794	−76,199	102,126	150,693	1,182,766	

INPUT-OUTPUT FLOW TABLE, which provides the statistical basis for input-output analysis, depicts all the real transfers of goods and services within a particular economy over a given period of time. As is shown in the diagram at the top, the bulk of a flow table is taken up by the "matrix of interindustry flows," in which the entries in each row describe the way the output of the sector corresponding to that row is distributed to all the producing sectors of the economy (including that sector itself). For example, in the flow table whose four corners are shown at the bottom the interindustry structure of the U.S. economy is described in terms of the flows among 79 producing sectors. (In this table, which was compiled for 1972, all entries represent millions of fixed 1972 dollars, and asterisks indicate transactions valued at less than $500,000.) Section at the upper right of a flow table lists the deliveries of the output of each sector to final users, or those that consume commodities directly instead of as inputs to the production of other commodities. In the U.S. table these "final deliveries" go to satisfy such demands as personal consumption, government purchases, exports and imports (which, since they reduce the aggregate domestic demand for a commodity to be satisfied by domestic production, must be entered in the table as negative values). Just as the distribution of the output of any sector can be read across the corresponding row of the flow table, so the combination of inputs that a sector requires for the production of its particular commodity or service can be read down the corresponding column. The section at the lower left of a flow table lists those inputs that are not accounted for by interindustry flows. In the U.S. table these inputs include wages, taxes and rents, and they can be summed to obtain the "value added" to the commodity produced by a sector. The deliveries made to final users can be summed to obtain the final demand for each commodity, a quantity whose dollar value represents the contribution of the corresponding sector to the gross national product of the economy. In input-output analysis the total final demand for the output of each sector, which appears in the next to last column of the U.S. flow table, accounts not only for allocations to current private and public forms of consumption but also for additions made to the stocks of various components of fixed and working capital such as equipment and buildings. An input-output table of this type is balanced in the sense that the total output of each sector (which appears in the last column of the U.S. table) is equal to the sum of all its interindustry and final-use deliveries and also to the sum of all its interindustry inputs and its value added (which appears in the bottom row). The "balancing entries" that appear in the section at the lower right of a flow table depict the equilibrium between income and spending in the economy whose interindustry transactions are described by the table.

of the interindustry transactions in an economy obviously plays a large part in determining the levels of income and consumption within the economy. One important advantage of input-output analysis is that these transactions are brought into the model of the economy through the system of linear equations (equations with variables to the first power only) that serve to describe it.

In a system of input-output equations the variables represent unknown quantities that describe a particular state of the economy and the coefficients reflect the interdependence of the various producing sectors of the economy. These structural coefficients must be determined empirically, and they are generally derived from the numerical matrix—the input-output table—that describes the flow of goods and services within the economy over a given period of time. Each row in an input-output table shows the deliveries made by the sector associated with that row to all the different sectors in the economy (including itself) and to all the final users [*see illustration on opposite page*].

In the basic format of an input-output table the list of major producing sectors of an economy appears twice, once along the top of the matrix and again along the left-hand side, creating a square array of interindustry flows that is the bulk of the table. In other words, the figure that appears in row *i*, column *j* of this part of the table represents the part of Sector *i*'s total output that is delivered as input to Sector *j*. The deliveries to final users, which include private households, government, exports, imports and investments in new productive capacity (that is, additions to the existing supplies of machinery, buildings and materials), are entered in the last columns of the matrix. And the last rows present the inputs that are not accounted for by intersectoral flows, including the cost of labor, interest payments, rents, taxes and so on. For each sector these last inputs can be summed to obtain the "value added" by that sector to the raw materials, energy and all other intermediate inputs received or purchased from the other sectors of the economy. Similarly, the last deliveries for each sector, or those parts of its output that go to final users, can be viewed as components of the "final demand" for the commodity the sector produces.

(All the commodity transfers shown in an input-output table involve physical quantities such as bushels of grain or tons of steel. In most cases, because of the absence of information about such physical quantities, the various inputs and outputs in the table are described in terms of their "fixed dollar" value. The advantage of expressing flows in this way can be seen by comparing two input-output tables for the same economy in different years. Suppose an examination of the tables reveals that the cost of the copper required to produce $1 million worth of television sets increased from $10,000 to $15,000 in the time that elapsed between the construction of the two tables. This change might be due at least in part to changes in the price of television sets or changes in the price of copper or both. If in both tables both the inputs and the outputs are measured in fixed prices, however, then the change in the cost of the required copper represents a real change in the input-output balance of the television-producing sector, one that arises from a real change in the technology.)

An input-output matrix of the type described above is called a flow table, and it is not hard to see that such a table is balanced in the sense that the total output of each sector is accounted for by the sum of all its interindustry and final-use deliveries and by the sum of all its interindustry inputs and its value added. And summing either the final demand for each sector's output or the value added to each sector's inputs over all the sectors yields the G.N.P. (It is important to note that imports, which reduce the aggregate demand for a commodity to be satisfied by domestic production, must be entered as negative quantities if the table is to balance.)

Hence in the schematic picture of an economy presented by the input-output flow table the allocation of all the goods and services generated by the economy (including the distribution of all the primary resources such as oil, ores and labor) is revealed when the table is examined row by row. The fundamental technological relations that control the transfer of goods and services within the economy, on the other hand, become apparent when the table is examined column by column. These structural relations are even more clearly revealed if the information in the flow table is recast by dividing the output delivered from one sector to another by the total output of the sector receiving the input. In this way a matrix of input coefficients is created in which the entry in row *i*, column *j* represents the part of the output of Sector *i* that is absorbed by Sector *j* for each unit of Sector *j*'s total output. Thus the set of coefficients contained in each column of the new matrix is equivalent to the recipe followed by the sector associated with that column in the production of its particular commodity. Indeed, multiplying the total output of the sector by each of these input coefficients in turn reproduces the corresponding column of the flow table: the set of input flows the sector had to receive from other sectors in order to produce the total output.

The combination of the various inputs a particular sector needs in order to produce its total output is governed essentially by technical considerations, and so the matrix of input coefficients is called a structural, or technical-coefficient, input-output table. It is the coefficients in this structural matrix that give rise to the system of linear equations that are the core of the input-output model of the economy, the equations that describe the balanced relations between the levels of output in all the productive sectors of the economy and the quantities of their respective products delivered to final users.

In the condensed notation of matrix algebra the system of equations can be expressed in the form $x - Ax = y$, where A is the square interindustry section of the technical-coefficient matrix, x is the column vector, or one-dimensional matrix, that lists the total output of each of the producing sectors of the economy and y is the column vector that lists the part of each sector's total output delivered to final users. Thus Ax describes the contributions made by the various sectors to fulfilling the intersectoral input requirements of the economy, and so the equation $x - Ax = y$ conveys the fact that an economy's G.N.P. (y) depends on the difference between its total output (x) and its interindustry transactions (Ax). (A description of the matrix arithmetic by which the simple equation $x - Ax = y$ is converted into the large system of linear equations that describe in detail the interrelations of the various sectors of the economy is provided in the illustration on page 216.)

The power of input-output analysis lies in the fact that the equation $x - Ax = y$, or rather the system of linear equations it implies, can be applied in a variety of ways, depending on which variables are fixed and which are considered unknown quantities. For example, an economist, knowing the limited production capacity of the economic system described by A, might want to consider the vector x (or at least some of its entries) as being given and solve the equation for the vector y to project the maximum G.N.P. the system can achieve. Another analyst, seeking to determine the implications of a change in government purchases or consumers' demand on the economy described by A, might assign values to y and solve the equation for x, in other words, project the amount of output from each sector needed to attain the desired G.N.P.

Besides explaining the physical flows of inputs and outputs in a particular economy, the input-output system described above also serves to clarify the relation between prices and costs in the economy. A vector of technical coefficients that describes, say, the amounts of ore, coke, flux, labor and other inputs

Industry number		Livestock and livestock products	Agricultural crops	Forestry and fishery products	Agricultural, forestry and fishery services	Iron and ferroalloy ores mining
	Industry number	1	2	3	4	5
1	Livestock and livestock products	0.26110	0.02481	-------	0.05278	-------
2	Agricultural crops	.23277	.03218	-------	.01444	-------
3	Forestry and fishery products	-------	-------	0.00467	.00294	-------
4	Agricultural, forestry and fishery services	.02821	.03673	.02502	.02959	-------
5	Iron and ferroalloy ores mining	-------	-------	-------	-------	0.01972
6	Nonferrous metal ores mining	-------	-------	-------	-------	.00268
7	Coal mining	-------	.00002	-------	-------	.00357
8	Crude petroleum and natural gas	-------	-------	-------	-------	-------
9	Stone and clay mining and quarrying	.00001	.00251	-------	.00034	.00511
10	Chemical and fertilizer mineral mining	-------	.00130	-------	-------	-------
11	Maintenance and repair construction	.00517	.00867	-------	.01534	.02637
12	Ordnance and accessories	-------	-------	-------	.00003	-------
13	Food and kindred products	.12284	.00003	.02855	.00729	.00008
14	Tobacco manufactures	.00001	.00001	.00005	.00011	.00008
15	Broad and narrow fabrics, yarn and thread mills	-------	.00027	-------	-------	-------
16	Miscellaneous textile goods and floor coverings	.00030	.00154	.02649	.01195	-------
17	Apparel	-------	-------	-------	-------	-------
18	Miscellaneous fabricated textile products	-------	.00055	.01142	.00367	-------
19	Lumber and wood products except containers	.00013	.00009	-------	-------	.00203
20	Wood containers	.00002	.00345	-------	.00468	-------
VA	Total value added	.22066	.55872	.64273	.48588	.41493
EC	Compensation of employees	.04276	.07285	.20020	.35031	.20065
IBT	Indirect business taxes	.01833	.01997	.02979	.03037	.04901
PTI	Property-type income	.15957	.46589	.41274	.10520	.16528
T	Total	1.00000	1.00000	1.00000	1.00000	1.00000

TECHNICAL-COEFFICIENT TABLE, derived from the input-output flow table for a particular economy, reveals the economy's internal structure. As is shown by these sections of the 1972 technical-coefficient table of the U.S. economy, each entry in this type of table is the ratio between an input to a particular sector and the total output that sector produces. Thus each column in the matrix displays the combination of inputs that the corresponding sector requires to be able to produce one unit of output, a recipe that is essentially governed by technology.

that are required to produce a ton of steel can be employed to set up an equation describing the necessarily balanced relations between the prices of all these ingredients and the price of steel. More precisely, the price of steel must be equal to the combined costs of all the inputs plus the normal profit the steel industry must earn per unit of its output. Without going into further detail, it is important to point out that in parallel to the system of equations representing the balance and therefore the interdependence among all the commodity flows in an economy a "dual" system of price-cost equations can be formulated, describing the balance between the costs and the prices of all the goods and services produced and consumed throughout the economy. The same large, square matrix of technical coefficients appears in both systems of equations, although it enters into the two in somewhat different ways.

The multiregional input-output model of the world economy consists of 15 technical-coefficient tables of the type I have described here. Each region is visualized as a set of 48 sectors of economic activity that include four different agricultural sectors (including "Livestock products," "Grain," "High-protein crops" and "Roots") and 22 manufacturing sectors (including "Food processing," "Textiles," "Fertilizer" and various types of machinery and equipment). There are individual sectors devoted to "Utilities," "Construction," "Transportation," "Communications" and other service activities such as medical care, education, repairs and trade. And inputs of nine minerals, including five metals and four types of fuel, are also treated.

Long before the construction of a world model was undertaken input-output analysis had been extended into areas generally considered to be outside the network of conventional economic transactions. For example, to reach out into the area of environmental protection it is only necessary to include in the basic structural matrix of an economy additional rows of technical coefficients describing either appropriate pollution-abatement technologies or pollutants (say the amount of particulate matter released into the air by a blast furnace per ton of pig iron produced or the amount of dirty water released into a river by a steel plant per ton of steel produced). Included in the description of the economic activities of each of the 15 regions in the world model are five types of pollution-abatement activity and the emission of eight major types of pollutants.

In addition to describing the flows of current inputs to each sector of a particular region the world model describes the degree to which each sector relies on existing "stocks" of buildings, machinery, auxiliary equipment, raw materials and finished and partly finished products. Economic growth involves a rise in productive capacities in the form of appropriately proportioned additions to the various components of these types of fixed and working capital, and an input-output model such as the multiregional world model that reflects the structural relations between stocks and flows is said to be dynamic rather than static.

In a dynamic input-output model the technical structure of newly created productive capacities is specified in an auxiliary matrix called a capital-coefficient table, whose entries represent the additional stocks of capital goods that (at a given state of the technology) each sector of the economy would have to acquire in order to increase the productive capacity of its plant by one unit of output [*see illustration on page 220*]. To take these capital coefficients into account a set of input-output equations more complex than those described above is constructed. It will not be necessary to describe the nature of this system of equations here. It is important to note, however, that since the multiregional model of the world economy is a dynamic one, the introduction of new technology into industrial processes registers in it as changes in both capital coefficients and input coefficients, and so technological changes are reflected in the equations from which projections are computed.

In the system of input-output equations derived from the capital and input coefficients for the world model there are only two types of variables: those representing sectoral outputs and those representing the final demands for goods and services. Obviously there are many other factors that determine the state of the world economy at any given time, and such factors do enter into the world model, through a subsidiary set of equations that serve to compute the final demand for each commodity in the economy. Overall more than 200 variables enter into these equations, ranging from the traditional macroeconomic aggregates and demographic quantities to geological variables that describe the condition of the land and the reserves of natural resources in the 15 regions of the world model. In this way a detailed representation of the world economic system is ensured.

To create a structural input-output table for the world economy the 15 sets of coefficients describing the technical structure of the different regions in the world model are arranged (in decreasing order of the per capita income of their respective regions) along the diagonal of a large, empty matrix [*see illustration on page 222*]. Each of these individual building blocks consists of 175 rows and 275 columns: the square technical-coefficient matrix for each re-

Industry number		Livestock and livestock products	Agricultural crops	Forestry and fishery products	Agricultural, forestry and fishery services	Iron and ferroalloy ores mining
	Industry number	1	2	3	4	5
1	Livestock and livestock products	1.45776	0.04320	0.01794	0.10723	0.00131
2	Agricultural crops	.36926	1.04669	.01665	.06182	.00119
3	Forestry and fishery products	.00203	.00065	1.00493	.00363	.00067
4	Agricultural, forestry and fishery services	.05760	.04167	.02585	1.03749	.00122
5	Iron and ferroalloy ores mining	.00063	.00061	.00123	.00070	1.02225
6	Nonferrous metal ores mining	.00090	.00134	.00140	.00111	.01340
7	Coal mining	.00251	.00226	.00160	.00244	.01091
8	Crude petroleum and natural gas	.01624	.02317	.01686	.01950	.01784
9	Stone and clay mining and quarrying	.00194	.00400	.00067	.00185	.00651
10	Chemical and fertilizer mineral mining	.00118	.00284	.00041	.00093	.00049
11	Maintenance and repair construction	.02547	.02522	.00875	.02886	.05205
12	Ordnance and accessories	.00003	.00003	.00003	.00007	.00003
13	Food and kindred products	.22235	.01087	.03972	.03916	.00357
14	Tobacco manufactures	.00010	.00007	.00012	.00021	.00017
15	Broad and narrow fabrics, yarn and thread mills	.00230	.00252	.01588	.00764	.00172
16	Miscellaneous textile goods and floor coverings	.00262	.00300	.02839	.01329	.00117
17	Apparel	.00049	.00034	.00101	.00085	.00048
18	Miscellaneous fabricated textile products	.00087	.00101	.01100	.00409	.00072
19	Lumber and wood products except containers	.00463	.00479	.00523	.00778	.00726
20	Wood containers	.00172	.00375	.00026	.00488	.00011

INVERSE COEFFICIENT TABLE, derived from the technical-coefficient table for a particular economy, shows the direct and indirect relations among the various producing sectors of the economy. Each column of the matrix lists the increases in the total output of the various sectors of the economy that would be required to deliver to final users an additional unit of the output of the sector associated with that column. The interdependence of all the sectors of a developed modern economy is so great that each sector contributes if not directly then indirectly to the production of every commodity delivered to final users. Hence, as is shown in this section of the 1972 inverse coefficient table of the U.S. economy, inverse table has no zero entries.

gion is made rectangular by the addition of the coefficients corresponding to supplementary variables. The dimensions of the larger matrix are somewhat more than 15 times 175 by 275, however, so that space is provided for two additional blocks of trade coefficients, which depict the flow of goods and services among the various regions in the model. This complex linkage mechanism describes not only the exports and imports of some 40 classes of goods and services but also capital flows, aid transfers and foreign interest payments, and the precise character of the coefficients in the linkage mechanism is based on the introduction of imaginary world "trade pools" into the analysis of interregional exchanges.

More precisely, in a world input-output model although the production and consumption of those goods and services that are not involved in interregional trading must be balanced within each region, just as they are in a national input-output model, the production and consumption of commodities that are transferred from region to region have to be balanced only for the world as a whole. Thus a set of equations that express the existence of such a worldwide input-output balance for each of the interregionally traded commodities must be tied into the internal commodity-balance equations of the 15 regions of the world model. The coefficients for these trade equations are derived by treating the quantity of each particular type of commodity exported from a given region as a predetermined share of the aggregate world exports of that commodity and the quantity imported into the region as a fixed proportion of the total amount consumed in that region, as if all the exports of each interregionally traded commodity were delivered to a single worldwide trading pool from which imports were then drawn.

$$
\begin{array}{ccccc}
x & - & Ax & = & y
\end{array}
$$

$$
\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} - \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}
$$

$$
\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} - \begin{bmatrix} a_{11}x_1 + a_{12}x_2 + a_{13}x_3 \\ a_{21}x_1 + a_{22}x_2 + a_{23}x_3 \\ a_{31}x_1 + a_{32}x_2 + a_{33}x_3 \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}
$$

$$
\begin{bmatrix} x_1 - a_{11}x_1 - a_{12}x_2 - a_{13}x_3 \\ x_2 - a_{21}x_1 - a_{22}x_2 - a_{23}x_3 \\ x_3 - a_{31}x_1 - a_{32}x_2 - a_{33}x_3 \end{bmatrix} = \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix}
$$

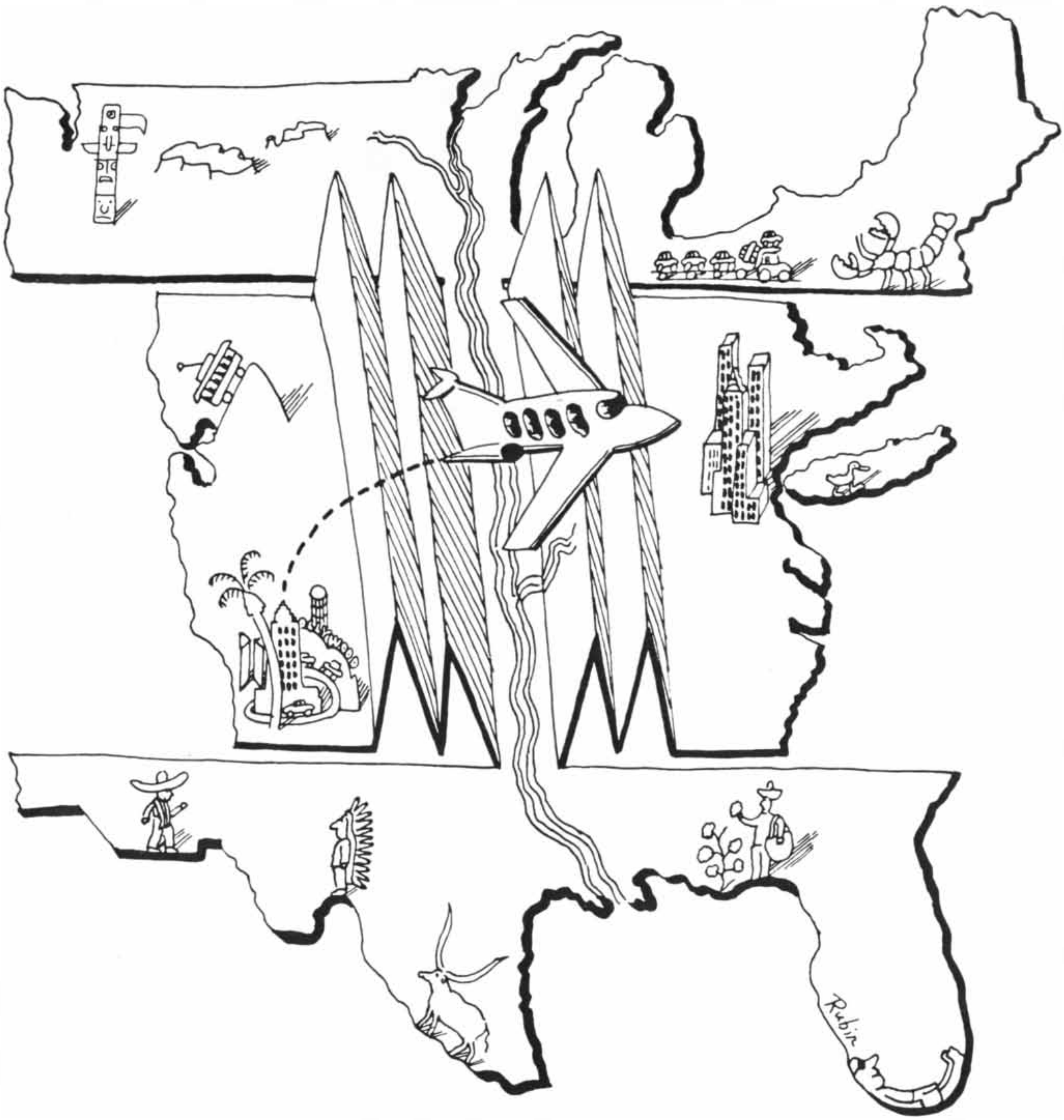
$$
\begin{aligned}
x_1(1-a_{11}) - a_{12}x_2 - a_{13}x_3 &= y_1 \\
x_2(1-a_{21}) - a_{22}x_2 - a_{23}x_3 &= y_2 \\
x_3(1-a_{31}) - a_{32}x_2 - a_{33}x_3 &= y_3
\end{aligned}
$$

SYSTEM OF EQUATIONS (*gray block*) from which projections of future economic development can be made are constructed from the empirically determined interindustry matrix of technical coefficients (*colored block*) for the economy under consideration. The matrix equation $x - Ax = y$ expresses the necessarily balanced relations among the levels of output of all the productive sectors of the economy (listed in the column vector x) and the quantities of their respective products delivered to final users (listed in the column vector y). This balance depends on the technical-coefficient matrix for the economy A, or more precisely on the vector Ax, which describes the goods and services absorbed in the production of the outputs listed in x. Substituting the appropriate matrixes into the equation $x - Ax = y$ (here those that symbolically describe a three-sector economy) and carrying out the required matrix arithmetic gives rise to a system of linear input-output equations. Since there are more variables than equations in the system, some of the variables must be fixed before the equations can be solved simultaneously. By fixing different variables and by changing the magnitude of fixed variables it is possible to apply the equations to generate a variety of projections concerning the development of the economy.

The coefficients for the equations that secure the balance between the production and the consumption of goods throughout the worldwide system are arranged in two blocks on the world input-output matrix, one running along the right-hand side and the other running along the bottom. (The large areas of empty space off the main diagonal of the matrix that are not accounted for by these two sets of coefficients can be considered to be filled with zeros.) The entries in the block to the right of the main diagonal are export coefficients, specifying the shares assigned to the different exporting regions by the imaginary international pools through which the trade in each particular commodity flows. The entries in the block below the main diagonal are import coefficients, specifying the regional import demands for each commodity calculated as a fixed percentage of each region's total domestic requirement for that commodity. (It is interesting to note that the process of "import substitution," which often plays an important part in discussions of industrialization, can be described concisely as a reduction in the magnitude of appropriate import coefficients.)

The introduction of imaginary world-trade pools into the world input-output model precludes analysis of the bilateral, or region-to-region, transfers that actually link the 15 regions in it, but this limitation should not be viewed as a weakness of the model. Analyzing trade balances and the international division of labor that sustains them presents problems that are best excluded from the workings of the model. Employing trade pools to describe the interregional flows of goods and services allows the world input-output model to be compatible with current theory with-

Imagine a jet engine that cuts one hour off the L.A. to New York run.



out relying unduly on the practical applicability of such theory.

As one might expect, applying input-output analysis to the world economy presents practical problems as well as theoretical ones. Assembling the thousands of numbers needed to implement the model was a formidable task. In putting together the world input-output model the bulk of the information about the technical structure of modern manufacturing, mining, transport, service industries and agriculture—the set of input coefficients for a world structural matrix—was derived from the existing tables for the developed countries, in particular the U.S. table for 1967 and the version of that table updated to 1970. The usefulness of the tables for most of the less developed countries was greatly diminished by incompatibilities in both the schemes for classifying economic activities and the conventions for the measurement of various types of transactions. On the other hand, national-income accounts, foreign-trade statistics and demographic statistics compiled by the UN and its affiliated organizations turned out to be treasure troves of systematically organized data, without which it would have been impossible to complete a base-year description of the world economy.

		Agricultural Crops	
…		…	
…		…	
…		…	
Metal cans		0	
Metal barrels, drums and pails		0	
Metal sanitation and plumbing products		0	
Nonelectrical heating equipment		0	
Fabricated structural-metal products		0.010305	
Screw-machine products and stamping		0	
Coating and plating		0	
Miscellaneous fabricated-metal products		0.004004	
Engines and turbines		0.036121	
General industrial machines and equipment		0.005974	
Machine-shop products		0	
Farm machinery		0.321164	
Construction machinery		0	
Mining machinery		0	
Oil-field machinery		0.008339	
Material-handling machinery except trucks		0.002851	
Industrial trucks and tractors		0.001907	
Metalworking machinery		0.000381	
Special-industry machinery		0.008089	
Automobiles		0.064838	
Trucks, buses, etc.		0.036630	
Aircraft and parts		0.001048	
Ship- and boatbuilding and repairs		0	
Locomotives and rail- and streetcars		0	
Cycles, trailers, etc.		0.003954	
Electric measuring instruments		0.003985	
Electric motors and generators		0.000397	
Industrial controls, etc.		0.001573	
Electric lamps and fixtures		0.000128	
Electronic components and accessories		0.000183	
Miscellaneous electrical machinery		0.000232	
Service-industry machinery		0.026472	
Household appliances		0.008185	
Radio, television and communication equipment		0.008345	
Scientific instruments, etc.		0.001059	
Medical, surgical and dental instruments		0	
Watches, clocks and parts		0	
…		…	
…		…	

CAPITAL-COEFFICIENT TABLE is employed in conjunction with technical-coefficient table to create a dynamic model of a particular economy, that is, a set of input-output equations that reflect not only the absorption of current inputs of labor, energy and various services and materials but also the creation of additional productive capacities through the acquisition of machinery, buildings and other capital goods. With the same basic format as an input-output table, a capital-coefficient matrix displays in each column the stocks of capital goods that the sector of the economy associated with that column must obtain (from the other sectors including itself) in order to increase the productive capacity of its plant by one unit. For example, the section of the 1972 capital-coefficient table for the U.S. economy shown here depicts some of the investments that would be required to increase the productive capacity of the agricultural-crops sector. The level of the investment flows specified in a capital-coefficient table for a particular economy can be tied into the economy's network of input-output flows specified in the technical-coefficient table by means of an appropriate system of input-output equations.

In the long run the most important aspect of economic development is probably the incorporation of technical knowledge into industrial and agricultural processes. For the developed countries this growth takes the form of the introduction of new technologies and even new commodities; for the less developed countries it generally involves the adoption or adaptation of technologies already incorporated in the industrial recipes of the more advanced countries. These transformations are reflected in the input-output structure of an economy by the continual replacement of old input and capital coefficients by new ones. In fact, since such technological transfer is closely associated with the economic advance of less developed regions (as measured by rises in their per capita income), in preparing a structural data base for implementing the world model it was also necessary to assemble series of what might be called structural templates: arrays of capital and input coefficients incorporating an increasingly advanced technology.

In the course of computing a projection, as the computer programs for implementing the world model advanced in their calculations from the base year 1970 to 1980, 1990 and finally 2000, the templates in these series were inserted one after the other into the world input-output matrix. A similar procedure was applied to estimate the prospective changes (for the most part decreases) in the magnitude of labor input coefficients resulting from the introduction of improved technology and also the prospective changes (for the most part increases) in the input and capital coefficients describing mining and other extractive industries reflecting future shifts to less accessible reserves of primary resources. Gradual changes in export shares and import coefficients were also registered in the model and played an important part in projecting the future flows of interregional trade. (In discussing changes in technical structure it is important to avoid confusing two related but essentially different notions: technology in the sense of technical knowledge and technology in the sense of such knowledge incorporated into working industrial processes. The development of the first type of technology necessarily precedes that of the second.)

The multiregional input-output model—the complex data bank and the set of linear equations describing the world economic system together with the computer programs devised to make use of them—is not a special-purpose

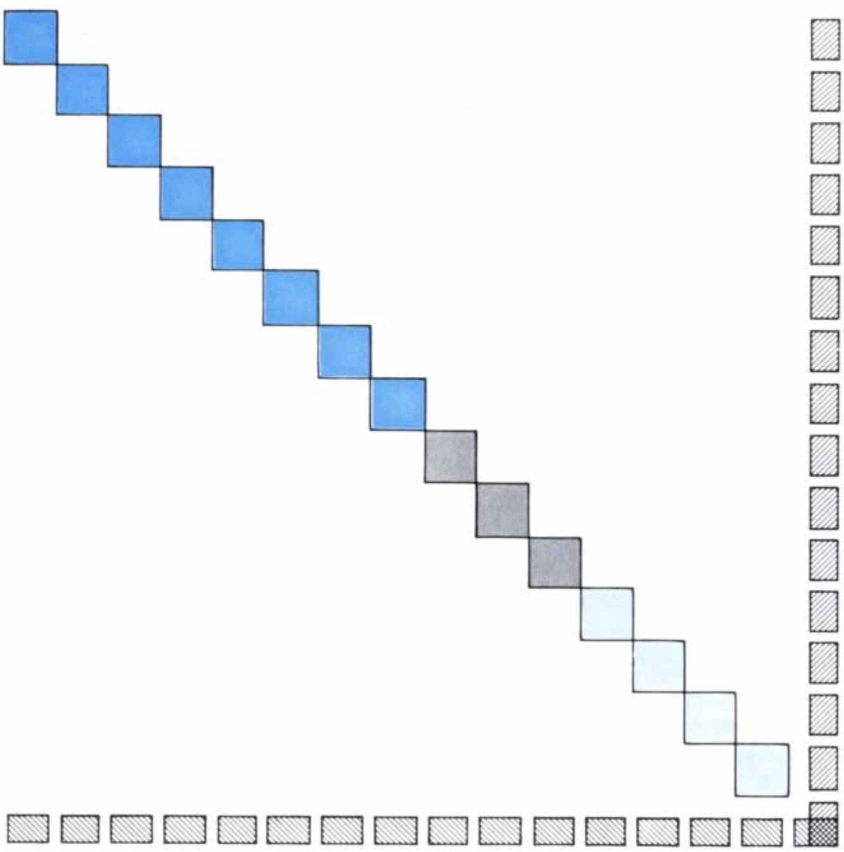
tool but one that, when it is provided with sufficient data, can be applied to a wide variety of tasks. In what follows I shall describe three alternative projections of world economic growth that have been carried out with the model. Each of these projections has a direct bearing on the future of the resource-poor less developed regions, which in 1970 accounted for 59 percent of the world's total population but produced only 15 percent of the total goods and services delivered to final users.

The first projection describes the development of the world economy through the year 2000 on the assumption that international economic relations will continue to be ruled by what might be called the old economic order. This is a conservative scenario in which it is assumed that the economic relations (in terms of trade, foreign aid and so on) between the developed and the less developed regions will be governed in the future as they have been in the past by financial and credit policies designed to maintain a strict balance-of-payments equilibrium for each region. More precisely, the scenario assumes that the annual difference between the total value of the goods and services exported from a particular region and the total value of those imported into it will continue to be financed exclusively by commercial borrowing in conjunction with what are currently considered normal levels of private capital transfers and governmental assistance. In other words, according to this scenario, in the future the richer, capital-exporting regions will transfer to the poorer, capital-importing ones approximately the same fraction of their national income (in the form of credits and foreign investments) that they did in the past, or before the base year 1970. Conversely, the poorer regions will have access to the same fraction of the worldwide pools of capital and aid provided by the richer regions that they did before 1970. (Since 1970 the resource-rich less developed regions have joined the developed ones in providing such funds.)

The projection based on these conservative assumptions takes the form of a 20-page computer printout describing in detail the state of the individual regional economies in the world model as well as the relations among them. The results of the projection can nonetheless be summarized concisely. To begin with, under the old-economic-order scenario the average per capita income in each of the three main groups of regions can be expected to increase. On the other hand, the income gap between the developed regions and the resource-poor less developed ones tends to grow through 1990. Indeed, in spite of the fact that the rate of growth of the developed regions decelerates from 1990 to 2000, whereas the rate of growth of the less developed regions accelerates, by the year 2000 the difference in the incomes of the regions in the two groups is projected to be somewhat greater than it was in 1970, both in relative and in absolute terms [*see illustration on page 226*]. In fact, under the stringent but not unrealistic conditions imposed by the old-economic-order scenario some of the less developed regions of the world would face an absolute decline in their standard of living.

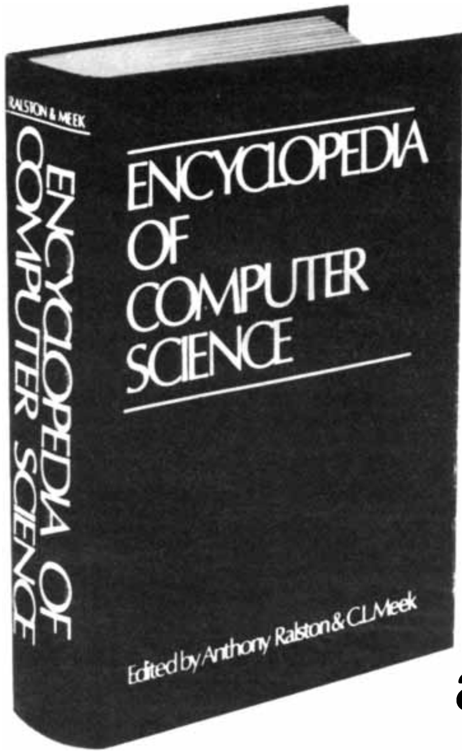
To what extent do these conclusions depend on the specific starting assumptions concerning future rates of population growth? The computations described above were based on the prediction that the population growth for each of the countries in the 15 world regions will follow the middle path of the three alternative paths generally projected by UN demographers, but an identical set of computations were also carried out, each one starting from a different combination of predictions about population growth in the three groups of regions. The period of 30 years from 1970 to 2000 is not long enough to allow the demographic structure of even a single region to adjust fully to the most drastic shifts in birth or death rates. Nevertheless, by studying the direction of the relatively small changes in developmental trajectories that can be distinguished in the resulting projections it is possible to make an assessment of the long-term economic repercussions of such shifts.

This set of projections demonstrates that the global per capita income obtained by averaging across the 15 regions in the world model is highest when the projected rates of population growth for both the developed regions and the two groups of less developed regions are low. The intermediate population-growth rates that were employed in computing the first projection result in a lower global income, and shifting to high population-growth rates reduces



GLOBAL STRUCTURAL MATRIX, shown schematically, represents each region of the world model by a 175-by-275 matrix of technical, capital and other types of coefficients. These 15 dynamic input-output matrixes, representing the eight developed regions of the world model (*dark color*), the three resource-rich less developed regions (*gray*) and the four resource-poor less developed regions (*light color*), are arranged along the diagonal of the global matrix. The complex network of commodity flows that link these regions is represented by two blocks of trade coefficients (*hatching*), one appearing along the bottom of the global matrix and one along the right-hand side. Model of the world economy derived from this matrix includes both "domestic" equations, which secure the balance of goods and services that flow exclusively within a region, and global equations, which secure the balance of interregional imports and exports, capital flows and payments. (In global matrix empty spaces can be considered filled with zeros.)

Take this $60.00 classic for $3.00



Encyclopedia of Computer Science

Edited by Anthony Ralston and Chester L. Meek. More than 1550 outsize pages of information on every aspect of computer science—from algebra to automata theory, from basic terminology to string processing languages. 470 articles by 208 experts. Over 700 charts, tables, graphs, and diagrams.

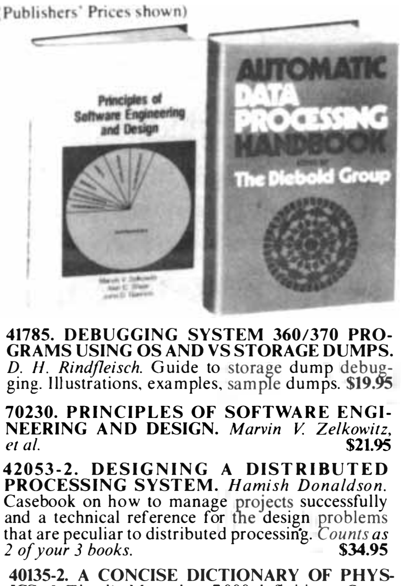
OR 3 other books for only $1.00 each *(values to $74.95)*

if you will join now for a trial period and take only 3 more books—at handsome discounts—over the next 12 months.

As your introduction to

The Library of Computer and Information Sciences

(Publishers' Prices shown)



41785. DEBUGGING SYSTEM 360/370 PROGRAMS USING OS AND VS STORAGE DUMPS. *D. H. Rindfleisch.* Guide to storage dump debugging. Illustrations, examples, sample dumps. **$19.95**

70230. PRINCIPLES OF SOFTWARE ENGINEERING AND DESIGN. *Marvin V. Zelkowitz, et al.* **$21.95**

42053-2. DESIGNING A DISTRIBUTED PROCESSING SYSTEM. *Hamish Donaldson.* Casebook on how to manage projects successfully and a technical reference for the design problems that are peculiar to distributed processing. *Counts as 2 of your 3 books.* **$34.95**

40135-2. A CONCISE DICTIONARY OF PHYSICS. *J. Thewlis.* More than 7,000 definitions. *Counts as 2 of your 3 books.* **$50.00**

80150. STANDARDIZED DEVELOPMENT OF COMPUTER SOFTWARE. *Robert C. Tausworthe.* How to incorporate principles and techniques of structured programming in the development of large-scale systems. **$19.95**

80155. STANDARDIZED DEVELOPMENT OF COMPUTER SOFTWARE, PART II. *Robert C. Tausworthe.* A detailed set of rules for software implementation. Contains extensive appendices. **$21.95**

35450-2. AUTOMATIC DATA PROCESSING HANDBOOK. *The Diebold Group.* Auxiliary memory, peripherals, systems design, consultant services, software packages. *Counts as 2 of your 3 books.* **$38.95**

39890-2. COMPUTER DATA-BASE ORGANIZATION. *James Martin.* An invaluable planning tool having over 200 diagrams. *Counts as 2 of your 3 books.* **$26.50**

60385. MANAGING THE SYSTEMS DEVELOPMENT PROCESS. *Charles L. Biggs, et al.* **$24.95**

62620. MICROCOMPUTER HANDBOOK. *Charles J. Sippl.* Detailed reference to the technology and applications of microprocessors. **$19.95**

70110. PRINCIPLES OF DATA-BASE MANAGEMENT. *James Martin.* Covers data structures, security, file storage, real-time vs. non-real time, more. **$19.95**

79155. SOFTWARE INTERPRETERS FOR MICROCOMPUTERS. *Thomas C. McIntire.* **$18.95**

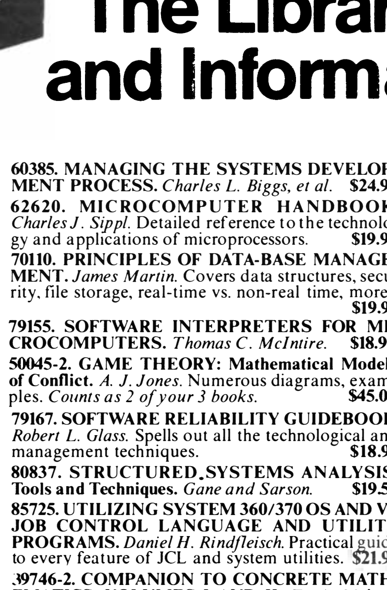
50045-2. GAME THEORY: Mathematical Models of Conflict. *A. J. Jones.* Numerous diagrams, examples. *Counts as 2 of your 3 books.* **$45.00**

79167. SOFTWARE RELIABILITY GUIDEBOOK. *Robert L. Glass.* Spells out all the technological and management techniques. **$18.95**

80837. STRUCTURED SYSTEMS ANALYSIS: Tools and Techniques. *Gane and Sarson.* **$19.50**

85725. UTILIZING SYSTEM 360/370 OS AND VS JOB CONTROL LANGUAGE AND UTILITY PROGRAMS. *Daniel H. Rindfleisch.* Practical guide to every feature of JCL and system utilities. **$21.95**

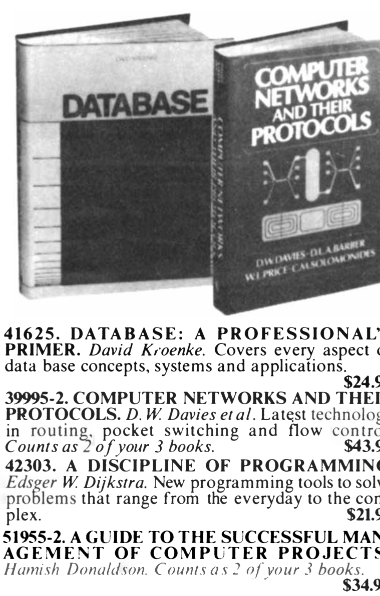
39746-2. COMPANION TO CONCRETE MATHEMATICS. VOLUMES I AND II. *Z. A. Melzak.* Mathematical techniques and various applications. *The set counts as 2 of your 3 books.* **$46.45**



70725. THE PROGRAMMER'S ANSI COBOL REFERENCE MANUAL. *Donald A. Sordillo.* **$22.50**

79150-2. SOFTWARE ENGINEERING. *Jensen & Tonies. Counts as 2 of your 3 books.* **$27.50**

50551. GRANTS: How to Find Out About Them and What to Do Next. *Virginia P. White.* **$19.50**



41625. DATABASE: A PROFESSIONAL'S PRIMER. *David Kroenke.* Covers every aspect of data base concepts, systems and applications. **$24.95**

39995-2. COMPUTER NETWORKS AND THEIR PROTOCOLS. *D. W. Davies et al.* Latest technology in routing, pocket switching and flow control. *Counts as 2 of your 3 books.* **$43.95**

42303. A DISCIPLINE OF PROGRAMMING. *Edsger W. Dijkstra.* New programming tools to solve problems that range from the everyday to the complex. **$21.95**

51955-2. A GUIDE TO THE SUCCESSFUL MANAGEMENT OF COMPUTER PROJECTS. *Hamish Donaldson. Counts as 2 of your 3 books.* **$34.95**

32485. ALGORITHMS + DATA STRUCTURES = PROGRAMS. *Niklaus Wirth.* A classic work on structured programming. **$20.95**

81845. SYSTEM/370 JOB CONTROL LANGUAGE. *Gary DeWard Brown.* Includes descriptions of hardware devices and access methods and reference to many useful JCL features. *Softcover.* **$13.50**

40065-2. COMPUTER STORAGE SYSTEMS AND TECHNOLOGY. *Richard Matick. Counts as 2 of your 3 books.* **$29.95**

54455. IMS PROGRAMMING TECHNIQUES: A Guide to Using DL/1. *Kapp and Leben.* Specific techniques to write application programs in ANS COBOL, PL/1, or Assembler Language in an IMS DL/1 data base environment. **$17.95**

If the reply card has been removed, please write to **The Library of Computer and Information Sciences, Dept. 7-AD7, Riverside, N.J. 08075** to obtain membership information and an application.

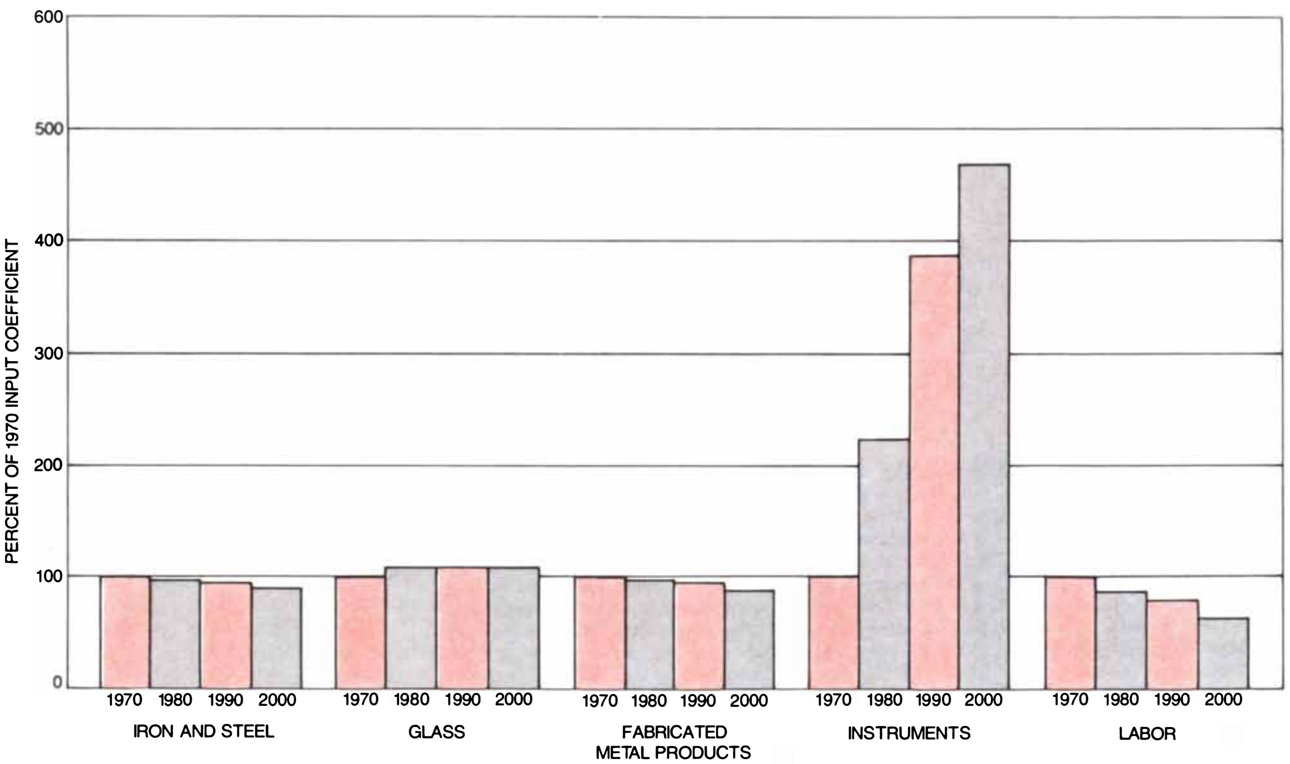
the global income still further. Moreover, if the rates of population growth in any two of the groups of regions are assumed to be constant, it can be shown that the same inverse relation between population growth and the global per capita income holds for the remaining group.

In addition, combining the resource-rich and resource-poor less developed regions into a single classification and comparing their projected growth in per capita income to that of the developed regions reveals that a shift from a low population trajectory to a high one in either of the groups invariably brings about an increase in the income of the other group. In other words, a change in the rate of population growth that has adverse effects on the economy sustaining it turns out to be quite beneficial for the other economies of the world. A plausible explanation for this phenomenon can be obtained by examining the corresponding total income figures (as opposed to the per capita ones) for the regions of the world model. An accelerated rate of population growth within a given region depresses that region's per capita income level, but it tends to raise the region's aggregate G.N.P. and total volume of external trade. This increased trade level in turn benefits the region's trading partners and increases their per capita income.

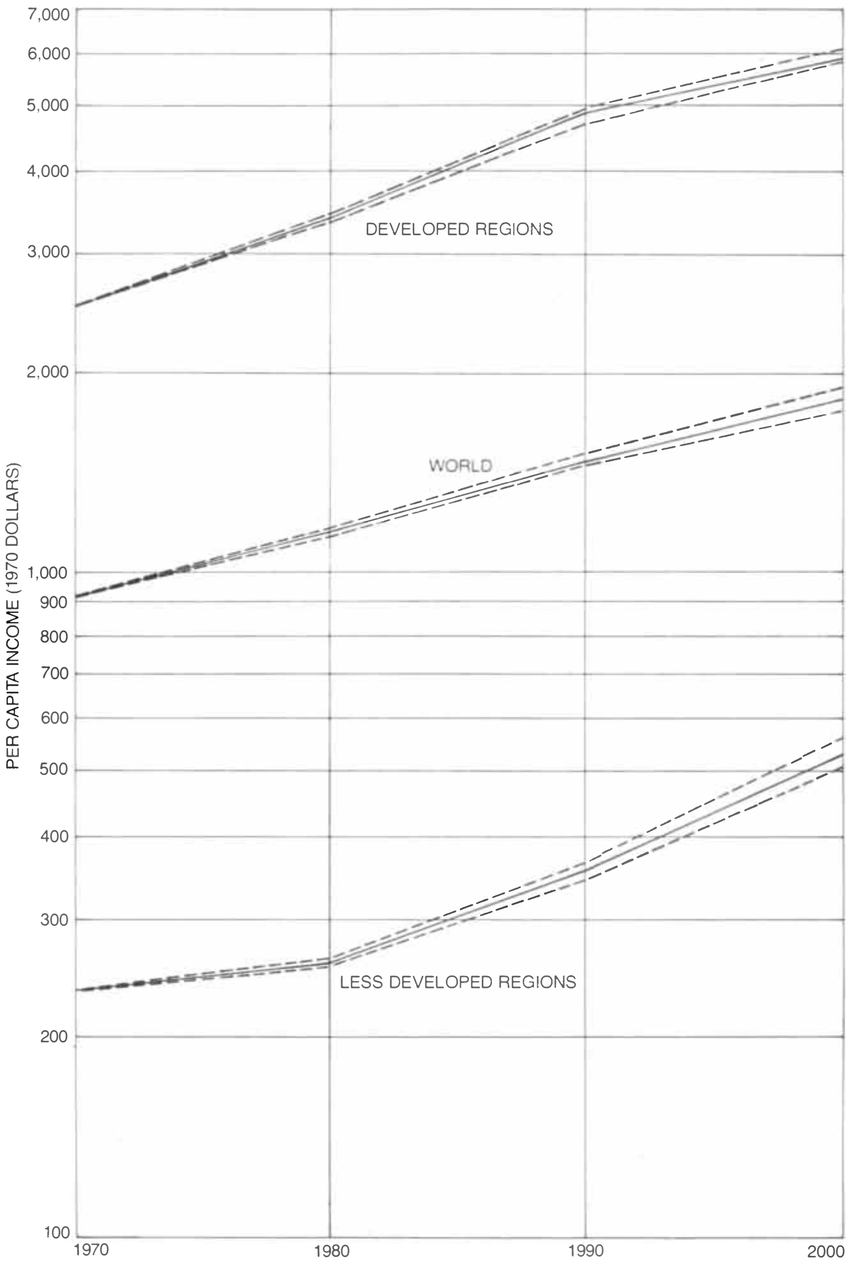
In spite of the variations in the projected income levels arising from different assumptions about the world's future population growth, the conclusions that must be drawn from the preceding projections are clear. Under the conditions imposed by the old economic order, although most of the less developed regions should advance economically and some can even be expected to develop quickly over the next decades, the gap between the developed regions and the resource-poor less developed ones can hardly be expected to diminish substantially by 2000.

There are, however, alternatives to the course of world development dictated by the old economic order. For the purposes of comparison the multiregional input-output model was also applied to prepare a projection concerning the future of the world economy under what might be called the new economic order. This is a highly optimistic scenario, which assumes that in the future the developed and resource-rich less developed regions will be willing to grant to the resource-poor less developed regions economic assistance in whatever amounts are required to reduce the income gap between the developed regions and the resource-poor less developed ones 50 percent by the year 2000. Whether this plan is politically viable, of course, has yet to be determined, but the multiregional input-output model can serve to calculate its economic implications.

To project the future of the world economy under the new economic order it was necessary to compute the changes in outputs, investments, personal and public consumption and regional imports and exports (starting from 1970 levels) that would be required from all regions of the world model to secure prespecified income targets for the resource-poor less developed regions by the year 2000. The attainment of these ambitious goals is made possible in this scenario by freeing the resource-poor less developed regions from the strict balance-of-payments requirements imposed on them under the old economic order. In other words, the quantities of goods and services imported into the poorer regions are determined by their developmental needs, not by their ability to pay for such imports. (In terms of the formal mathematical structure of



PROSPECTIVE CHANGES in technical coefficients relating to the production of automobiles in the U.S. between 1970 and the year 2000 are shown by these bars. Such significant changes, which arise from the introduction of advanced technology into the industrial and agricultural processes of an economy, play an important part in determining the economic growth of less developed regions. In order to make projections concerning future world economic development it was necessary to construct a series of arrays of capital, input and other types of coefficients incorporating increasingly advanced technology. These were inserted into the global structural matrix as the computer programs for implementing the world model moved in their computations from base year 1970 to 1980, 1990 and finally 2000.



PROJECTED GROWTH IN PER CAPITA INCOME for the developed regions, the less developed regions and the world as a whole is shown in this graph. (The vertical scale is logarithmic, so that curves with equal slopes represent equal percentage rates of growth.) Here the multiregional input-output model of the world economy was applied to the projection of future income levels under a set of conditions that can be called the old economic order. This scenario for world development assumes that economic relations between the developed and the less developed regions will continue to be governed by current strict policies concerning credit and balance of payments. The scenario also assumes that in the future the richer, capital-exporting regions of the world will transfer to the poorer ones approximately the same fraction of their national income (in the form of credits and foreign investments) that they did before 1970. The solid lines show the projections for this scenario based on the intermediate United Nations estimates of world population growth, in which between 1970 and 2000 the population of the developed regions is expected to grow from 1.108 billion to 1.435 billion and the population of the less developed regions from 2.512 billion to 4.813 billion. The set of projections demonstrates that with this conservative scenario in the year 2000 the gap in income between the developed regions and the less developed regions should be somewhat greater than it was in 1970, both in relative and in absolute terms. The broken lines show the corresponding projections based on the most extreme estimates of population growth for the developed regions and the less developed regions, demonstrating that assumptions about future population levels have little effect on the outcome of the old-economic-order scenario over this period of time.

the world model this means that some of the model's input-output equations, namely those expressing the strict balance-of-payments regulations, must be declared invalid and dropped from the system. On the other hand, fixing the future income levels of the resource-poor less developed regions reduces the number of unknown variables in the system. In fact, if no equations were dropped, the system would be overdetermined, that is, the number of equations would exceed the number of remaining variables, and no solution would be possible.)

To provide a quantitative measure of the amount of assistance the resource-poor less developed regions would have to receive year after year under the new economic order it was also assumed in the formulation of this scenario that the import surpluses, or equivalently the balance-of-payments deficits, of those less developed regions would be financed each year by extraordinary credits granted by the developed and resource-rich less developed regions: credits carrying a nominal annual interest rate of 5 percent on accumulated debts. The projected volume of such extraordinary noncommercial borrowing (or lending, if it is viewed from the vantage of the developed and resource-rich less developed regions) provides a measure of the cost of implementing the new-economic-order scenario.

The projection based on the new set of assumptions shows that since the developed regions would be required to work overtime in order to be able to provide the huge amounts of economic aid that would be required under this scenario, their G.N.P. would be somewhat larger in 2000 than it would be under the old economic order, but since a larger part of their total output would have to be exported, their per capita consumption of commodities would be slightly lower. (In general, the shift from the first scenario to the second has a smaller effect on the developed regions than it does on the less developed ones; after all, if one region has a total income of $1 billion and another has a total income of only $100 million, then a transfer of $50 million from the first to the second represents a 50 percent gain for the poorer country but only a 5 percent loss for the richer one.)

The projection also reveals that the massive developmental drive envisioned under the new economic order would call for the financing of an increasingly large part of the steadily growing imports of the resource-poor less developed regions by means of extraordinary loans. By the year 2000 the exports from these regions would pay for only 25 percent of their annual imports, and the other 75 percent would have to be obtained on credit. Indeed, by

Side-tracked onto the wrong desk, swirling in a maelstrom of printed matters, these lost magazines are perused, scissored, paper-clipped, stapled or shuttled into the outbox by parties unknown.

The Dial, on the other hand, goes directly into the The Great Person's home, climbs up onto the tv set and *stays* there. For one whole month.

T.G.P. turns to it at a relaxed and reflective time, when there's nobody around except him and her and maybe the wee ones.

Short of advertising in a sex manual, it's hard to imagine a more intimate environment.

HOW TO ADVERTISE TO PEOPLE WHO SHUN ADVERTISING. We all benefit from candid criticism, so come on, honestly, even if you're *in* advertising, don't you find many tv commercials strident, stupid, or worse?

Public tv viewers do, and knowing that you won't be ambushed by Mr. Whipple is one of the serene satisfactions of watching public tv.

But if you were to conclude, therefore, that The Dial's readers are anti-advertising, you'd be wrong.

These are hardly communists. They're bringing home large amounts of capitalist money, intending to do lots of capitalist things with it and relying on advertising to help them choose—provided, of course, that the advertising doesn't insult their intelligence.

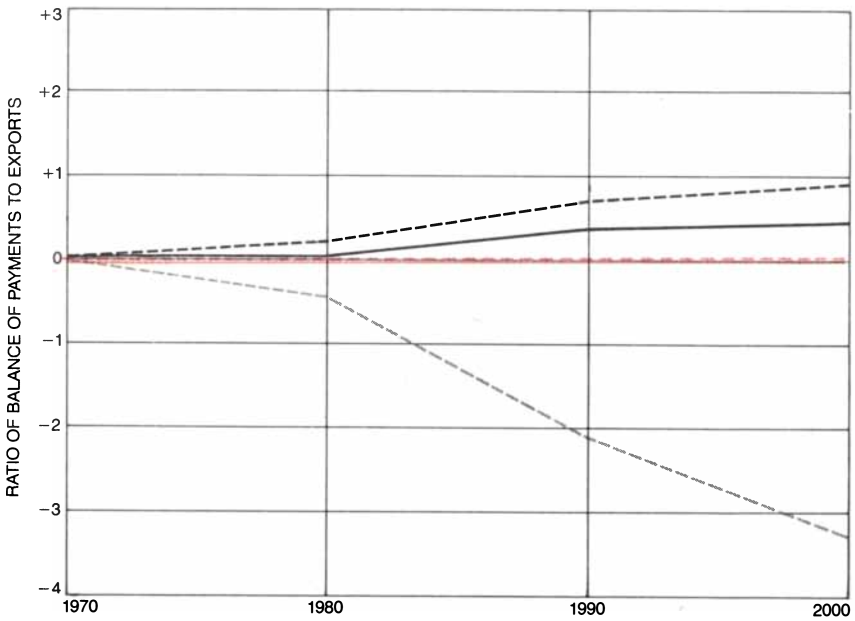
If your ad is good, it will work in The Dial, and work *well.*

If it isn't good, shouldn't you be doing something about *that*?

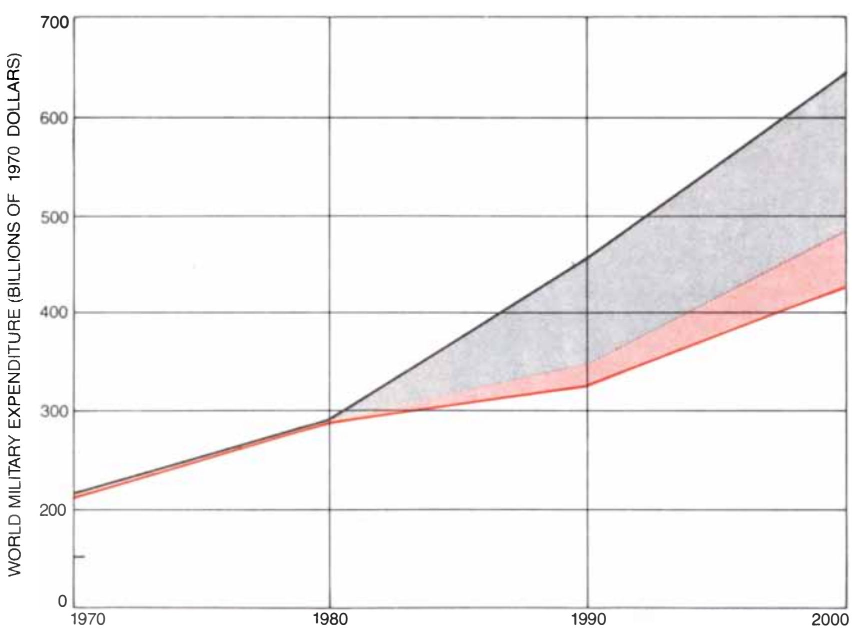
SHARE YOUR CUSTOMERS' PREJUDICES. The Dial's readers will know that advertising generates funds for public tv. So your ad in The Dial sends a clear signal that you share one of our readers' fondest prejudices.

They want good tv. *You* want good tv. And both of you put your money where your mouths are.

THE DIAL: The guide to public tv



RATIO OF BALANCE OF PAYMENTS TO EXPORTS is projected for the developed regions (*light color*), the resource-rich less developed regions (*black*) and the resource-poor less developed regions (*gray*) under two sets of assumptions about future world economic relations: the old-economic-order scenario (*solid lines*) and the new-economic-order scenario (*broken lines*). The new-economic-order scenario assumes that in the future the developed and resource-rich less developed regions of the world will be willing to allocate to developmental assistance whatever resources are required to reduce the income gap between the developed and the resource-poor less developed regions 50 percent by the year 2000. To make this goal attainable it is also assumed that the resource-poor less developed regions will be allowed to expand their imports as much as is needed to maintain their specified income targets, so that they will be released from the strict balance-of-payments requirements imposed on them under the old economic order. The steep decline in the curve representing the resulting ratio of the balance of payments to exports for the resource-poor less developed regions provides a measure of the cost of implementing the new economic order for the other regions of the world model.



ARMS-LIMITATION SCENARIO assumes that in the year 2000 the total world expenditure for the maintenance of military establishments (*colored line*) will be 35 percent less than it is projected to be under the old-economic-order scenario (*black line*). As is shown here, it is also assumed that the bulk of the resources made available by the limitation of military spending (*gray*) will be allocated to increase civilian domestic consumption and investment in the regions where they originated, mainly the developed ones. The remaining resources (*color*) would be allocated to increase nonmilitary foreign aid, mainly to the resource-poor less developed regions.

2000 it would be necessary for the developed regions to allocate 3.1 percent of their total G.N.P. to support such an effort. (The current figure is less than 1 percent.) On the whole this projection of the future development of the world economy under the new economic order suggests that the practical possibility of carrying out such an optimistic program must be seriously questioned.

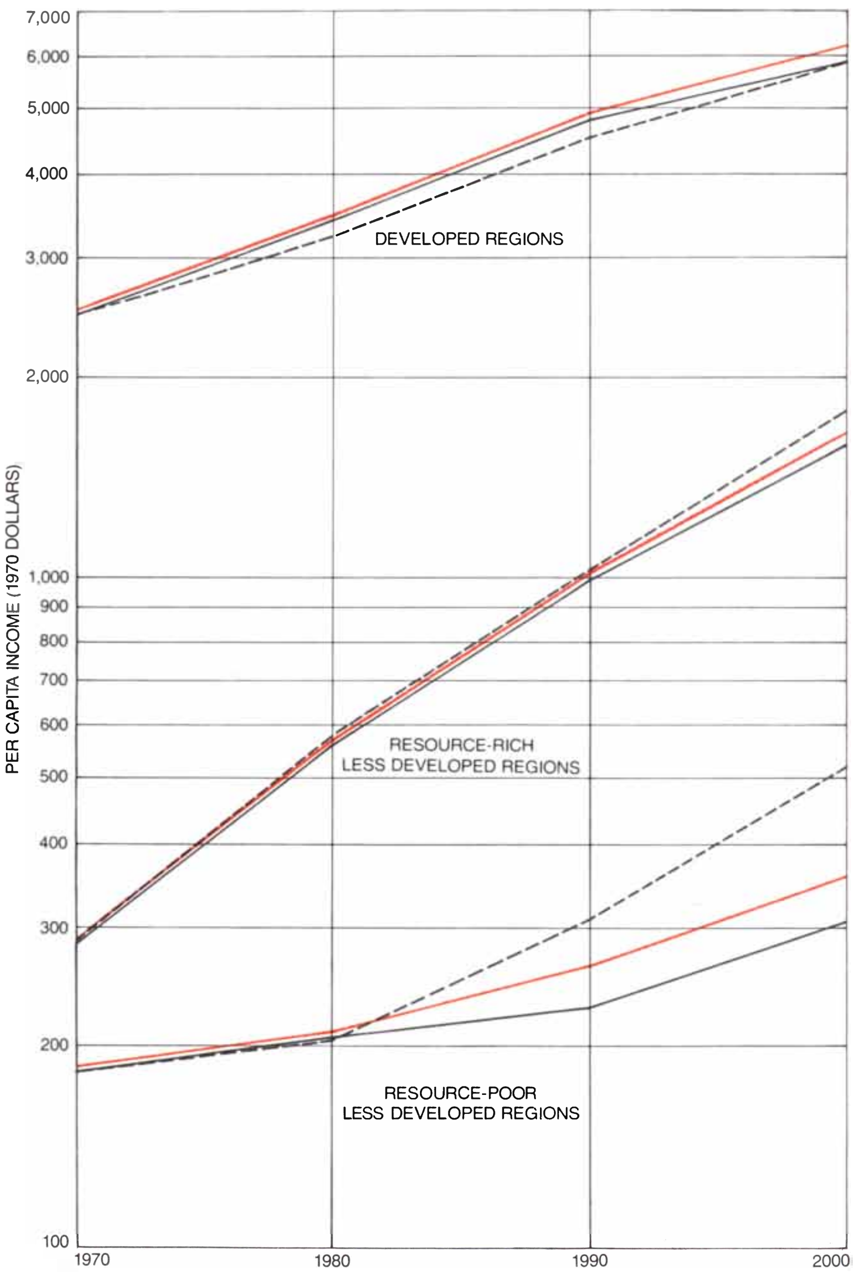
The last projection made with the multiregional input-output model of the world economy I shall discuss here is based on what might be called the arms-limitation scenario. The more than $450 billion per year currently spent on the maintenance of military establishments throughout the world (which is equivalent to $290 billion at the much lower 1970 prices) is the largest existing economic reserve that might be utilized to accelerate the growth of the resource-poor less developed regions. In addition some of the funds that would be made available by an international agreement to limit military spending could well serve to bring about marked improvement in the economic position of the lower-income groups within the developed regions.

The arms-limitation scenario specifies a hypothetical reduction in future military spending to levels below those that can be expected under the old economic order. According to the old-economic-order scenario, in the future all the regions of the world model will devote to military purposes the same fraction of their respective regional incomes that they did in 1970. Moreover, under this scenario a provision is made for the maintenance of parity in military spending between the U.S.S.R. and the U.S. (For strategic reasons the amounts allocated to military needs by the U.S.S.R. and the U.S. tend always to be about equal. At present, however, the national income of the U.S.S.R. is only slightly more than half that of the U.S., so that it devotes nearly twice as large a percentage of its income to military spending. On the other hand, according to most projections, the Russian economy will grow somewhat faster than the U.S. economy up to the year 2000, so that as long as military parity is maintained the difference between those two percentages will gradually decrease.)

For the purposes of the arms-limitation projection it was assumed that by the year 2000 the combined military expenditures of the U.S.S.R. and the U.S. will be reduced to two-thirds of the level they are projected to reach under the old-economic-order scenario. It was also assumed that all the other regions of the world model will cut their military spending 25 percent by the year 1990 and 40 percent by the year 2000. The arms-limitation scenario specifies that the "savings" realized in each region from the cuts will go first of all to the satisfaction of its own civilian needs but that by 1990 the developed regions will allocate 15 percent of the savings to developmental aid and that by 2000 they will allocate 25 percent. The redistribution of these savings, which gives rise to changes in the levels of production, consumption and investment for each sector in the world model with corresponding changes in the interregional commodity flows, is determined by the sets of technical and other structural parameters incorporated into the input-output model of the world economy.

An idea of the advantages of the arms-limitation scenario for world economic development can be gained by comparing the aggregate results of the projection based on these assumptions with the projections describing the world economy under the old economic order and the new [*see illustration at right*]. To begin with, given the developmental assistance provided under the arms-limitation scenario both the per capita income and the per capita consumption of the resource-poor less developed regions can be expected to increase far quicker than they would under the old economic order. (In the new-economic-order scenario such growth is of course fixed from outside the system.) In addition under the arms-limitation scenario, which provides for assistance to the resource-poor less developed regions in the form of direct aid, the projected trade deficit of those regions is smaller than it would be under the old economic order and naturally much smaller than it would be under the new one. Finally, since the arms-limitation scenario specifies that part of the savings resulting from reduced military spending must go to increasing civilian consumption and investment in the developed regions, the projected levels of per capita income of those regions are higher with this scenario than they are with either of the others. Therefore a comparison of the three sets of projections made with the multiregional input-output model of the world economy clearly indicates that the reallocation of economic resources arising from the kind of international arms-limitation agreement that has been suggested repeatedly, both formally and informally by individuals and organizations inside and outside the UN, is by far the most promising of the three schemes for world economic development.

Analysis of the kind that I have described here, dealing with the general prospects for development in the world economy, must of necessity draw pictures with only a few bold strokes, relying on aggregate figures such as average per capita incomes or net balances of payments to describe the economies of regions with hundreds of millions of people. The economic projections for these large regions and the factual data on which they were based, however, comprise tens of thousands of numbers describing the structure and the specific states of the world system in detail. Thus the construction of a multiregional input-output model of the world economy to some extent rescues economists from their traditional dilemma of having to choose between seeing the forest or seeing the trees. The model, which can describe the entire forest in terms of the individual trees (or at least in terms of the specified structural relations between small groves), serves as a valuable tool for tracing possible economic paths through the future.



PROJECTED ECONOMIC DEVELOPMENT of the developed regions of the world, the resource-poor less developed regions and the resource-rich less developed regions is shown to the year 2000 under the old-economic-order scenario (*solid black lines*), the new-economic-order scenario (*broken black lines*) and the arms-limitation scenario (*colored lines*). For the resource-poor less developed regions the levels of per capita income and consumption (not shown) grow much faster under the arms-limitation scenario than under the old-economic-order scenario, but not so fast as under new-economic-order scenario, where income targets are prespecified.