

Social scientists use the CRAY

# LARGE-SCALE NETWORK OF WORLD ECONOMY

"O f course it's appropriate that social scientists should be using the super-computer. We have very complex data," says Douglas White, professor of anthropology at the University of California, Irvine, and one of the first social scientists to compute on the SDCS CRAY. His project with David Smith, assistant professor of sociology at Irvine, is a large-scale network analysis of distributive social phenomena. They use an algorithm White developed with Karl Reitz of Chapman College. Called REGE-D (relational distance analysis), this algorithm measures the relative distances between structural positions occupied by networked entities linked by multiple relations. The results of this analysis, according to White, "are the first valid tests of several hypotheses about world-system structure and dynamics."

When social scientists use the term network, they refer to links among people or categories of people in social situations. Basically, these links range from the links of one person to links involving categories of persons or even links among organized role systems or groups.

From the time of one of his early studies of four communities in Tlaxcala, Mexico, in 1975, White has been using network analysis as a way of understanding social structure. Smith has specialized recently in the structure of the worldwide economy and international trade networks.

Their current research focuses on role structure networks, i.e., repeated interactions of the same kinds of people or groups with the same kinds of others, within the "community" of global economics. Or as White puts it, "We looked at what nations are *similar* in their patterns of trade with *similar* others; in other words, it's a recursive definition of trading equivalence." Such links are called parallel flow. Only after determining values for the parallel flow in world economic systems can the question of how this can be related to international development theory be handled.

One early global network analysis used a technique called block modeling, a quantitative method to sort nations into distinct strata on the basis of the similarity of their links to other

countries (via trade, treaties, military interventions, diplomatic exchange). The results suggested that nations of the world could be divided into three basic groups—core, periphery, and semiperiphery—and that these strata (identified by their equivalence in international relations) were related to national performance on a number of indexes of development (Snyder, D., and E. Kick: *American Journal of Sociology* 84, 1096, 1979). A second study focused exclusively on commodity exchanges and found a different classification of nations: core, periphery, strong semiperiphery, and weak semiperiphery (Nemeth, R., and D. Smith: *Review (Fernand Braudel Center)* 8, 517, 1985).

The core nations are "first-world" countries like the United States, Canada, and the United Kingdom; semiperiphery countries include Denmark, New Zealand, Argentina, and Hong Kong, for example; and periphery countries include many "third-world" countries, e.g., many Latin American and African nations.

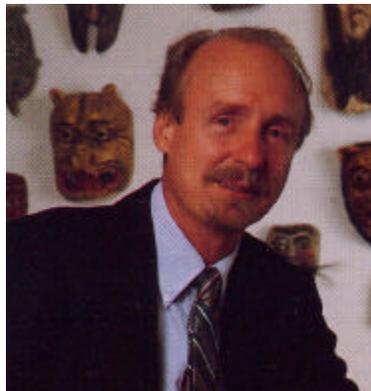
## TRADE FLOW ANALYSIS ON THE SUPERCOMPUTER

White and Smith took some of the same data used in the 1985 study and applied the measure technique refinements of REGE-D to the structure of international economic exchanges for three chosen years: 1965, 1970,

and 1980. The use of a longitudinal design made it possible to measure changes in the overall structure of the world system and to answer questions about upward and downward mobility of countries in the global economy.

The data were based on the *Commodity Trade Statistics*, which are compiled annually and contain matrix-style information on thousands of specific types of products classified by country of import and export. The flows are reported in U.S. dollars. To limit the field of nations, only countries with more than one million in population were used. Then countries with incomplete data were eliminated, narrowing the number of countries to 63.

The number of matrices on commodity flows was narrowed to 55, from the thousands available in the data, using the first two digits of the five-digit *Standard International Trade Classifications*. Although it was possible to use all 55 matrices, previous research by Smith and colleagues had suggested that five empirically defined clusters of commodity trade sort into a two-dimensional scale that contrasts production with extraction and capital-intensive with labor-intensive processing. On the premise that these world trade patterns reflect a global division of labor in which core-periphery differences are shown partly by the relative level of processing of their exports, the three

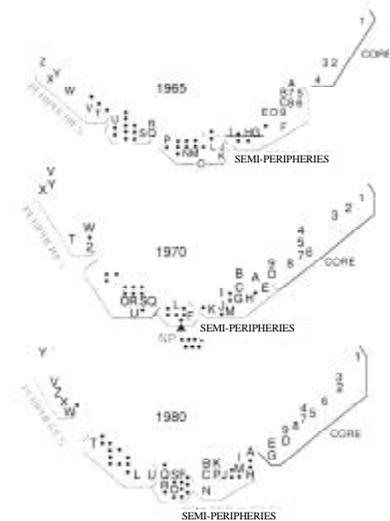


Douglas White, professor of anthropology at the University of California, Irvine, at home with his collection of masks from studies of cultures in Mexico.



David Smith, assistant professor of sociology at the University of California, Irvine, has worked with White on a study of the changing relationships of nations of the world as reflected in trade relations.

most highly loaded trade variables for each of the five key categories were chosen. The export of finished goods (e.g., TVs) takes precedence over the export of raw materials (e.g., food products) in core countries; the balance shifts the other way in the peripheries. Thus, for each of the 63 x 62 ordered pairs of countries, White and Smith had complete data on trade magnitudes for 15 commodities. These provided the raw data for the network analysis.



- |                   |                             |
|-------------------|-----------------------------|
| 1. United States  | I. Ireland                  |
| 2. Canada         | J. Brazil                   |
| 3. West Germany   | K. Yugoslavia               |
| 4. United Kingdom | L. Pakistan                 |
| 5. France         | M. South Korea              |
| 6. Japan          | N. Greece                   |
| 7. Italy          | O. Egypt                    |
| 8. Netherlands    | P. Singapore                |
| 9. Switzerland    | Q. Morocco                  |
| A. Denmark        | R. Tunisia                  |
| B. New Zealand    | S. Libya                    |
| C. Argentina      | T. Jordan                   |
| D. Belgium        | U. Ecuador                  |
| E. Sweden         | V. Ibo                      |
| F. India          | W. Niger                    |
| G. Austria        | X. Burkina Faso             |
| H. Hong Kong      | Y. Central African Republic |
|                   | Z. Malawi                   |

The trade flow data were run through the REGE-D algorithm, and relational distance was computed for the chosen years. REGE-D is based on a precise algebra of role relations in which nations are equivalent, approximating zero relational distance, to the extent that they have equivalent amounts of trade in the same commodities with equivalent other nations. Alternatively, two countries have a relational distance coefficient of 1 to the extent that when one has a given amount of trade with nation X, the other has a dissimilar amount of trade with even the most closely matched equivalent country 7. Equivalence of trading partners is found by measuring positional distances in successive iterations, starting with the assumption that all countries have zero relational distance and augmenting the distance between pairs in each iteration to the extent that they fail to meet the definition.

Then each row of the symmetric REGE-D matrix is scaled with respect to itself, with

maximal distances normalized to 1 rather than scaled relative to other rows and columns for nations with very different volumes of trade. REGE-DS iterative procedure converges to the exact algebraic measure. In practice, however, two or three iterations are sufficient to determine global positions accurately. An equivalence analysis is then superimposed on the results of the optimal scaling to show the clustering of the countries with close or similar trade patterns. See the figure for illustration of this clustering analysis.

### MOBILITY IN THE WORLD ECONOMY

The results indicate that the positions of the nations within the world system over the three separate year-long time periods are relatively stable. However, there is progressive expansion of the core cluster, elongation and differentiation of the periphery in 1980, and shrinkage of the semiperiphery. Currently, White and Smith are analyzing the data in an attempt to find relationships between centrality in particular trade networks and patterns of upward or downward mobility. They believe that most of the changes in position can be related to specific events, such as military conflicts, political destabilization (e.g., coups), world recession or expansion, oil cartel activities, and development of or specialization in specific economic activities.

The results (as illustrated in the diagram) show that mobility from semiperiphery to core is greatest during the period from 1965 to 1970. Six countries move into the core: Japan, Belgium, France, Italy, the Netherlands, and Switzerland. From 1970 to 1980, only Sweden and Austria shift.

The United States remains in the far upper right for each time period. But the gap between it and other nations narrows after 1965. In 1980, Japan, Canada, and West Germany move closer to the United States, and the United Kingdom slips to a less central position. White and Smith relate the upward mobility of Japan and West Germany to their export of high technology and heavy manufactures. "This pattern clearly dovetails with qualitative descriptions of the recent decline of U.S. hegemony and realignments in the core," White says.

All core countries, they note, seem to have diversified economies. However, relatively advanced economies that are specialized in the export of food products (e.g., Ireland, New Zealand) are more likely to remain in the semiperiphery, they believe, than to move to the core.

The most prevalent pattern in the analysis is upward mobility from the periphery to the semiperiphery. In the semiperiphery itself, there is movement between the lower and upper parts. Brazil, South Korea, and Yugoslavia move into the upper cluster between 1965 and 1970, and Greece and Singapore make a similar jump in 1980. White and Smith suggest that this mobility is related to rising levels of manufacturing; the nations in the upper semiperiphery show some development of heavy industry, while those in

the lower semiperiphery seem to concentrate on low-wage industry.

Between 1965 and 1970, there is no movement in or out of the periphery apart from Egypt's temporary slippage. Jordan shows a similar dip in 1970 toward the lower end of the periphery. Between 1970 and 1980, however, five countries move out into the lower semiperiphery: Libya, Tunisia, Ecuador, Morocco, and Egypt. Only three countries go from semi-periphery to periphery: Egypt (which was temporary), India, and Pakistan.

### PREDICTING CHANGE IN THE WORLD-SYSTEM STRUCTURE

The most significant result of White and Smith's large-scale network analysis is that it gives empirical support to the existence of three major positions in the world economy, with subdivisions in the periphery and semiperiphery. Using data consisting of only trade relationships among countries, White and Smith have built measurements and representations of world-system structure that they believe have succeeded in effecting a pure structural analysis by which to measure and compare positional structures through time. This they trust will provide a much better set of positional variables with which to consider new research on the causes and consequences of change in the global economy.

In their most recent project, they use these position measures to assess the mobility of each country at successive time periods. Their study is unique in that it achieves sufficiently precise and reproducible measures of structural mobility to permit the estimation of changes in world-system position quantitatively over short time periods (1-10 years). Using a set of measures of the relative centrality of each country, in terms of flows of a particular commodity in the world trade network, the researchers have been able to devise tests for theories that predict upward mobility as a result of brokerage of certain light industrial commodities and downward mobility as a result of dependencies on certain industrial imports. They can account for a significant amount of change in position in the world economy using canonical hypotheses of structural economics.

### FUTURE OF SOCIAL SCIENCE AND SUPERCOMPUTING

White, who has done much programming of network applications himself, would like to see computer science students take their skills to social science and help with the massive job of developing computer programs to apply to social scientific problems, especially those using supercomputing technology. He recently organized Linkages, a nonprofit consortium of anthropologists with 20-30 years of longitudinal field work, and he is leading an effort to develop software methods and theory to share internationally "We are still studying cultures other than our own. We are still interested in culture change and process," White says. "But the new direction is a multilevel approach—looking at time qualitatively and quantitatively. We are looking at the development process in terms of theory, not just application." ■ MJ