Technology in Commerce

Technology and Global Industry. Companies and Nations in the World Economy. BRUCE R. GUILE and HARVEY BROOKS, Eds. National Academy Press, Washington, DC, 1987. viii, 272 pp., illus. Paper, $19.95. National Academy of Engineering Series on Technology and Social Priorities. Based on a symposium, Feb. 1986.

It is by now a commonplace that the world economy is being "globalized." Firms are increasingly organized as "multinational" corporations, manufacturing their products in multiple countries and selling them throughout the world.

In *Technology and Global Industry* a group of distinguished business and policy analysts examine the important contributions of technology to this process. As the editors explain in their overview chapter, the papers address a formidable set of issues, including the effects of changing technologies on the production and distribution of goods and services in a global economy; the role technology plays in shifts of relative competitive advantage of nations, regions, and firms; and how government and enterprises respond to technological advance.

The papers do not live up to this challenging agenda. No clear theme emerges from the collection. Nevertheless, several of the papers individually make an important contribution, and for this reason the book merits attention.

One of the most interesting essays, "Does technology policy matter?," is by Henry Ergas, a trade counselor at the Organization of Economic Cooperation and Development (OECD) in Paris. Ergas compares technology policies in different countries and finds that they basically fall into three groups.

In "mission-oriented" countries (such as the United States, the United Kingdom, and France), governments generally try to boost the emergence of a specific emerging technology—the breeder reactor, the space program, or the supersonic airplane. In contrast, countries pursuing "diffusion-oriented" policies (Switzerland, West Germany, and Sweden) do not target specific technologies but rather construct environments—through strong support of education, cooperative research efforts by universities and industry, and industry standard-setting—that are designed to promote the development of mature products and processes. Only Japan has taken a third course, mixing elements of each of the first two strategies but focusing its greatest effort on assisting industries in their "consolidation phase"—well after new technologies have emerged but before final product designs have been established.

Which approach works best? Ergas gives each of the strategies its due but in the end avoids choosing. Instead, he counsels nations to avoid putting too many of their eggs in a single technology basket—as the United Kingdom and France have done with the Concorde. The United States, he notes, has greater freedom by virtue of its size to pursue large projects, but Ergas makes an excellent case that, like Japan, we should place greater emphasis on commercializing innovations than on creativity and novelty.

David Teece, a professor of business administration at the University of California at Berkeley, follows up on this theme in his chapter. Specifically, Teece points to the experiences of a number of firms that were successful innovators—EMI, which developed the CAT scanner; Royal Crown Cola, which first introduced cola in cans and diet cola; and Bowmar, which introduced the pocket calculator—and asks why each ultimately failed to withstand the competition from later imitators.

Teece provides a persuasive answer. Unless the innovator has ironclad patent or copyright protection or is able, like Coca-Cola, to guard its secrets effectively, being first will not guarantee market dominance or even success. Firms must have the ability to manufacture, market, and deliver innovations. If innovators do not have these "complementary assets," imitators will appropriate the profits from their efforts. Teece provides no specific policy recommendations but directs his advice to corporations, warning them against divorcing their R&D activities from manufacturing and marketing.

Two other chapters, by James Brian Quinn of Dartmouth and Raymond Vernon of Harvard, place the current concern about the ability of the U.S. manufacturing sector to compete in international markets in some perspective. Quinn argues that it is wrong to despair about the growing importance of services relative to manufacturing, a trend that is apparent not only in the United States but in other industrialized countries as well. In addition, he presents convincing evidence that high technology is quite important in services—communications, transportation, financial services, and health services, among others.

Vernon, meanwhile, contends that the ease of acquiring new technologies around the world is the primary reason why so many other countries have been able to compete successfully against U.S. producers. If the United States is to counter this trend, Vernon argues, it must enhance its "factors of production"—notably improve education and better target federal R&D support—while avoiding trade protection.

In short, readers of this book will find few new policy suggestions for significantly improving the technological performance of the United States. Moreover, they will find no thorough discussion of two of the most important and controversial policy instruments now used to promote technology in the United States: the R&D tax credit and the recently approved process for reducing the antitrust exposure of firms that collaborate on R&D projects. Indeed, the basic weakness of the book is that it provides little "bottom-line" advice for federal policy-makers interested in promoting technology and its contribution to the nation's economic performance. However, selective readers will find several interesting essays that help shed light on the role of technology in the new global economy and how different broad government approaches to technology policy have fared in the past.

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Global Currents

General Circulation of the Ocean. HENRY D. I. ABARBANEL and W. R. YOUNG, Eds. Springer-Verlag, New York, 1987. xiv, 291 pp., illus. $69. Topics in Atmospheric and Oceanic Sciences. From a lecture series, San Diego, CA, 1983.

This volume from a workshop on ocean dynamics begins with a set of lectures by P. P. Niiler on the observational basis for large-scale ocean circulation. Niiler's presentation of direct measurements of the flow obtained by moored current meters and profilers illustrates the new view of the ocean interior provided by modern instrumentation. The trick is to blend information obtained in this way with the temperature and salinity data painstakingly accumulated over the past 100 years of shipboard expeditions—not easy, because there is a real mismatch of scale between the eddies and the global circulation, and this affects each measurement (pressure, velocity, density, and so on) in a different way. Real discoveries were rare in

the early days of these instruments, no matter how much fun it was to see the currents directly for the first time; now such instruments are beginning to fill in our global picture of the eddies and circulation in a more extensive way. A central dynamic quantity, for example, is the rate at which heat is carried poleward by the oceans, a process tending to diminish the temperature difference between the poles and the equator. Niiler and his collaborators made key measurements in the Florida Straits many years ago, and these have now been used to give us reliable estimates of heat transport in the tropics.

J. Pedlosky and W. R. Young follow with lectures on the theory of the three-dimensional circulation. Pedlosky deals with thermocline theory, which describes the idealized, steady flow of a large-scale ocean in response to forcing by both wind and heating/evaporation at the sea surface. The equations governing the system, even if the average effects of eddy activity are not included, are nonlinear with respect to both horizontal and vertical advection. The difficulty is that one is trying to predict everything with one boundary-value problem. We now have reason to believe that natural discontinuities arise—rather like shock waves in a supersonic airflow—that make simple solutions of these equations unlikely to satisfy realistic boundary conditions at the sides, top, and bottom of the seas. The newer theories Pedlosky describes have the more modest goal of modeling limited elements of the circulation, rather than its totality. By specifying the winds and the surface density field, for example, one can integrate the conservative equations downstream, following the fluid as it descends to the ocean interior, and begin to see the shape of the wind-driven flow. It is these gyres of circulation, one or two to an ocean, that dominate the flow in the uppermost kilometer.

Young examines the morphology of the potential vorticity, which is the central dynamical variable describing the circulation. In this work the more global constraints on the recirculating gyres of flow become apparent. Flow tends to proceed along geostrophic contours (that is, curves of constant potential vorticity that cover the nearly horizontal, stable surfaces of constant potential density in the seas). Yet the flow itself reshapes the density surfaces and hence the geostrophic contours. For round-and-round flow characteristic of these gyres, the potential vorticity is determined by global integrals of eddy mixing. Eddy motions are crucial to these theories, in stirring the potential vorticity, sending momentum downward, and eventually shaping the mean "lens" of warm water that marks the subtropical gyre. Observations of the actual potential vorticity field of the oceans have been important in bringing these ideas close to reality, and this technique is described by Young.

M. C. Hendershott gives an account of the theory of circulation of a single layer of constant-density fluid. It was Stommel's use of this model that made analytical progress possible and produced the first "whole model" of an idealized ocean basin in motion. This, more than any other example, shows the spirit of geophysical fluid dynamics, where progress is made by simplification of the problem at the outset, rather than by mathematical approximation of the complete "gory mess." Hendershott's lectures take one from first principles, through the sequence of classical circulation models, to nonlinear and time-dependent one-layer flows. Rossby waves make their only appearance here; their key role in producing the "constitutive relation" that holds together the large-scale flow makes them important to studies of the development of the circulation as a time-dependent problem.

G. Veronis introduces the methods of inverse modeling, in which one aims to match a sparse set of observations to a model, either heuristic of dynamical, of the underlying continuous flow. Inverse modeling attempts both to map the fields between observed data points and to estimate unknown fields. The classic case is to infer velocity from observations of fluid density, using assumed global conservation properties and local force balance. Operationally it is an exercise in over- and underdetermined sets of linear equations. A difficulty is that assumptions used to select among a forest of possible solutions do not always have great strength. More powerful dynamical ideas are needed, either analytical or numerically implemented. Looking toward the future, one sees inverse models being combined with predictive dynamical models to yield a hybrid that takes whatever data are available and uses them to nudge the equations of motion in the right direction. In fact, K. Bryan and his collaborators at Princeton have been doing this less formally for some years. A decade ago physical oceanography had focused on the problem of the 100-kilometer-wide eddies that dominate the kinetic energy of the oceans. A result of that research has been an increasingly clear understanding of the way in which eddies can shape and distribute the global general circulation. In crucial ways the general circulation without these eddies is an underdetermined mathematical problem with no unique answer. A synthesis is now beginning to occur.

This volume would make a good textbook for a course on ocean circulation that includes basic derivations. A classical mechanicist might enjoy seeing how natural scientists approach their dynamics problems. A note of criticism is that although experimentation both in the laboratory and on the computer has acted as an essential intermediate step between dynamical ideas and observations, neither technique has an advocate in this book. We see increasingly that numerical models can help to develop theory and to forecast the state of the oceans. We are quickly moving to consider the complex behavior of the interactive ocean and atmosphere, and this campaign is more and more being waged on a numerical grid.

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Effects of Predation

Predation. Direct and Indirect Impacts on Aquatic Communities. W. CHARLES KERFOOT and ANDREW SIH, Eds. University Press of New England, Hanover, NH, 1987. viii, 386 pp., illus. $60. Based on a symposium, Fort Collins, CO, 1984.

The study of predation in aquatic communities has been a particularly fascinating and fruitful endeavor because predators often have effects that are both strong and far-reaching. Suppression of numbers in the immediate prey population is considered a direct effect. As a result of food web linkages, however, a predator's impact may extend well beyond the target species. In addition, many prey species have evolved defensive tactics that not only minimize predation risk but also affect the prey species' behavior or morphology, with consequences for its ecological role. It is these diverse, indirect effects that account for much of the current excitement in the field and most of this volume.

Just what is to be included under "indirect effects" of predation still seems to elude concise definition. The breadth of phenomena involved makes the grouping of chapters into sections somewhat arbitrary, and the redefinition of exploitative competition (that is, predation on a common resource) as an indirect effect does not strike me as helpful. One major theme clearly is the ramification of predation effects through the food web, and another is the variety of adaptations that have evolved in response to predation risk. However, the distinction blurs when, for instance, a prey species