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Scientists are highly aware of a climate of rapid change in many technologies, including, for instance, those of computers and materials. But most of us have not been as conscious of a rapid globalization of industry and roles of international companies in promoting it. An interesting discussion of factors that have led to intense global competition in manufacturing is provided in a publication* that stemmed from a symposium conducted in 1986 by the National Academy of Engineering.

Globalization was rooted in a homogenization of markets, decreasing costs of transport and communication, and decreasing trade barriers. In the developed countries, national markets have become increasingly similar in taste as income distributions have equalized. In this changing environment companies noted that they could achieve growing economies of scale in their R&D and production through tapping global markets. Changes in product and process technology have increased the minimum efficient size for production in a variety of industries.

The multinational companies originally established factories abroad to avoid tariff and other barriers in various countries. But with time they perceived that they might attain cost advantages in the new locations. As the multinational corporations have gained experience at such locations, their subsequent responses to opportunities have been quicker and more assured. Earlier, their practice was to develop a new product or technology in the home country and to manufacture and market the products at home before introducing them abroad. With time, the pace has quickened, and technology may be transferred abroad almost as quickly as it is developed at home.

Technological changes in communications and transportation have greatly reduced costs to late-industrializing countries for assimilating technological information and for moving goods and people across great distances. They can be highly competitive in supplying finished goods. They can also manufacture many components at low costs. The multinational companies have been quick to locate plants in those countries or to buy components from them. The practice of out-sourcing is important and growing. With U.S. multinational enterprises accounting for two-thirds or more of U.S. industrial output, most U.S. producers will be ceaselessly looking abroad for cost reductions.

Many of us have hoped that competence in science and innovation would enable this country to be competitive in global trade. However, experience is showing that firms and nations can lose ground in the commercialization of advanced technologies at a time when they are the major sources for technological innovations of industrial significance. Rarely do patents confer perfect protection. Trade secrets are useful but only if the product can be distributed while the underlying technology is kept secret. Today, with widespread scientific and engineering competence and powerful analytical and computing capabilities, technological secrets are hard to keep. When a new product achieves widespread consumer acceptance, many companies are likely to produce it. The winners among them will be those who achieve low costs of manufacture and high quality and have marketing skill. The United States has been comparatively weak in achieving low-cost manufacturing with high quality. In the past, U.S. engineers have tended to shun the factory floor. In contrast, Japanese engineers are active there, and through a series of small incremental improvements they usually succeed in achieving substantial economies.

Another source of U.S. failure to compete is in the quality of the labor force, particularly in its lack of vocational training. Both West Germany and Japan are superior in these aspects. More important is the impact of military R&D on U.S. engineering talent. Roughly half of total U.S. R&D expenditures are devoted to military research. In Japan about 2 percent is allocated to that effort. Earlier, there were important spin-offs for the United States, but military hardware is becoming increasingly remote from civilian applications. Another source of U.S. failure is an archaic set of antitrust policies. There is also need to revise national policies to influence managements to respond to foreign competition by creating new facilities and achieving higher productivity here rather than sourcing aboard. —PHILIP H. ABELSON

**Technology and Global Industry: Companies and Nations in the World Economy* (National Academy Press, Washington, DC, 1987), $19.95.