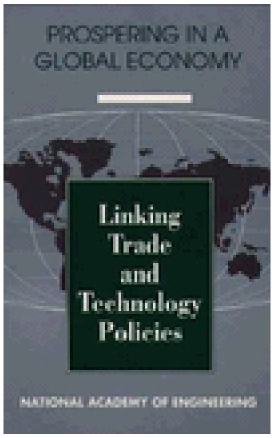

Linking Trade and Technology Policies: An International Comparison of the Policies of Industrialized Nations

Martha Caldwell Harris and Gordon E. Moore, Editors; Steering Committee on Linking Trade and Technology Policies, National Academy of Engineering

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Linking Trade and Technology Policies

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An International Comparison of the Policies of Industrialized Nations

Martha Caldwell Harris and Gordon E. Moore, Editors

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Preface

On the eve of the twenty-first century, the increasing globalization of technology creates new challenges for American policymakers. The clear economic and technological lead that the United States enjoyed at the end of World War II has now been replaced by intense competition with Japan and other countries that have achieved new and highly effective ways of moving innovations to the marketplace. At the same time, the postwar era of U.S. relative economic and technological self-sufficiency has given way to a world in which U.S. economic prosperity and national security depend increasingly on access to foreign capital, products, services, markets, talent, and technology.

Competition and cooperation are both elements of this new global context. A variety of approaches have evolved in Japan, Europe, and the United States for achieving collaboration between the public and private sectors in research and development and, in some cases, in manufacturing and marketing. Paralleling these national experiments has been a rapid proliferation of transnational technical alliances among companies. At the same time, global competition has intensified in many industries, with competition in R&D-intensive or high-technology industries attracting increasing attention and involvement from governments seeking to capture these high value-added, high-growth industries within their national borders.

Except for the opening chapter, the papers in this volume were originally presented at a National Academy of Engineering symposium, "Linking Trade and Technology Policies: An International Comparison," on June 10 and 11, 1991. They address the changing nature of global competition in high-technology industries and the role of government policies of industrialized nations in influencing that competition. Exploring the evolving relationship between trade and technology policies from a comparative international perspective, the chapters of this volume underline difficult challenges facing U.S. policymakers and their foreign counterparts in an age of deep economic and technological interdependence.

A unifying question that runs through both the authored papers and the summaries of panel discussions is whether in this new global environment national governments can effectively link trade and technology policies to create competitive advantages for industries located within their national borders. Drawing upon the recent experiences of Japan, the major European countries, and the United States, the authors focus on the implications of global competition in high-technology industries for U.S. technology and trade policies and suggest the need for new, more integrated approaches (both at home and in international forums) in these two policy areas. Above all, this volume makes it clear that the United States must adapt its policies to deal with the new challenges of global competition across a broad range of technologies and industrial sectors.

On behalf of the Academy I would like to thank the chairman and members of the symposium steering committee (whose names appear on p. iii), and the authors of the papers in this volume for the valuable analyses, expositions, and insights they provided. The symposium discussions and the papers published here were greatly enriched by the contributions of panelists and other symposium participants from Europe and Japan as well as the United States. I would like to thank all of those who participated in the symposium for their contributions.

I would also like thank the staff members who worked on this project. Martha Caldwell Harris, who directs the National Research Council's Office of Japan Affairs, was primarily responsible. Proctor P. Reid, Senior Program Officer with the NAE Program Office, contributed to all phases of the project. Barbara L. Becker and Margery J. Harris of the NAE Program Office provided critical administrative and logistical support for the project. Bruce R. Guile, director of the NAE Program Office, and H. Dale Langford, the NAE's editor, also deserve thanks for their efforts, particularly for their assistance in preparing the publication.

Finally, I would like to express my appreciation to the Alfred P. Sloan Foundation for its generous support of this project and related elements of the National Academy of Engineering's multiyear program of symposia and committee studies titled Prospering in a Global Economy.

ROBERT M. WHITE
PRESIDENT
NATIONAL ACADEMY OF ENGINEERING

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Linking Trade and Technology Policies

Linking Trade and Technology Policies: Themes and Issues

GORDON E. MOORE AND MARTHA CALDWELL HARRIS

Traditional approaches to analyzing competition and developing policies appear inadequate to deal with a new context for international competition in which technology is a driving and increasingly global factor. A growing literature documents ways in which high-technology competition differs from traditional models. Today governments of advanced industrial nations are competing to attract high-technology industries, trying to create comparative advantage, in an era in which the economic dimensions of national strength appear more salient than a decade ago. The old policy frameworks appear inadequate to deal with this new reality. Hence the need to reexamine old assumptions, to search for new approaches.

Two sets of issues—the changing nature of global competition and the role of government policies—are central themes around which this volume is organized. The issues can be articulated as questions: How is technology changing the nature of global competition? Can governments devise policies that help to create competitive advantages for national firms?

The chapters that follow address these questions in detail and deserve careful reading. By way of introduction and reflection, this brief chapter highlights some major themes—areas of agreement as well as disagree

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The plan for the symposium on "Linking Trade and Technology Policies: An International Comparison" was developed by a steering committee that included Gordon Moore (Intel Corporation), John Gunter (Bell South), Henry Lichstein (Citicorp), David Mowery (University of California, Berkeley), John Odell (University of Southern California), and Laura Tyson (University of California, Berkeley). Martha Harris, of the National Research Council, served as the primary responsible staff person. Proctor Reid on the staff of the National Academy of Engineering also participated.

ment—that emerged from the presentation of these papers at a June 1991 symposium at the National Academy of Engineering and from the discussions at the symposium. Summaries of the panel discussions appear in this volume.

THE NEW INNOVATION PARADIGM AND CHANGING GLOBAL COMPETITION

The symposium presentations and discussions indicated a broad consensus that global competition is changing. As panel member Sylvia Ostry put it, there is a new innovation paradigm operating; innovation and global market competition today depend less on independent achievement of scientific and technological research breakthroughs and more on continuous improvement in process and product. In Japan this new innovation paradigm is operating especially effectively, and it is changing the nature of global competition.

Understanding the changes in the technological character of global competition provides a basis for assessing the relative trade performance of the United States. While there are many difficulties in interpreting the data on international trade in technologically advanced industries, including effects of exchange rate shifts, one clear change has taken place in the past 10 to 15 years. The United States is no longer the world's dominant economy, but rather first among equals.

Paul Krugman's paper highlights the idea that all industries are not "equal" in terms of their importance to the national economy; the strength of an industry is in its "positive feedback loops" of interaction with the skilled labor and supplier base and with the knowledge base. Such loops are self-reinforcing processes that create and recreate comparative advantage in particular sectors and regions.[1] Japan, in particular, appears to have developed a system that is uniquely successful in exploiting the positive intersectoral linkages of innovation.

Changes in the composition of U.S. production, on the other hand, are particularly worrisome. The United States has been "downscaling" in terms of the technological sophistication of its production mix as compared to other major industrial countries. Paolo Guerrieri, in his paper in this volume, provides a finer-grained picture of the changed nature of international trade by developing an analysis of trends in trade performance of major industrial nations that divides industries into categories according to differences in technological dynamism, user requirements, and scale intensity. This analysis shows a weakening of the scale-intensive and specialized-supplier industries in the composition of U.S. high-technology trade. Meanwhile, Japan's comparative advantage has grown in the specialized-supplier and science-based (high R&D) industries increasingly important in global trade. It can be argued that these industries provide added benefits throughout the economy through externalities such as their linkages to innovation in other sectors.

Overall, the differences among the major industrial countries in terms of trade specialization have increased rather than decreased during the past two decades. Krugman's analysis shows that U.S. industry has had increasing difficulty translating its advanced research capability into competitive industrial products. In other words, the United States has been less successful than Japan in developing a production base that features specialization in both science-based and production-intensive sectors, with a resultant worsening of its trade position in R&D-intensive industries such as electronics.

The symposium discussions suggested the need to learn more about the causes of these striking differences in national performance. There was strong agreement that a key to understanding differences in national performance may be in understanding differences in national systems. These differences include not only public policies, but also organizational and institutional approaches, attitudes and enduring features of research and market systems. David Mowery, in his paper, outlines unique aspects of the market-driven, U.S. innovation system—deeply embedded structures that have made it difficult for the United States to develop a coherent civilian technology policy that focuses on strengthening specific technologies important to future industrial competition or on enhancing the intersectoral technological and economic linkages. The distinctive U.S. approach features large investments in defense technology, in research and education at U.S. universities, the dynamic role of new start-up companies, and an emphasis on antitrust policy. In contrast to the situation in the United States, some systems, particularly the Japanese managed market model, appear to be more "innovation friendly" than others.

While understanding of these factors is at present limited, the effect is to remind us that competition is strongly affected by the market and organizational contexts. Viewed from this perspective, systems are competing for high-technology production, value-added, and the resulting benefits in standards of living. Competition is not just among firms for market share, but their capabilities—and, therefore, their long-term performance—are strongly affected by the research and market systems in which they operate. Differences among the market systems of the industrialized countries have strong implications for the long-term well-being of their societies. Fundamental differences in organization and structure create asymmetries in the ability of countries to have similar access to the technology and markets of others. The traditional international trade rules do not, however, take these differences into account.

LINKING TECHNOLOGY AND TRADE POLICIES TO CREATE COMPETITIVE ADVANTAGES

Can government policies effectively create competitive advantages for domestic firms? Perhaps. A number of factors influence the ability of companies to compete in the marketplace and government policy is only one of them. Japan's success may have been "overdetermined"—a result of a variety of conductive factors that include government policy along with favorable macroeconomics, microeconomics, and good judgment by business people. Japanese and European participants in the symposium noted, furthermore, that industrial policies in these countries are undergoing substantial change. They cautioned U.S. policymakers against pursuing an elusive (and perhaps somewhat outdated) goal of emulating policies used by other countries in years past, policies that may no longer be appropriate to deal with a new global context. The symposium speakers did not include a recognized true skeptic on industrial policy or a strong advocate of free trade in the most literal sense, but a number of participants in the meeting articulated these perspectives, as the summaries of the panel discussions indicate.

Despite these cautions, some messages come through quite clearly in the papers that follow. One is that high-technology industries are important because they often bring benefits to the larger economy and society that flow from high value-added production. Whether governments are able to encourage the development of domestic economic structures that feature high valued-added industries is an important question because the effect could be to enhance the nation's comparative advantage in global trade competition.

High-technology competition raises new challenges for policymakers. David Yoffie's paper in this volume presents an argument that competition in high technology is different. High R&D content, the importance of intellectual property rights, short product life cycles, steep learning curves, low transportation costs, and high capital mobility are characteristics that, taken together, distinguish high-technology industries in his view. Actions taken today can importantly affect the industries of tomorrow, because of first-mover advantages that permit the company that gets the market first to retain it. Government policymakers who want to improve the competitiveness of domestic high-technology industries must take these distinctive features into account in formulating approaches.

A second theme that came through is that the United States, more than its major trading partners, has attempted (albeit unsuccessfully) to use trade policy as a substitute for civilian technology policy. When product life cycles are only two to three years, trade dispute mechanisms are often too time consuming to take effect before the outcome is decided in the marketplace. David Yoffie's paper points to the U.S.-Japan semiconductor agree ment as evidence that trade policy alone cannot solve the problems of U.S. high-technology industries. Although the agreement did buy the U.S. industry some time and improve access to the Japanese market, it could not address the fundamental financial and managerial challenges that the U.S. semiconductor industry must still deal with today.

Given the high stakes and special characteristics of international competition in high-technology industries, a number of participants in the symposium agreed that the lack of a civilian technology policy and attachment to a laissez-faire approach taken by the United States in years past may pose a serious liability in the future. The papers in this volume highlight substantial evidence that Asian and European nations have had much more vigorous civilian technology policies than the United States and that these policies have in many cases been complemented by trade policies. They also suggest that there is little evidence that foreign governments abroad are eschewing such policies. On the contrary, some of them have managed to make the development and commercialization of civilian technology a high-priority national goal.

The papers that follow deal with policy issues for long-term, multilateral attention as well as issues that the United States must deal with "in the meantime." Laura Tyson's paper provides a long list of policy issues that must be addressed to create a multilateral trading regime that takes into account the changing global nature of technology and competition. Government procurement, intellectual property rights, industrial targeting and subsidy practices, foreign direct investment, local content, competition policies, and standards were all mentioned in the symposium discussions. It is difficult to devise precise rules in these areas, however, because policy approaches differ and because laws are interpreted differently by different countries. The absence of a transnational court to deal with competition policy, for example, is a major obstacle to developing and enforcing new rules of the game on a multilateral basis. Efforts to establish new, multilateral rules that address the need for a "balance of benefits" are, in the view of many, a more promising approach than the exclusive pursuit of bilateral, sector-specific policies that can lead to formation of cartels.

While these papers show a general appreciation of the need for a long-term, multilateral approach to developing new trade rules, there is a good deal of disagreement over what to do in the meantime. Panelist Jean-Claude Derian recalled the lessons of the "second battle of Poitiers"—the controversial French decision to slow down a flood of Japanese VCR imports. In cases where a speedy reaction is needed, there may be no practical alternative to bilateral approaches. Laura Tyson's paper provides some suggestions on how to make bilateral approaches more effective; the United States may need to consider modifying antidumping laws to require evidence of predatory intent and enforce these laws more stringently when the evidence is clear.

Whether the United States can effectively use bilateral approaches as a bargaining chip to prod nations toward multilateral reform is an important question. Can Section 301 and Super 301 be used to negotiate nondiscriminatory concessions that benefit all suppliers, not just the United States? Skeptics see these sections of U.S. trade law as protectionism in another guise that will only hasten the unraveling of the multilateral trading system as currently constituted. A productive tension between the multilateral and bilateral trade approaches, between the idealism needed to create new rules of the game for the future and the realism grounded in current unresolved issues in high-technology competition, is clear in the papers, as it was in the symposium discussions.

Although there was a good deal of disagreement about its content and preferred tools for implementation, a strong case emerged for a civilian U.S. technology policy. Civilian technology policy, as the term is used here, is designed to use technology as a tool to stimulate national economic growth and innovation; elements include incentives for technology development, for technology diffusion, for human resource development, and strategic visions of technology and the future of the economy. In view of the evidence from the semiconductor agreement, a direct approach (technology policy) seems more likely to address the real challenges faced by U.S. high-technology industries than exclusive reliance on trade policy. Some of the European participants in the discussions noted that the United States has found it easier to accuse its trading partners of subsidizing their industries than it has to formulate a domestic technology policy. The United States, according to many of the participants, has yet to make a serious attempt at developing a civilian technology policy.

The political dimensions of creating a U.S. technology policy deserve serious attention. While some call for direct government support for key technologies or industries like semiconductors, there are legitimate concerns that need to be addressed. The political process in the United States could result in pork barrel politics that may benefit the most vocal interests but does not improve U.S. competitiveness. Another challenge is to consider the interests of the major technology users, such as the financial services, in formulating policy. Policies aimed at supporting individual industries without regard for their effects on users could distort our innovative and competitive capabilities.

Another issue for U.S. technology policy is the appropriate substantive focus, which also determines priority areas for policy action. Manufacturing in many ways is the central challenge for the United States. Panelist William Spencer argued that manufacturing is the horse and technology policy is the cart. While some may assume that a technology policy will emerge if we simply increase investments in R&D, the problem is not with R&D investment per se in the United States. The fundamental problem in many companies is the inability of U.S. industry to bridge the gap between the laboratory and the production line. Panelist Hajime Karatsu emphasized the need to use technology as a tool to revitalize key industries like the automobile industry. This means nurturing engineers and thinking about technology as a whole process of producing marketable goods.

A number of panelists pointed to the importance of new U.S. experiments designed to improve manufacturing capabilities. There has long been disagreement about the pros and cons of U.S government support for selected industries. Sematech, a consortium of companies working to improve semiconductor manufacturing technology with U.S. government support, is seen by many as a promising model for cooperative research in the U.S. context. Despite the need for better analysis to provide a foundation for selecting industries for government support, the symposium discussions suggested general agreement that the United States must find ways to encourage investment in design and manufacturing in the United States. They also highlighted the comparative ease with which such decisions have been made and acted upon abroad.

As nations compete for high-technology production and value-added, the United States may need to try new approaches and to learn from ongoing experiments abroad. Panelist Margaret Sharp noted that Europe is following the twin tracks of promoting R&D cooperation through consortia while, at the same time, strengthening policies to stimulate competition. Viewed from this perspective, the significance of ESPRIT is as a European catalyst for collaboration in R&D among competing firms. Europeans speak from experience with a wide array of failed experiments in industrial policy; their stress on competition policy as a necessary counterpoint to technology policy is an important theme. Swimming with the tide of internationalism—not against it—may require significant efforts in both competition policy and R&D collaboration policy.

While the focus of attention in discussions of technology and trade policies is typically government action, new approaches must also be taken by private companies in order to realize a coherent technology policy. Private leaders, in particular, will need to develop new approaches to organization and management. Symposium discussions highlighted the fact that in order to be politically effective, technology policy will have to based on a political coalition that involves *both* government and the private sector.

In summary, the symposium discussions suggested the importance of maintaining a delicate balance and coordination—between multilateral and bilateral approaches, between technology and trade policies, between government and private sector efforts, between competition and cooperation. Articulating U.S. national economic interest in a context of technological globalization and new forms of competition will require a subtle strategy, not an either/or approach.

SUGGESTIONS FOR U.S. POLICY ACTION

A host of suggestions for U.S. policy action emerged from the symposium presentations and discussions. Not surprisingly, there were differences in viewpoint over priorities and preferred approaches. At the same time, there was general agreement around some themes and principles.

In the area of trade policy, there was strong agreement on the need to establish new "rules of the road" in areas such as competition policy, R&D subsidies, government procurement, industrial targeting, local content, intellectual property rights, foreign direct investment, and standards, as outlined in more detail in Laura Tyson's paper. Panelists Fumitake Yoshida and Margaret Sharp also called for reinvigorated efforts at the multinational level to improve the macroeconomic environment, in such areas as integration of financial markets. In view of the asymmetries that exist in research and market systems, David Mowery highlighted the critical importance of expanding reciprocal access to markets and technology as a basis for mutual benefit in a new era of technological competition and globalization.

Despite agreement around these long-term goals, the symposium papers and discussions revealed deep controversy over what to do in the meantime. Laura Tyson's paper makes a case for the judicious use of managed trade (featuring bilateral and sectoral approaches) as a stop-gap measure until a new set of multilateral rules is established. A number of suggestions were made along these lines. Panelist Robert Lawrence called for increased penalties for price-discriminatory dumping, while others called for the use of a countervailing subsidy approach to provide direct benefits to U.S. producers.

While panelist Clyde Prestowitz called on policymakers to accept the reality of managed trade and develop a more effective U.S. approach, others argued on the need to avoid managed trade at all costs because it raises costs and distorts market competition. Regardless of actions taken in the trade arena to open foreign markets to U.S. products, the symposium papers and discussions make clear the need for policies that will increase the attractiveness of the United States as a location for high valued-added production. Doing so will require that the United States develop parallel efforts to build a new multilateral trading regime while at the same putting in place domestic policies that use these same elements to ensure effective adaptation of the U.S. economic structure to a new global context of competition.

In the area of technology policy, the symposium papers and discussions suggested general agreement among participants on the value of policies that feature expanded investments in skilled human capital and those that promote technology diffusion. While time did not permit a full discussion of how to accomplish these goals, panelist Robert Lawrence called for

R&D tax credits and promotion of collaborative R&D in precompetitive research. Other important themes that would need to be addressed by the private sector include David Mowery's call for improved mechanisms to access and use technology developed abroad, calls for improved mechanisms of corporate governance to reward long-term investments, and repeated emphasis on the need to bridge the gap between the laboratory and the production process.

Two subjects of implicit and explicit disagreement emerged in the symposium discussions. One concerns the role of "foreign" participation in U.S. R&D, particularly R&D sponsored with government support. While some called on the United States to avoid restrictions on foreign participation in R&D consortia and U.S. universities, there was also some discussion of cases where limitations may be necessary. For example, restrictions may be justified when a foreign investment or acquisition seems likely to severely limit competition.

Whether the U.S. government should provide strategic and symbolic financial support for critical U.S. industries was another controversial subject. The traditional lines of debate were clear between those advocating the appropriateness of such steps when there is a need to buy time so that the industries can make themselves more competitive and those who believe that such intervention is misguided and ineffectual. There is at least the possibility that the political stalemate of the traditional policy debates can be transcended by a focus on technologies needed for a broad array of industries. Panelist Craig Fields, for example, stressed the importance of information technology infrastructure needed for the twenty-first century as a broad organizing theme for U.S. technology policy.

Approaches to linking the trade and technology policy realms are also a major theme in the papers that follow. Not only is there a need to increase interaction between individuals and organizations with special expertise in the trade and technology policy areas, but there is also a need for improved coordination between agencies like the Office of Science and Technology Policy and the Office of the U.S. Trade Representative that have very different institutional cultures. In practice, building consensus will probably require establishing a stronger analytical capability within the government to assess and link trends in technology and global trade. This may make it possible to establish criteria, based on analysis, for supporting technology development and diffusion in particular areas. Improving coordination is also, fundamentally, a political challenge. John Odell, a member of the steering committee, emphasized the importance of an industry-government coalition to articulate the need for linking trade and technology policies.

These ideas are explored in more detail in the chapters that follow. They include papers presented at the symposium as well as brief summaries of the discussions. Combining these suggestions into a comprehensive approach that links U.S. trade and technology policies is beyond the scope of this volume, but the papers here provide a starting point for those ready to take on this important challenge.[2]

The challenge is an urgent one—the nature of competition is changing and there is no guarantee that the United States will remain a frontline player in the first tier of global competitors. More is at stake than the fate of any particular industry. There is a need to consider what kind of economic structure is desirable in terms of creating value-added and economic benefits to the larger society. There is also a need to define actions that will create a conducive environment. We have to think not just about who comes up with new products and technologies and processes, but whether they are being used effectively in commercial products and services. The symposium discussions pointed to new approaches that must be seriously considered if the United States is to adapt successfully to a new global competitive context. This is the message we take away from the rich discussions on "Linking Trade and Technology Policies."

NOTES

1. See Krugman, in this volume, Figure 1.

2. See Committee on Science, Engineering, and Public Policy, *The Government Role in Civilian Technology* (Washington, D.C., National Academy Press, 1992) and National Academy of Engineering, *Technology Policy Options in a Global Economy* (Washington, D.C., forthcoming) for more detail.

Technology and International Trade Competition-Historical Trends

Technology and International Competition: A Historial Perspective

Paul R. Krugman

In a broad sense, the relationship between technology and trade has been a central theme of international economics since the early nineteenth century. The basic Ricardian model of comparative advantage takes as its starting point international differences in productivity across industries, which is to say differences in technology. Empirical work confirms that countries tend to be net exporters in industries in which they have relatively high productivity. So one could say that the study of technology and international trade is virtually the same thing as the study of international trade in general.

In practice, however, discussions of technology and trade usually focus on a narrower issue: trade in so-called high-technology products. A high-technology industry may be defined conceptually as one in which knowledge is a prime source of competitive advantage for firms, and in which firms invest large resources in knowledge creation. Operationally, high-technology industries are usually defined by above-average spending on research and development, above-average employment of scientists and engineers, or both. Several basically similar classifications of high-technology industries are in circulation; Table 1 lists the U.S. Department of Commerce set of high-technology industries, which is pretty representative.

The purpose of this paper is to describe trends in high-technology trade, and to try to assess what those trends mean. The paper is in four parts. The first part asks why it is meaningful to study high-technology industries and why they should be a focus of special concern. The second part describes the actual trends in high-technology trade. The third part offers some hypotheses regarding the causes of these trends. The last part of the paper presents a summary and some tentative conclusions.

TABLE 1 High-Technology* Sectors

Sector	1988 Exports (billions of dollars)
Guided missiles and spacecraft	1.1
Communications equipment and electronic components	21.5
Aircraft and parts	25.1
Office, computing, and accounting machines	24.4
Ordnance and accessories	0.7
Drugs and medicines	4.0
Industrial inorganic chemicals	4.1
Professional and scientific instruments	3.5
Engines, turbines, and parts	3.8
Plastics and synthetic resins	7.4

* The U.S. Department of Commerce identifies high-tech products as those having significantly higher ratios of direct and indirect R&D expenditures to shipments than do other product groups.
SOURCE: The U.S. Department of Commerce (1989, p. 22).

The focus of this paper is somewhat U.S.-centered. This emphasis reflects in large part availability of data. It also makes some analytical sense, however, since the story of international competition in high technology over the past generation is largely the story of the erosion of U.S. dominance.

WHY WORRY ABOUT HIGH TECHNOLOGY?

It is surely fair to say that most observers place more stress on competition in high-technology industries than the sheer size of those industries would warrant in itself. The U.S. loss of most of the semiconductor memory market to Japan is a famous, much-emphasized story, even though memories are only a part of the semiconductor industry, and the semiconductor industry itself is by no means among the nation's largest. Europe's Airbus challenge to Boeing has attracted at least as much attention as Europe's far larger program of subsidized agricultural exports, which competes with U.S. producers just as directly. Most observers, in other words—myself included—feel that there is something special and important about high-technology industries.

It is widely suspected that high-technology industries are particularly likely to generate positive external economies, both within particular high-technology sectors and for the economy as a whole. Thus, the social return to resources placed in those sectors exceeds the private return; and to the extent that international competition leads a country to shift resources away from high technology, such competition can reduce that country's welfare.

The arguments for external economies within high-technology sectors, and those for spillovers from high-technology sectors to the economy as a whole, are somewhat different. In the next section, we will go over the argument for within-sector externalities at some length before turning briefly to the much more diffuse question of spillovers to other sectors.

External Economies within Sectors

It is a familiar observation—although not an observation popular among traditional theorists of international trade—that local, regional, and perhaps national advantages in particular industries are not necessarily the result of underlying differences in primary resources. Instead, advantage is often *created* through a process of positive feedback.[1,2] This process has recently been emphasized as a source of international competitive advantage by Porter (1990); although Porter's cases are new, his conceptual framework is essentially that introduced a century ago by Alfred Marshall.

Figure 1—a triangle that resembles Porter's "competitive diamond," but with a somewhat different grouping of factors—illustrates schematically how a local or national advantage in a particular sector can be self-reinforcing. At a conceptual level, there are two kinds of external economy: market size effects, and pure informational spillovers. In practice, the two types of external economy tend to interact and to be hard to distinguish.

Market size effects act on both the labor market and on suppliers of intermediate goods (including capital equipment). A strong local or national industry, by providing a large market for labor with the right specialized skills, helps to encourage workers to acquire those skills (or to encourage workers with those skills to migrate into the relevant location). That strong

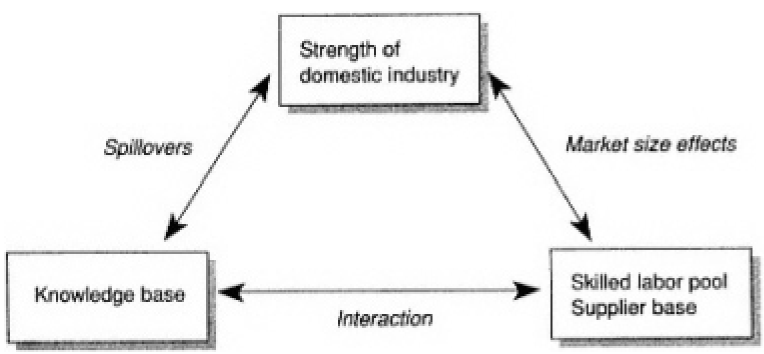

Figure 1 Self-reinforcing advantage in high technology.

industry also supports local or domestic suppliers of inputs. In turn, the availability of skilled labor or inputs helps make an industry internationally competitive, completing the loop.

When there are a number of firms in an industry, there may also be direct technological spillovers: firms may be able to learn from each other either through personal contact or by reverse-engineering each others' products. Again, the availability of a common knowledge pool helps make the industry competitive, completing a second loop.

Finally, technological spillovers and market-size effects surely interact in a mutually reinforcing way. Ideas spread best when there is a pool of highly skilled people able to appreciate them; and the process of technology diffusion often takes place between firms and their suppliers or customers rather than directly between rivals. Conversely, the skill of the labor force comes partly from knowledge that spreads informally rather than from formal training; and the strength of input suppliers rests in part on their access to the latest knowledge.

The important point for economic policy is that when industrial advantage is the result of this kind of self-sustaining process, an industry in being is more than the sum of its parts. The external economies represent a hidden asset, a sort of invisible part of the nation's infrastructure. In effect, part of the industry's value lies not in the boxes in Figure 1 but in the arrows. This immediately suggests a potential role for government policy, as well as the possibility that foreign competition may sometimes have adverse effects. We will return briefly to this touchy issue later in this paper in relation to trends in high-technology trade.

How relevant is this discussion? The role of positive feedback loops in generating self-sustaining advantage is obvious in interregional trade. One need only think of the traditional economic geography of the United States, in which many industries were highly concentrated in one or two cities—autos in Detroit and Flint, furniture in Grand Rapids, rubber in Akron, hats in Danbury. In this sense, Silicon Valley is only a recent manifestation of a phenomenon with deep historical roots. To argue for the special importance of created advantage in high-technology sectors, however, one must make the case that such positive feedback is (i) relevant to international competition and (ii) especially important in high-technology sectors.

It is fairly common now to hear the argument that to the extent that there are external economies in high-technology sectors, they are global in scope rather than national—and therefore there is no real international conflict of interest. To the extent that knowledge spreads by reverse engineering, that can be done anywhere; to the extent that ability to compete depends on sophisticated inputs, in a world of low transport costs, fast travel, and high-speed communication, inputs can be acquired easily at great distances.

It is certainly true that one must be careful before assuming that external economies represent a source of national as opposed to global advantage. Within the United States, the localization of industry has by most measures been declining since the 1940s, suggesting that local feedback loops have increasingly become national instead; probably national loops are becoming international as well. Yet one should not carry the argument too far. In several important ways it seems likely that external economies continue to be strongly national and even local in scope—a point emphasized by Porter (1990).

The first point is that specialized labor markets remain local; even movement between cities within a country is costly, and international migration is limited. When executives from Silicon Valley or Boston's Route 128 are asked why their firms continue to locate there, they usually respond by first citing the availability of a pool of skilled labor; thus, the existence of these famous high-tech clusters, as well as less well-known ones like the group of optics-related firms in Rochester, can be attributed to a highly localized kind of external economy.

The relationship between a domestic industry and a domestic supplier base is also far from gone, in spite of global communications and low transport cost. There are intangible costs to transactions at a distance; in some ways the move to modern management systems based on just-in-time inventory and production has increased the premium placed on proximity, so that in the electronics industry in particular there has been a discernible trend for firms to move production back from low-wage offshore sites to home locations close to suppliers and customers. Perhaps the best evidence of the continuing importance of local markets is the wide disparities that still exist between domestic and overseas market shares. Table 2 shows the share of U.S. high-technology sales in the domestic and foreign markets from 1980 to 1987. While some movement toward internationalization is visible, U.S. high-technology firms still have nearly eight times as high a share of the domestic market (which consists to an important extent of other high-technology firms) as they do of the foreign market.

TABLE 2 U.S. Market Share for High-Technology Products (percent)

	World Market	Domestic Market	Foreign Market
1980	40	92	10
1987	38	87	9

SOURCE: National Science Board (1991, pp. 402, 405, 406, Appendix tables 6-3, 6-5, 6-6).

So one may argue that external economies at the national level remain an important determinant of competitive advantage in high-technology industries. But is high tech special in this respect? It is clearly not unique. To take only the most obvious example, international trade in financial services is dominated by New York and London; there is no question that the dominant role of these centers is the result of self-reinforcing advantages rather than basic resources. One can, however, argue plausibly that the knowledge intensity of high-technology industries probably makes external economies more important there than in the average industry. The need for a highly skilled, specialized labor force is greater than in the average industry; close contact between suppliers and customers is more important when technology changes rapidly; knowledge spillovers are greater because there is more knowledge to spill.

Economic history also suggests that there is a life cycle to the location of industries, which reinforces the suggestion that external economies are particularly important in high tech. The characteristic pattern—illustrated by the joint history of autos and of Detroit—is that an emergent industry first develops a local focus, frequently as a result of accident or personality. Then, as the technology stabilizes, production begins to move away from that focus to save on production or transportation costs. High-technology industries are characteristically, though not always, in that first stage of rapid innovation.

External Economies Across Sectors

It is widely believed that high-technology sectors are important, not only because of the income they generate directly, but because they yield external economies to other sectors. For example, it is often remarked that semiconductors are a "technology driver" for many other sectors, or the "crude oil to technology," phrases that are presumably meant to imply that a country that has a strong semiconductor sector will have higher productivity, other things equal, than one without.

In contrast to the almost self-evident case for external economies within high-technology sectors, intersectoral external economies are harder to argue forcefully. The market-size effects associated with localized high-technology industries are not visible for interindustry effects; there is a Silicon Valley, but not an Everything Valley.

The best argument for strong spillovers from high-technology sectors to the economy at large is that the lines of communication between domestic firms give countries with strong high-technology sectors a head start in introducing applications of new technology. This is easiest to think of in the case of consumer electronics, in which new developments in semiconductors may be crucial to new product development. It is hard to see compara ble links for other high-technology sectors or other parts of the economy, however; on the whole we must say that the case that high-technology sectors generate strong returns over and above their direct return is at best unsupported by the evidence.

TRENDS IN HIGH-TECHNOLOGY TRADE

The beginning of the 1990s represents a particularly difficult time to assess trends in international competition and trade. The reason is that during the past decade a volatile international macroeconomic and financial environment threw up so much dust that it is difficult to detect any underlying trends. For example, from 1980 to 1986 U.S. exports of high-technology products grew at an annual rate of less than 6 percent, while Japan's high-tech exports grew at an annual rate of 13 percent; yet from 1987 to 1988 the U.S. rate was 24 percent. Clearly not all of this change represented a reversal in the long-term competitive trend, but it is difficult to tell what, if anything, happened to that trend.

The most important source of confusion about the 1980s is, of course, the rise and fall of the dollar. Figure 2 illustrates the extent to which that rise and fall affected the competitive position of major competitors. In 1980

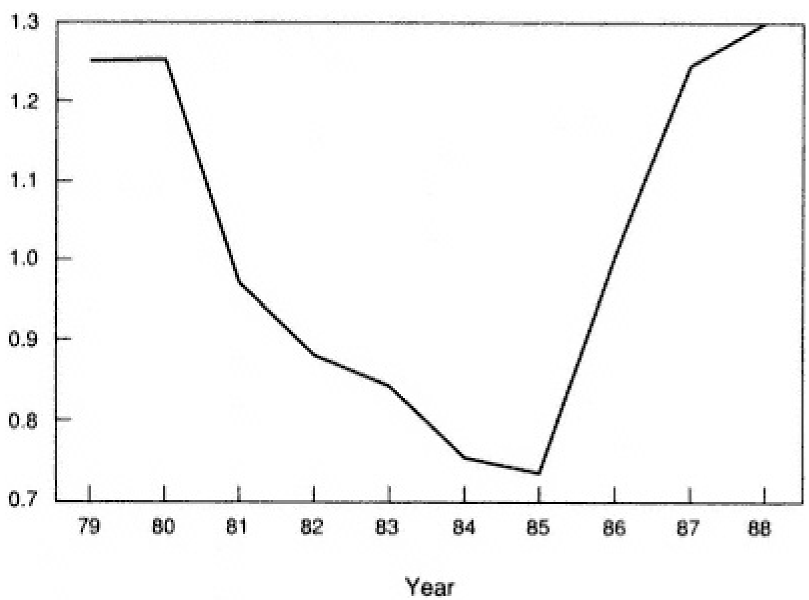

Figure 2 Ratio of German to U.S. hourly compensation costs in manufacturing.
SOURCE: U.S. Department of Labor (1989, p. 575, Table 149).

German manufacturing workers received an hourly compensation that was 25 percent higher than that of their U.S. counterparts. By 1985 the rise of the dollar had shifted the German rate of compensation to 25 percent below the American; by 1988 the dollar's plunge had more than restored the German premium, bringing the German rate of compensation to a level 30 percent higher than the U.S. rate.

The consequence of these huge changes in comparative labor cost has been roller-coaster behavior of trade in manufactures. Table 3 shows U.S. trade balances in high-technology and low-technology manufactures. During the 1980s, the traditional U.S. surplus in high technology disappeared, while the deficit in other manufactures ballooned; then both balances began to recover—a recovery that has without doubt continued beyond the dates covered in this table. One cannot infer from the decline in the high-technology surplus over this period that the United States was experiencing a fundamental decline in its high-technology competitiveness—nor can one refute this proposition. The point is that the financial shocks obscure the evidence.

Nonetheless, it is possible to discern, albeit rather dimly, some broad underlying trends in international high-technology competition. Perhaps the best way to highlight the nature of the trend is to place it in opposition to a straw man representing conventional wisdom about the competitive position of the United States. The conventional wisdom, which one still finds in many popular discussions, sees a U.S. economy that is suffering a progressive process of deindustrialization due to imports of manufactured goods; U.S. industry supposedly cannot compete with low-cost imports of traditional manufactures. The only available strategy is to compensate with growing exports of high-technology products. For a while the United States was able to offset its growing trade deficit in low-tech manufactures with a growing surplus in high-tech goods; the risk is that the United States will lose what remaining edge it has, and that high-technology industry will go the way of apparel and textiles.

The reality is quite different, and in some ways nearly the reverse. De

TABLE 3 U.S. Trade Balances in Manufactures (billions of dollars)

	High Technology	Non-High Technology
1981	27.4	-5.4
1986	-0.7	-116.4
1987	2.7	-127.5
1988	8.1	-114.5

SOURCE: U.S. Department of Commerce (1989, pp. 21-22).

industrialization, a "hollowing out" of the U.S. manufacturing base by imports was never a possibility that made sense: given the dominant role of manufactured goods in U.S. trade, one could always count on the dollar eventually to fall to a level that made U.S. production competitive in world markets. And in practice, the negative impact of trade deficits on the size of the U.S. manufacturing base has never been extensive and has been diminishing in the last few years. Table 4 shows the U.S. trade balance in manufactures as a percentage of manufacturing value added, for selected years. Before the 1980s the number was very small, so that trade had no significant deindustrializing effect before 1983 or so. At the trade deficit's peak it was more than 14 percent of manufacturing value added; by 1990 it had again fallen to about 9 percent. Only part of that 9 percent represents manufacturing value added shifted abroad, since some of the cost of imports and exports consists of inputs that the manufacturing sector purchases from other sectors. Thus, at a rough estimate the U.S. manufacturing sector in 1990 was only about 5 percent smaller than it would have been had the U.S. economy been closed to foreign competition.

TABLE 4 U.S. Trade Balance in Manufacturing as a Percent Share of Manufacturing Value Added

1970	0.9
1981	1.7
1987	-14.1
1990	(est.)-8.5

SOURCE: Economic Report of the President (1991) and Survey of Current Business (Various issues).

It is widely believed that until the 1980s the stability of the overall U.S. trade balance in manufactures was the result of a simultaneously growing surplus in high technology and a deficit in other goods. This is certainly true of the nominal trade balances. Virtually all of the growth in these imbalances, however, can be tied to inflation and the general growth of the U.S. economy. Table 5 shows the relevant trade balances in nominal terms and as a share of gross national product (GNP); these latter numbers show little pronounced trend, and were in any case quite small.

If one looks at the composition of output, furthermore, one sees if anything a somewhat worse U.S. comparative performance in high technology than in other goods. Table 6 compares the U.S. share of world high-technology output with its share of manufactures in general; both shares have declined since 1980, but the decline has actually been faster in high technology—or, to put it differently, the distinctive U.S. specialization in high technology has eroded. Table 7 offers a similar form of evidence, comparing the high-tech share of output in the United States, Japan, and Europe; this share has risen for all three, but much more slowly for the United States and Europe than for Japan; again, one sees U.S. distinctiveness eroding. Finally, Table 8 shows measures of U.S. and Japanese "revealed comparative advantage" in high-technology products—the ratio of their export shares in that sector to all manufactured exports. Again the evidence suggests that since 1980 the U.S. position has become less distinct.

TABLE 5 U.S. Trade Balances in Manufactures

	Billions of Dollars		Percent of GNP	
	High Tech	Non-High Tech	High Tech	Non-High Tech
1970	6.1	-3.8	0.6	-0.4
1981	27.4	-5.4	0.9	-0.2
1988	8.1	-114.5	0.2	-2.3

SOURCE: U.S. Department of Commerce (1988, 1989).

Putting all of this together, one may offer a hypothesis that is pretty much the opposite of the common view that the United States is now competitive, if at all, only in high-technology industries. In fact U.S. manufacturing in general continues to be able to sell both in the domestic and the international market; the soaring trade deficits of the 1980s were an aberration due to a strong dollar, and the subsequent several years have been marked by a widespread export revival across a broad spectrum of industries. The terms of competition, however, have gradually changed. In 1970 the United States, with a dominant position in advanced technology, was able to compete internationally despite high wages relative to other nations. At present, the United States sells goods that are no more advanced and

TABLE 6 U.S. Shares of World Output

	High Technology (Percent)	All Manufactures (Percent)	Ratio
1980	40.4	33.5	1.21
1986	36.9	30.8	1.20
1987	37.5	32.0	1.17

SOURCE: National Science Board (1991, pp. 401-402, Appendix tables 6-2 and 6-3).

sometimes less so than those produced by other countries; it is able to do this because U.S. wages are not much higher and often less than those of our competitors. In other words, the United States remains able to compete; but it has shifted its manufacturing downscale relative to other advanced nations, Japan in particular.

TABLE 7 High-Tech Manufactures' Share of Total Manufacturing Output (percent)

	U.S.	Japan	Europe
1980	20.0	16.3	16.1
1987	27.9	29.5	20.9

SOURCE: National Science Board (1991, p. 404, Appendix table 6-4).

The interesting question is whether this process of relative decline shows any signs of ending. Here the wild currency fluctuations of the 1980s make it difficult to arrive at an answer, because it is impossible to separate long-term trends from short-term events. It is possible to find pieces of evidence that point in either direction. On one side, U.S. manufacturing has experienced an impressive revival of productivity growth. Table 9 compares U.S. productivity performance with Germany, Japan, and an average of trading partners. Since 1980 the historical trend of U.S. relative decline has slowed or even reversed, thanks to a remarkable burst of productivity improvement

TABLE 8 Revealed Comparative Advantage in High-Technology Industries (Share of world high-tech manufacturing exports/share of total world manufacturing exports)

	U.S.	Japan
1980	1.66	0.90
1984	1.80	0.92
1988	1.79	1.22

NOTE: The revealed comparative advantage index shows each country's share of world exports in a given product, or in this case, all high-tech manufactured products, relative to that country's share of world exports of all manufactured products.
SOURCE: National Science Board (1991, p. 407, Appendix table 6-7).

in the United States. This could represent a one-time gain as U.S. firms have grown leaner and meaner, or it could in part represent a more basic turnaround in the U.S. ability to apply new technology; it is still too early to tell.

TABLE 9 Growth of Output per Hour in Manufacturing (Average annual rates of change, in percent)

	U.S. Percent	Japan Percent	Germany Percent	U.S. Relative Productivity Index
1960–1970	2.6	10.3	5.7	113.9
1970–1980	2.3	6.1	4.2	91.6
1980–1988	3.7	4.5	2.8	90.4

SOURCE: U.S. Department of Labor (1989).

On the other side, studies of the relationship between trade and exchange rates have shown little sign of a change in basic trends. Lawrence (1990), who earlier showed that the United States appears to need a persistent depreciation of the dollar in real terms to make up for lagging trade performance, finds no sign that this fact has changed in the past decade.

At this point one is forced to rely on impressions. And here it is hard not to feel that, whatever the numbers say, the United States has continued to slide in relative terms, and Japan to rise. As recently as the early 1980s it was common for economists to argue that the United States retained a dominant position in advanced technology and that despite Japanese inroads in a few areas, U.S. dominance remained largely intact. Few economists would now make the same statement; even if the measured high-technology share has remained fairly stable, there is a deeper underlying erosion.

SOURCES OF TRENDS IN HIGH-TECHNOLOGY TRADE

In a broad sense the picture of high-technology trade over the past 20 years is one of gradual erosion of U.S. preeminence, with the main beneficiary being Japan. This paper is not the place to attempt a comprehensive review of explanations for these trends; all that will be attempted is a quick presentation of the main issues.

In general one may identify two main kinds of explanation for the relative decline of the United States and rise of Japan. One explanation stresses aggregate inputs, especially capital and highly educated labor. The other stresses differences in the competitive environment, such as the alleged closed nature of the Japanese market.

Extensive attention has been given to the difference in the cost of capital between the United States and Japan. A high cost of capital discourages firms from making all kinds of long-term investments, perhaps including in particular the willingness to accept low returns during the initial development phases of new technologies. For technical reasons (involving international differences in taxation and financial structure) it is difficult to make firm estimates of the cost of capital; Table 10 reports several representative estimates, all of which suggest a substantially higher U.S. cost.

The high U.S. cost of capital may, in turn, be explained by low national savings rates. The United States has consistently had somewhat lower savings rates than other advanced countries, while Japan has saved more; during the 1980s the U.S. rate plunged to only 3.6 percent of GNP, less than half the average of nations in the Organization for Economic Cooperation and Development, while Japan saved 17.8 percent of GNP.

Trends in human capital can also help explain the trends in high-technology trade. A useful indicator—albeit a problematic one, as we will see in a moment —is the employment of scientists and engineers. Table 11 shows the number of scientists and engineers engaged in R&D per 10,000 workers in the labor force, for the United States, Japan, and Germany. The erosion of the distinctive U.S. position is evident.

The problem with this measure is that it does not clearly distinguish between supply and demand. Japan may be employing more people in R&D because its high-technology industries are successful, rather than the other way around. One can try to get around this by appealing to evidence on the quality of basic education—which is sufficiently poor in the United States to explain just about any pattern of decline. It is also possible to argue, however, that Japanese high-technology success is at least in part generated by government policies and by the advantages of a de facto closed domestic market. Given the description earlier in this paper of how advantage can be created in high-technology industries, one certainly cannot rule out such an explanation. A closed market can in principle allow a country to break into industries in which the self-reinforcing advantages of established competitors would otherwise block entry and can conversely deny foreign

TABLE 10 Alternative Estimates of the Cost of Capital (percent)

Study	Year	U.S.	Japan
Hatsopoulos-Brooks	1985	9.7	3.8
McCauley-Zimmer	1988	11.2	7.2
Bernheim-Shoven	1988	11.1	4.1

NOTE: Hatsopoulos-Brooks values correspond to the cost of fixed asset services (before depreciation). McCauley-Zimmer estimates correspond to the cost of a twenty-year plant.
SOURCE: Poterba (1991, p. 30, Table 7).

rivals the opportunity to establish the virtuous circles that allow an industry to succeed.

TABLE 11 Employment of Scientists and Engineers Engaged in R&D per 10,000 Workers in Labor Force for Selected Countries

	Germany	Japan	U.S.
1970	30.8	33.4	64.1
1980	44.3	53.6	60.0
1987	53.7	68.8	75.9

SOURCE: National Science Board (1991, pp. 300-301, Appendix table 3-19).

TABLE 12 Import Share of the Domestic Market for High-Tech Products (percent)

	Germany	Japan	U.S.
1980	25.1	6.6	8.0
1987	33.9	8.3	13.2

SOURCE: National Science Board (1991, p. 405, Appendix table 6-5).

All of this is very iffy. The best one can do without getting down to detailed cases is to point out that the evidence does suggest in a circumstantial way that Japanese high-technology markets are indeed remarkably closed to imports. Table 12 shows the share of the domestic market for high-technology products accounted for by imports (import penetration) for the United States, Germany, and Japan. One might have expected that import penetration of the Japanese market would have been somewhat greater than that of the still considerably larger U.S. market, and that Japan would have shared in the trend toward internationalization. In fact, however, Japan has consistently remained nearly self-sufficient in high-technology products. At least on the face of it, the caricature of Japanese high-technology industries as being protected from imports, but free to export if they succeed in acquiring a competitive advantage, appears consistent with the numbers.

SUMMARY AND CONCLUSIONS

This brief overview of technology and trade has made three main points. The first is that the special emphasis many observers place on international competition in high-technology industries makes considerable sense. The qualification to this is that it is not the technology per se that makes the industries special, but the likelihood that such industries are characterized by strong external economies that give rise to self-reinforcing advantage. From this perspective, the financial services sector is as worthy of special concern as microelectronics.

Second, there has been a long-term trend of U.S. industry "downscale" and of Japanese industry "upscale." That is, what was once a distinctive U.S. position of dominance in high-technology industries has eroded over time, and Japan has begun to show the kind of distinctive pattern that the United States no longer has. This trend is *not*, however, associated with wholesale U.S. deindustrialization.

Third, the sources of this trend are ambiguous. Aggregate factors such as the cost of capital and the supply of highly educated labor have moved in a direction that helps explain the trends in high-technology competition, but the circumstantial evidence is also consistent with stories that emphasize market access and government action.

This overview, then, leaves the most crucial issues—how does policy affect the relationship between technology and trade, and what should be done differently—open for further discussion.

NOTES

1. The use of the term "positive feedback" to describe the particular sort of external economies that creates advantage is due to Arthur (1990).

2. Or, for the economists, pecuniary versus technological external economies. It is common for economists to argue that pecuniary externalities have no welfare significance, and that only technological external economies are a proper matter of policy concern. This would be right if the economy were characterized by perfect competition and constant returns to scale. In the presence of increasing returns and imperfect competition--which is to say in most real industries--market size effects do matter.

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Technological and Trade Competition: The Changing Positions of the United States, Japan, and Germany

Paolo Guerrieri

Deep technological changes in the past two decades have profoundly affected all the major economies of the world. Technological change has forced countries to make wide-ranging domestic adjustments and has continuously modified their competitive economic positions. In this respect, the major economies reacted according to different patterns and with different degrees of success.

This essay deals with the three technological leaders—Japan, the United States, and West Germany—and compares their international trade performance and specialization in the past two decades, providing empirical evidence of the differences in their technological levels and innovative capabilities. In effect, trade performance and specialization provide a relatively objective and convenient test of comparative efficiency of industries in each of the three countries.

This essay is in five sections. The first outlines an analytical framework and methodology, explaining why in comparing national technological performances and capabilities not only high-tech products but the entire industrial structure must be considered. A taxonomy of industrial sectors depicts the industrial system of a country not as a simple list of independent sectors but rather as a structure with its own internal hierarchy, characterized by a complex technological interdependence between its various component sectors. The empirical findings of this analysis are presented in the second, third, and fourth sections with an evaluation of changes in the relative competitive positions and technological capabilities of Japan, the United States, and West Germany in the past two decades. The final section provides some concluding comments on these findings.

TECHNOLOGY, INDUSTRIAL STRUCTURE, AND INTERNATIONAL COMPETITIVENESS

Technology is widely recognized as an important factor determining the trade performance and international competitiveness of a country. If we try to define and quantify such technological levels and innovative capabilities of single countries, however, many methodological and empirical problems arise. To face such problems it is helpful to rely on the results of the considerable volume of theoretical and empirical research that has been carried out over the past 15 years on the nature, determinants, and effects of innovative activities.[1]

In general terms, innovative activity may be viewed as the result of a long and complex process of accumulation and appropriation of a stock of knowledge (technical and managerial). Most of this stock of knowledge, however, cannot be equated with "information" that is generally applicable and easily reproducible. In fact, neither the means and channels for accumulation and appropriation of the stock of knowledge nor the resulting output is the same for all firms and product groups. Technology has a cumulative, firm-specific nature, because it is differentiated in both its technical characteristics and its market application (Cantwell, 1989; Krugman, 1987; Pavitt 1988; Teece, 1986). Processes of technological accumulation tend to assume varying sectoral features, through differences in technological opportunities, sources, and appropriability conditions (Levin, 1984; Scherer, 1986). It follows that the technological content of various product groupings and sectors can be differently defined and quantified according to the typologies and sources of technology being considered.

Technological change also affects a wide range of structural relationships linking different industries (Pavitt, 1984; Scherer, 1982; Schmookler, 1966). Some sectors will be more productive in terms of innovations while others will be users of innovations developed by others. So, the linkages among various parts of the production system can assume great importance, in terms of technological complementarities and interdependencies affecting competitiveness of each sector and hence of the industrial system as a whole (Chesnais, 1986; Dosi et al., 1990, Lundvall, 1988).

These features of technology have important implications for a comparison of technological capabilities and international trade performance of various countries. More traditional taxonomies divide industrial sectors into high and low (or high, medium, and low) technology-intensity groups of products on the basis of indicators of both technological input (R&D expenditures) and output (patents). Such taxonomies are unsatisfactory for evaluating a country's technological capability and international trade performance, because they ignore those prominent differences with respect to the mechanisms of introducing and diffusing technologies, already mentioned, within and across industrial sectors. Therefore, they tend to reduce technological change to a physiological alternation of "growth" industries (high-tech sectors) and "declining" industries (low-tech sectors).

An alternative and more useful sectoral taxonomy is that developed by Pavitt (1984, 1988) at the Science Policy Research Unit of the University of Sussex, which represents the differences in the opportunities and mechanisms of appropriability of technological innovations characterizing various industrial sectors. In Pavitt's taxonomy, industries are divided into four major groupings according to a combination of sectoral technology sources, user requirements, and means of appropriation (see Figure 1).

The first group, so-called science-based sectors, includes industries such as fine chemicals, electronic components, telecommunications, and aerospace, which are all characterized by innovative activities directly linked to high R&D expenditures. Their product innovations generate broad spillover effects on the whole economic system, and a large number of other sectors heavily rely on them as capital or intermediate inputs.[2]

A second group—scale-intensive sectors—includes typical oligopolistic large-firm industries, with high capital intensity, wide economies of scale and learning, high technical or managerial complexity, and significant inhouse production engineering activities. Examples are the automobile industry, certain consumer electronics and consumer durables industries, and the rubber and steel industries.

The third group of industries—specialized suppliers—includes most producers of investment goods in mechanical and instrument engineering, such

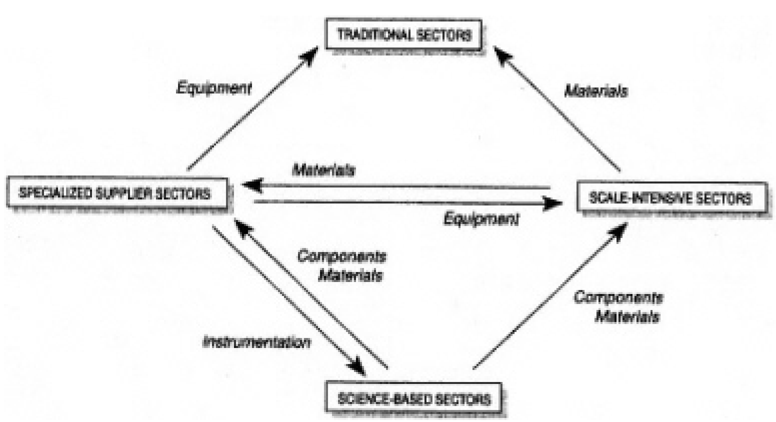

Figure 1 The main technological linkages among different groups of industrial sectors. SOURCE: After Pavitt (1984).

as the machinery for specialized industries (that is, machine tools). It is characterized by a high diversification of supply, high "economies of scope," medium-sized to small companies, and a notable capacity for product innovation that enters most sectors of scale-intensive and supplier-dominated groups as capital inputs.

Finally, there is a group of "supplier-dominated" sectors, which encompass the more traditional consumer and nonconsumer goods industries that are net purchasers of process innovations and innovative intermediate inputs from other suppliers of production equipment and materials (specialized-supplier and scale-intensive sectors, as represented in Figure 1). These sectors are notably sensitive to price competition, but are also influenced by "nonprice factors" such as product design and quality. This group includes textiles, clothing, wood and furniture, leather and shoes, ceramics, and the simplest metal products.

Pavitt's classification of industrial sectors has the merit of emphasizing two key aspects of technological change and innovative activities. First, the technological capability of firms and countries is not linked solely to their R&D expenditure or patent acquisitions since the typologies of innovative activity have industry- and firm-specific characteristics. Second, the linkages among different groups of industries and the related complex technological interdependencies (see Figure 1) are of great importance, because they differently characterize, as shown below, each national system of production and innovation. Such interdependencies are also important to achieving a proper understanding of the links between technological capabilities and international competitiveness at the country level.

Certainly this sectorial taxonomy, as may be expected from any such broad classification, has some limitations, mainly stemming from the heterogeneity of the products included in each group of industries and, in this respect, it requires further validation and elaboration. It nevertheless permits a more accurate assessment of technological capabilities and international trade performance at the level of a country than do more traditional classifications.

The present comparative analysis of the technological and trade competitive positions of the three major leaders in world trade—the United States, Japan, and Germany—therefore makes use of Pavitt's classification. For this investigation, I have employed the SIE-World Trade data base (see Appendix), which I built, together with colleagues at the Institute for Studies on Foreign Trade (Servizi Informativi per l'Estero—SIE) in Rome, by using United Nations and OECD official statistical sources for more than 80 countries (including less-developed countries, newly industrialized countries, and members of the Organization for Economic Cooperation and Development and the former Council for Mutual Economic Assistance). The data base allows us to conduct research on the changing pattern of world trade at a rather disaggregated level (400 product classes, 98 sectors and 25 commodity groups).

In this study, all traded-manufactured products included in the SIE trade data base at a highly disaggregated level have been classified into four groups (science-based, specialized suppliers, scale-intensive, and supplier-dominated) plus the group of food industries, which is considered separately, for a total of five product groups representing the whole industrial system.[3]

THE UPSURGE OF JAPAN IN WORLD MARKETS

The present analysis uses a long-term approach (1970–1989) for a clear overall appraisal of the major changes in trade (industrial) structures and performance of three major countries—United States, Japan, and Germany. It also uses a variety of indicators of a country's competitiveness and trade specialization. While no single indicator can provide an adequate view of a country's international trade performance, it is possible to draw fairly reliable conclusions if various indicators are considered together.

Of the three countries, Japan undoubtedly achieved the best trade performance in the past two decades. To evaluate it, the first two sets of indicators employed are both more directly tied to the competitive position of a country; they are worked out below for the manufacturing system as a whole and for all the sectoral groups considered in the preceding section.

The first set of indicators is the share of country exports in world exports with reference to each group of products.[4] The performance of market share will be considered over a long period (1970–1989), to overcome the effects of short-run fluctuations and highlight the major trends characterizing the international competitiveness of a given country. The second set of indicators includes trade balances by country either in overall manufacturing or in single sectoral groups standardized by total world trade in each group of products. This indicator highlights the international distribution of trade surpluses and deficits in each group of products by country over time, thus underlining major shifts in relative competitive positions of various countries.[5]

In trade of manufactured products, Japan's share in world exports has been increasing sharply over the period considered (see Table 1), and standardized trade balances have been growing even more impressively (see Figure 2). Both had partially decreased by the late 1980s, only marginally altering, however, the net gains achieved by Japan in the whole period here considered.

In the case of single sectoral groups, both sets of indicators show a marked improvement in the performance of Japanese industry. The improvement is apparent, first, in science-based sectors, with more than a doubling

TABLE 1 Shares of Selected Countries and Areas in World Trade in Manufactures* (Percentage shares in values)

	1970–1973**	1973–1976	1976–1979	1979–1982	1982–1985	1985–1988	1989	1970–1989
United States	13.52	13.07	12.23	12.68	12.33	10.88	11.57	–3.45
Japan	9.01	9.55	10.16	10.45	12.09	12.28	11.44	3.03
EEC (12)	48.63	48.23	48.47	46.15	42.40	43.68	43.94	–3.62
Germany, Federal Republic	15.02	15.22	14.91	13.68	12.75	13.88	13.82	–0.7
France	7.43	7.68	7.85	7.49	6.58	6.59	6.6	–0.53
United Kingdom	7.76	6.78	6.96	6.69	5.71	5.55	5.72	–2.31
Italy	5.58	5.35	5.83	5.85	5.59	5.72	5.7	0.15
Non-OECD Countries	13.53	15.15	15.76	17.76	20.00	20.05	20.19	6.67
NICs in Asia	2.53	3.40	4.24	5.24	6.83	7.63	7.44	5.36

*Ratio of national exports to world exports (percentage).
**Average value in each subperiod.
SOURCE: SIE-World Trade data base.

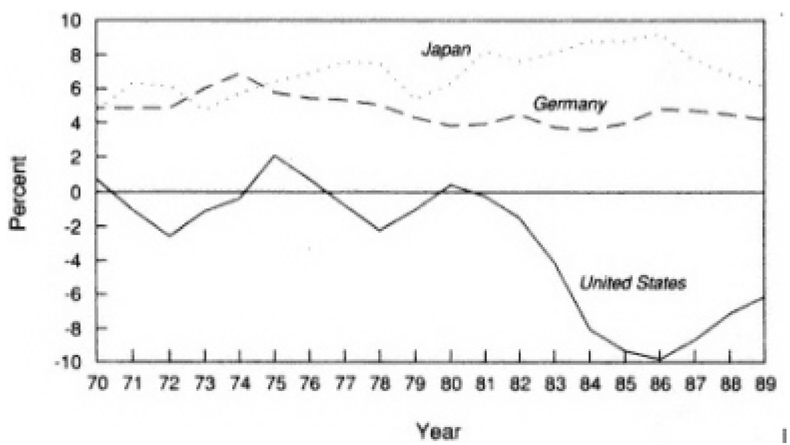

Figure 2 Trade balance in total manufactures. Standardized trade balances are expressed as a percentage of total world trade in manufactures. For methods and sources, see note 5.

of market shares (from 7.8 percent in 1970 to 16.5 in 1989, see Table 3) and a sharp increase in trade surpluses (+9.2 percent of world trade for this product group, see Table 4). Second, the strengthening is apparent also in the specialized-suppliers sector (mechanical engineering), with considerable gains in Japan's shares in world exports (from 6.4 percent in 1970 to 15.5 in 1989, see Table 5) and rapidly increasing positive trade balances (see Table 6). In the scale-intensive sectors, Japanese industry has further consolidated its competitive position that was already strong in the early 1970s, registering significant losses, however, in the second half of the 1980s (see Tables 7–8). On the contrary, in traditional sectors—such as textiles, clothing, leather, and footwear—the sharp decrease of export shares (Table 9) and the shift from high surpluses to increasing deficits in the late 1980s (Table 10) show that Japanese industry has carried out a relative disengagement from these areas of production, investing heavily abroad and reducing its export propensity.

TABLE 2 Weights of the Sectoral Groups in Total Exports*

	Germany (Federal Republic)		Japan		United States	
	1970–1973	1986–1989	1970–1973	1986–1988	1970–1973	1986–1989
Food items	1.50	1.21	0.99	0.30	15.95	9.74
Fuels	0.98	0.38	0.03	0.01	2.13	1.67
Other raw materials	0.37	0.30	0.05	0.08	1.11	0.89
Food industries	2.90	4.27	1.68	0.51	4.73	4.64
Traditional	15.08	14.32	17.63	6.81	7.84	7.24
Scale intensive	41.64	41.78	55.81	48.38	28.90	26.94
Specialized suppliers	22.83	18.56	10.79	16.17	16.91	11.61
Science based	12.06	16.28	10.93	26.35	18.03	29.41
Others	2.67	2.92	2.09	1.39	4.40	7.88
TOTAL	100	100	100	100	100	100

* Average value in each subperiod (in percentage).
SOURCE: SIE-World Trade data base.

Through the use of constant market shares analysis (CMSA), applied here with a new method of calculation, the changes in Japan's market share for the manufacturing sector and for various sectoral groups in the period has been broken down into two components: the "structural effect" and the "competitiveness effect," each of which represents a different set of determinants of Japan's trade performance.[6]

The "structural effect" refers to the geographic and commodity structure of a country's exports relative to the structure and the dynamics of world

TABLE 3 Shares of Selected Countries and Areas in World Trade in Science-Based Sectors* (Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987	1989	1970–89
United States	29.25	25.39	24.41	22.46	25.17	23.87	19.86	20.24	-9.01
Japan	7.81	9.07	9.61	10.37	11.6	14.75	16.16	16.52	8.71
EEC (12)	45.01	47.24	46.78	46.42	42.03	38.06	39.02	37.07	-7.94
Germany, Federal Republic	15.85	17.33	16.19	15.37	13.83	12.04	13.13	11.84	-4.01
France	6.81	7.31	8.61	8.67	7.76	6.73	7.01	6.67	-0.14
United Kingdom	9.87	9.48	8.74	9.72	8.93	8.09	7.23	7.11	-2.76
Italy	4.61	4.07	4.05	3.81	3.69	3.55	3.55	3.4	-1.21
Non-OECD Countries	3.29	4.91	7.26	9.52	11.35	13.35	15.43	16.25	12.96
NICs in Asia	1.04	2.32	3.75	4.76	5.42	7.61	9.29	9.76	8.72

* Ratio of national exports to world exports (percentage).
SOURCE: SIE-World Trade data base.

TABLE 4 Trade Balance of Selected Areas and Countries in Science-Based Sectors*

	1970	1973	1976	1979	1982	1985	1987	1989	1970–89
United States	18.87	13.79	13.85	10.99	10.91	3.62	1.38	1.45	-17.42
Japan	3.28	4.74	6.19	7.02	8.05	10.99	12.61	12.5	9.22
EEC (12)	5.38	5.05	8.16	5.48	4.96	2.59	0.26	-1.73	-7.11
Germany, Federal Republic	7.82	8.65	7.22	5.01	4.15	3.11	3.53	2.18	-5.64
France	-0.66	-0.67	1.01	1.01	0.81	0.86	0.15	0.21	0.87
United Kingdom	4.03	2.66	2.75	1.83	1.71	0.46	-0.21	-0.51	-4.54
Italy	0.06	-0.68	-0.07	-0.42	-0.32	-0.61	-1.15	-1.04	-1.1
NICs in Asia	-2.14	-2.32	-1.47	-2.02	-1.51	0.08	0.45	-0.91	1.23

* Standardized trade balances expressed as percentage of total world trade in science-based sectors. (For methods see note 5.)
SOURCE: SIE-World Trade data base

TABLE 5 Shares of Selected Countries and Areas in World Trade in Specialized-Supplier Sectors* (Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987	1989	1970–89
United States	22.79	19.17	21.06	16.67	19.06	15.26	11.01	14.37	-8.42
Japan	6.36	7.45	8.15	10.29	12.35	15.61	14.6	15.49	9.13
EEC (12)	55.96	57.07	54.45	54.95	47.9	47.76	51.83	49.28	-6.68
Germany, Federal Republic	24.01	26.55	23.81	22.96	19.02	19.31	22.19	20.47	-3.54
France	6.83	7.44	7.99	7.81	6.49	6.14	5.94	5.72	-1.11
United Kingdom	10.54	8.63	8.22	8.32	7.71	6.98	6.67	6.67	-3.87
Italy	7.14	6.28	6.23	7.24	7.22	7.72	8.77	8.28	1.14
Non-OECD Countries	3.24	4.51	4.58	5.33	8.43	8.37	8.52	8.04	4.8
NICs in Asia	0.77	1.52	1.22	1.62	2.44	3.71	4.02	3.71	2.94

* Ratio of national exports to world exports (percentage).
SOURCE: SIE-World Trade data base.

TABLE 6 Trade Balance of Selected Areas and Countries in Specialized-Supplier Sectors*

	1970	1973	1976	1979	1982	1985	1987	1989	1970–89
United States	14.97	11.13	14.11	7.59	8.99	-1.86	-4.73	-0.38	-15.35
Japan	3.14	4.85	6.34	8.35	10.41	13.36	12.43	12.32	9.18
EEC (12)	17.47	18.74	22.09	21.29	18.75	17.12	14.89	11.37	-6.1
Germany, Federal Republic	16.45	19.93	17.79	15.92	13.11	12.67	14.23	12.51	-3.94
France	-0.46	-0.47	1.24	1.41	0.44	0.57	-0.89	-1.25	-0.79
United Kingdom	4.71	2.78	2.96	2.66	2.58	1.01	0.57	-0.11	-4.82
Italy	2.68	1.81	2.97	3.95	4.24	4.57	4.47	3.86	1.18
NICs in Asia	-2.64	-2.86	-2.77	-3.72	-3.06	-2.12	-3.18	-5.03	-2.39

* Standardized trade balances expressed as percentage of total world trade in specialized-supplier sectors. (For methods see note 5.)
SOURCE: SIE-World Trade data base.

TABLE 7 Shares of Selected Countries and Areas in World Trade in Scale-Intensive Sectors* (Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987	1989	1970–89
United States	13.21	10.66	10.85	9.77	9.83	9.35	8.47	9.53	-3.68
Japan	10.23	12.05	14.18	11.9	14.62	15.71	14.61	13.06	2.83
EEC (12)	44.99	47.69	45.34	48.14	42.52	39.73	44.44	44.32	-0.67
Germany, Federal Republic	14.29	16.11	14.38	14.95	13.69	12.77	15.71	14.98	0.69
France	7.13	7.56	7.53	8.51	6.65	6.21	6.94	6.76	-0.37
United Kingdom	7.14	6.01	5.62	5.92	5.15	4.77	5.42	5.42	-1.72
Italy	4.42	4.53	4.54	5.21	4.52	3.92	4.16	4.11	-0.31
Non-OECD Countries	13.35	13.17	14.29	16.12	18.72	19.63	16.57	17.76	4.41
NICs in Asia	1.11	1.89	2.39	2.96	4.59	5.46	5.38	5.24	4.13

* Ratio of national exports to world exports (percentage).
SOURCE: SIE-World Trade data base.

TABLE 8 Trade Balance of Selected Areas and Countries in Scale-Intensive Sectors*

	1970	1973	1976	1979	1982	1985	1987	1989	1970–89
United States	-2.92	-5.28	-3.88	-4.89	-6.21	-13.44	-11.58	-8.57	-5.65
Japan	6.39	8.63	11.1	8.21	10.92	11.9	10.24	7.48	1.09
EEC (12)	5.29	8.11	7.66	7.12	5.59	5.01	4.21	2.13	-3.16
Germany, Federal Republic	4.58	6.48	5.25	4.72	5.22	4.47	6.34	5.46	0.88
France	1.21	1.13	1.32	2.21	0.27	0.72	0.14	-0.21	-1.42
United Kingdom	1.27	0.17	0.47	-0.42	-0.72	-0.94	-1.04	-1.69	-2.96
Italy	-0.25	0.21	0.61	0.48	-0.04	-0.71	-1.27	-1.74	-1.49
NICs in Asia	-1.26	-0.87	-0.42	-0.48	0.41	0.97	0.33	-1.16	0.1

* Standardized trade balances expressed in percentage of total world trade in scale-intensive sectors. (For methods see note 5.)
SOURCE: SIE-World Trade data base.

TABLE 9 Shares of Selected Countries and Areas in World Trade in Traditional Sectors* (Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987	1989	1970-89
United States	7.43	6.66	7.33	6.43	6.71	5.21	4.42	5.56	-1.87
Japan	9.29	6.33	6.23	4.63	6.03	5.53	4.01	3.78	-5.51
EEC (12)	50.9	49.11	48.44	48.94	44.42	42.48	42.69	42.25	-8.65
Germany, Federal Republic	12.06	12.04	12.07	11.07	10.51	10.12	10.69	10.46	-1.6
France	7.06	7.27	6.55	6.27	5.74	5.34	5.17	5.22	-1.84
United Kingdom	8.51	7.63	7.06	7.76	5.14	4.62	4.39	4.38	-4.13
Italy	9.01	7.68	8.81	10.81	10.63	10.51	10.33	10.01	1
Non-OECD Countries	18.24	23.35	25.95	25.77	30.5	33.97	36.82	36.69	18.45
NICs in Asia	6.13	8.67	10.7	10.64	13.80	15.86	17.01	13.55	7.42

* Ratio of national exports to world exports (percentage).
SOURCE: SIE-World Trade data base.

TABLE 10 Trade Balance of Selected Areas and Countries in Traditional Sectors*

	1970	1973	1976	1979	1982	1985	1987	1989	1970-89
United States	-8.46	-7.56	-5.66	-6.99	-8.98	-19.07	-15.57	-13.71	-5.25
Japan	6.62	1.39	3.05	0.75	2.48	2.04	-0.61	-2.82	-9.44
EEC (12)	7.26	2.78	1.94	0.82	3.21	4.77	0.61	-0.11	-7.37
Germany, Federal Republic	0.82	-0.31	-0.35	-1.68	-0.16	0.45	-0.47	-0.13	-0.95
France	1.21	0.77	-0.88	-1.27	-1.56	-1.01	-2.03	-1.84	-3.05
United Kingdom	0.66	-1.18	-0.45	-1.53	-2.24	-2.59	-2.95	-3.25	-3.91
Italy	5.51	3.94	5.38	7.13	7.16	7.12	6.47	5.97	0.46
NICs in Asia	2.21	4.65	6.88	6.57	8.24	9.81	10.3	5.2	2.99

* Standardized trade balances expressed as percentage of total world trade in traditional sectors. (For methods see note 5.)
SOURCE: SIE-World Trade data base.

demand. The structural effect will be positive if a country concentrates its export on markets or commodities that grow faster than the world average. This structural effect can be further divided into three elements: (1) the "market effect" due to the structure of a country's exports by geographical destination; (2) the "commodity effect" due to the structure of a country's exports by products; and (3) the "specific market-commodity effect" due to the structure of a country's exports by specific market and product groups. The competitiveness effect reflects the actual changes of a country's market shares, assuming that its trade structure is constant, and it represents that part of a country's trade performance deriving from its competitive factors (both price-, and nonprice-related).

TABLE 11 Shares of Selected Countries and Areas in World Trade in High R&D-Intensive Electronic Sectors* (Percentage shares in values)

	1970–1973**	1973–1976	1976–1979	1979–1982	1982–1985	1985–1988	1989	1970–1989
United States	28.48	26.42	24.27	26.05	27.13	21.49	19.51	–13.12
Japan	9.43	10.77	13.06	14.21	17.44	20.22	21.47	13.68
EEC (12)	44.97	42.59	39.89	36.14	30.72	31.30	28.98	–14.62
Germany, Federal Republic	15.03	14.37	12.43	10.43	8.24	8.09	7.09	–6.48
France	7.76	7.48	7.34	6.41	4.96	4.94	4.14	–3.37
United Kingdom	8.02	7.55	7.31	7.18	6.69	7.05	7.08	–0.79
Italy	5.37	4.18	3.91	3.80	3.06	3.21	3.17	–3.06
Non-OECD Countries	5.52	9.19	12.51	14.66	17.13	19.79	23.24	19.31
NICs in Asia	3.36	6.33	8.43	9.20	11.20	13.95	16.21	14.12

*This product group includes data processing equipment, electronic components, and telecommunications equipment.

**Average value in each subperiod.

SOURCE: SIE-World Trade data base.

The results of CMSA (see Table 12) confirm that Japanese industry achieved the highest gains in the specialized-supplier and science-based industries in terms of both structural and competitiveness effects. This was particularly evident in the 1980s in connection with the deep restructuring process under way after the second oil shock.

Certainly, this sharp strengthening of the competitiveness of Japanese production may be attributed to many heterogeneous factors. It is far from easy to identify them and cannot be attempted within the limits of this paper. In general, however, it may be said that a set of macroeconomic and socioinstitutional factors, together with a unique strategy of industrial

TABLE 12 Results of the Constant Market Shares Analysis of the Exports in a Single Group of Sectors* 1970–1987 (percentage values)

	Market Share Changes (c) = (d)+(e)	Effect Competitiveness (d)	Total (e) = (f)+(g)+(h)	*Structural Effect* Market Effect (f)	Commodity (g)	Specific Effect (h)
United States, 1970–1987:						
Total:	–4.86	–4.31	–0.55	–1.12	1.02	–0.45
Food Industry	–0.72	–1.2	0.48	0.7	0.23	–0.45
Traditionals	–3.01	–1.87	–1.14	–0.77	–0.25	–0.11
Scale intensive	–4.74	–4.02	–0.71	–0.52	0.5	–0.7
Specialized suppliers	–11.77	–8.25	–3.52	–2.55	–0.66	–0.32
Science based	–9.39	–6.25	–3.14	–3.48	0.01	0.34
Japan, 1970–1987:						
Total	3.38	1.07	2.31	1.97	0.55	–0.21
Food Industry	–0.93	–1.29	0.37	0.14	0.18	0.05
Traditionals	–5.29	–4.77	–0.51	0.68	–0.82	–0.37
Scale intensive	4.38	2.08	2.31	1.6	1.01	–0.28
Specialized suppliers	8.23	4.29	3.94	3.47	0.21	0.27
Science based	8.36	5.52	2.84	3.57	–0.55	–0.18
Asian NICs, 1970–1987:						
Total	6.17	3.85	2.32	0.93	1.04	0.35
Food Industry	1.74	0.88	0.87	0.06	0.3	0.5
Traditionals	10.87	5.26	5.61	2.58	2.71	0.32
Scale intensive	4.27	4.05	0.22	0.1	–0.4	0.52
Specialized suppliers	3.25	2.22	1.03	0.81	0.3	–0.08
Science based	8.25	2.03	6.22	2.1	4.77	–0.65
Germany (Federal Republic), 1970–1987:						
Total	0.04	–0.23	0.27	–0.56	0.22	0.61
Food Industry	5.6	3.32	2.28	0.95	0.36	0.97
Traditionals	–1.37	–0.29	–1.08	–1.01	–0.41	0.33
Scale intensive	1.42	–0.29	1.72	–0.06	1.32	0.46
Specialized suppliers	–1.82	–1.32	–0.5	–1.01	0.43	0.07
Science based	–2.72	–0.57	–2.15	–1.83	–2.24	1.92

development, contributed to the success of Japanese industry. In this respect, many studies[7] have pointed to a significant role played by structural competitiveness factors, especially technological factors.

	Market Share Changes (c) = (d)+(e)	Effect Competitiveness (d)	Total (e) = (f)+(g)+(h)	*Structural Effect* Market Effect (f)	Commodity (g)	Specific Effect (h)
France, 1970–1987:						
Total	–0.41	–0.07	–0.34	–0.72	0.01	0.37
Food Industry	2.59	0.78	1.81	0.6	0.2	1.01
Traditionals	–1.89	–1.15	–0.74	–0.81	–0.22	0.3
Scale intensive	–0.19	–0.32	0.13	–0.5	0.5	0.13
Specialized suppliers	–0.89	–0.09	–0.8	–0.86	0.17	–0.11
Science based	0.21	1.55	–1.35	–0.82	–0.7	0.17
United Kingdom, 1970–1987:						
Total	–2.32	–2.25	–0.07	–0.32	0.24	0.01
Food Industry	0.42	–0.44	0.86	0.51	0.23	0.12
Traditionals	–4.11	–3.7	–0.41	–0.74	–0.02	0.35
Scale intensive	–1.72	–1.82	0.1	–0.25	0.33	0.01
Specialized suppliers	–3.87	–3.32	–0.56	–0.16	–0.28	–0.12
Science based	–2.65	–1.35	–1.3	–0.62	–0.36	–0.32
Italy, 1970–1987:						
Total	0.33	–0.05	0.38	–0.26	0.34	0.3
Food Industry	1.56	1.32	0.25	–0.04	0.29	0.01
Traditionals	1.32	0.66	0.66	–0.1	0.68	0.08
Scale intensive	–0.26	–1.08	0.82	–0.22	0.53	0.51
Specialized suppliers	1.62	1.87	–0.25	–0.45	0.13	–0.07
Science based	–1.05	–0.27	–0.78	–0.53	–0.66	0.42

* The CMSA was carried out within each group of sectors.
SOURCE: Guerrieri and Milana (1990).

The latter may be connected with the profound changes that have taken place in the industrial structure and in the patterns of Japan's trade specialization in the past two decades. Japan has adapted to the changing dynamic and commodity composition of world demand, as shown below, much more and better than have the specializations of the other partner countries.

To evaluate Japanese specialization patterns (see Figure 3), an indicator of the contribution to trade balance (ICTB) of a country has been worked out for the various groups of sectors in consideration (Center for International Prospective Studies [CEPII], 1983) (see Figure 2). If the contribution (positive or negative) of each group of sectors to a country's trade balance is proportionally equivalent to its weight in total trade (import plus export), then the values of the ICTB indicator for that group of sectors (or group of products) will be zero. Hence, positive ICTB values indicate those sectoral groups with positive contributions to trade balance greater than their weight in total trade. Therefore, they represent sectors with comparative advantages in the trade specialization of a given country. Opposite considerations are associated with negative ICTB values. They generally identify those commodity groups for which a country depends on other countries (comparative disadvantages) and which generate a relatively high trade deficit.[8] The ICTB indicator has been worked out for each year in the period from 1970 to 1989.

In the case of Japan, in the early 1970s, the scale-intensive and traditional sectors represented the strong points (comparative advantages) of the Japanese industry's specialization pattern (see Figure 3). But in the mid-1970s and throughout the 1980s, profound changes took place. Following a deep industrial restructuring process, with unprecedented intensity and quality in the advanced countries, positive contributions to the trade balance

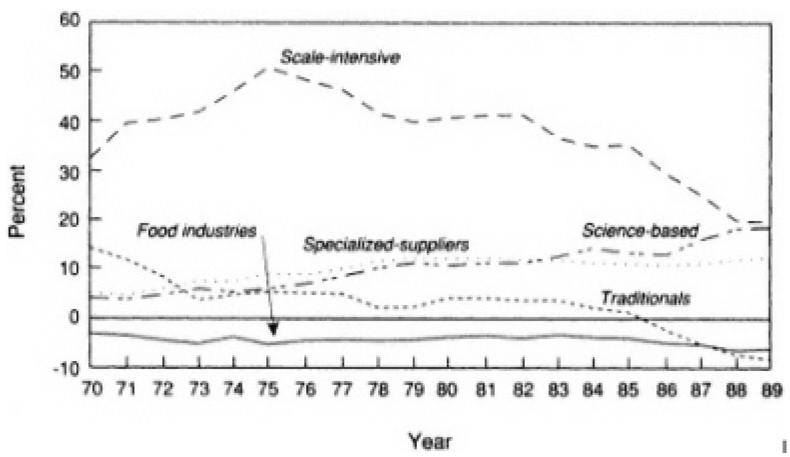

Figure 3 Patterns of trade specialization of Japan. Indicator of comparative advantage (>>0) or disadvantage (<0). For methods and sources, see note 8.

strongly increased: (i) in the case of the R&D-intensive sectors (science-based), by a quadrupling of their indicator ICTB (+14.4 percentage points); (ii) for the specialized-supplier sectors, by a doubling of their ICTB (+7.6 percentage points).

The strengthening of Japanese specialization in R&D-intensive products (science-based) may be largely attributed to the notable gains of Japanese industry in electronics, and particularly in those sectors with the highest technological content. In the latter sectors, such as data processing systems, electronic components, and telecommunications, the increase in market shares since the early 1970s was so impressive that by 1989 Japan became the world's largest exporter of these groups of electronic products (Table 11). In its trade balance, Japanese performance was even more successful, with huge and increasing trade surpluses, which confirmed its supremacy, quite sharply in most electronic sectors (see Figure 4).

The adoption of the most advanced product and process innovations, mostly imported from the United States, the lower costs linked to firm organization and large-scale production processes, aggressive industrial and trade policies have all contributed to the rapid rise of the Japanese electronics industry in international markets, which severely penalized most U.S. and European productions, as shown below. The use of new electronic tech

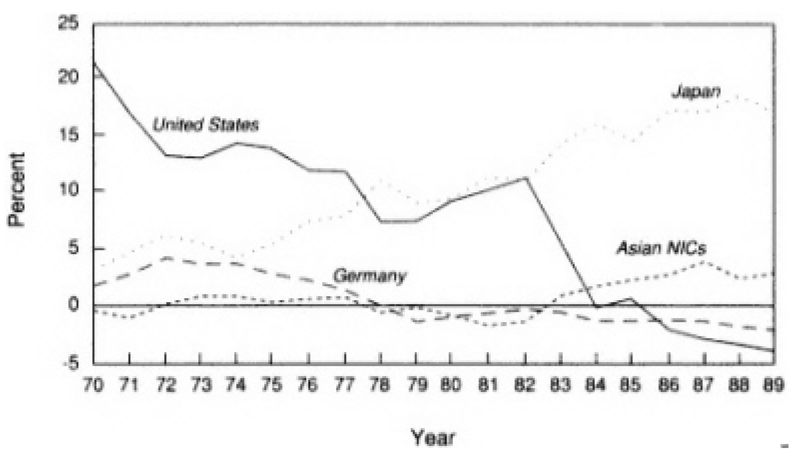

Figure 4 Trade balance in R&D-intensive electronics sectors. This group of sectors includes data processing equipment, electronic components, and telecommunications equipment. Standardized trade balances are expressed as a percentage of total world trade in R&D-intensive electronics sectors. For methods and sources, see note 5.

nologies, on the other hand, also sustained the strengthening of Japanese specialization in specialized-supplier sectors (Figure 3), and particularly in machinery for specialized industries, such as numerically controlled machine tools. Together with the increase in comparative advantage in science-based and specialized-supplier sectors, the evolution of Japanese specialization patterns reveals that the contribution of scale-intensive sectors to the trade balance has significantly decreased since the second half of the 1970s and was equivalent to that of science–based sectors in 1989 (see Figure 3).

A new element has been the great reduction in the role of traditional sectors, which registered negative ICTB indicators in the second half of the 1980s, following a decrease of more than 22 percentage points [from 14.45 (1970) to -8.28 (1989)] since the early 1970s (Figure 3). The share of exports of traditional goods in total Japanese exports has also strongly declined in the past two decades, while there has been a notable symmetrical increase of the share of the R&D intensity group (see Table 2).

Thus, the evolution of Japan's trade specialization pattern has been characterized by a dynamic reallocation of productive resources, oriented toward a marked strengthening of the science-based and specialized-supplier sectors in the 1980s. To the extent that technological change is increasingly dependent on the quality and intensity of interaction between producer and user sectors of the innovation (Lundvall, 1988), in the case of Japan these intersectoral transmission mechanisms of innovation functioned properly (as between science-based and specialized-supplier sectors) and help to explain the strengthening of the Japanese competitive position in the period considered.

To sum up, Japan's performance shows clear-cut patterns: a rapid growth in the export of manufactures in a restricted number of sectors and a substantial shift in specialization patterns. Both of these trends are based on growing technological capability, apparently enhanced by strong intersectoral dynamics in the generation and dissemination of innovation and have led Japanese industry to achieve the best results of the three most advanced countries with respect to nearly all indicators.

In recent years, however, Japan has had to face both the revaluation of the yen and growing protectionist barriers. The first reaction has been a significant increase in imports of manufactures and an upsurge in direct investments abroad, particularly in the U.S. market. Furthermore Japan is now undergoing a changing growth pattern, bound also to modify the organization of its productive structure to facilitate radical innovations in addition to the incremental innovations that characterized its strategy in the past. It is too early for any sound forecast on this transition phase.

THE DETERIORATION OF THE U.S. COMPETITIVE POSITION

The relative decline in the U.S. international competitive position throughout the 1970–1989 period contrasts with the relative rise of Japan. The evolution of aggregate trade flows since the late 1970s shows that the pattern of U.S. industry's competitiveness has changed in a way diametrically opposed to that of Japan.

The U.S. share in world export of manufactures experienced a significant decrease from 1970 to 1989, which is distributed over the entire period (see Table 1). The results of CMSA (Table 12) show that this decrease is wholly attributable to a loss of U.S. industrial competitiveness both in the 1970s and in the 1980s, because structural effects, comprising a positive commodity effect and a negative market effect, on the whole played only a marginal role.

Further evidence that the U.S. trade performance in the past two decades was anything but positive stems from trade balance patterns in total manufactures. The U.S. deficit in total manufactures grew enormously in the first half of the 1980s (Figure 2). After the first oil shock, the U.S. economy, unlike all other advanced economies, was not able to counterbalance growing oil deficits with trade surpluses in manufactures. Despite the depreciation of the dollar in the second half of the 1970s, the manufacturing trade balance improved only marginally. An appreciation of the dollar's exchange rate until 1985 led to an enormous increase in the U.S. deficit, which decreased only partially in the most recent years.[9]

Further evidence of this overall deterioration can be seen in the evolution of U.S. competitiveness in various sectoral groups, because it has followed quite different patterns. The most negative results have been those in specialized-supplier sectors—such as machine tools—and in science-based sectors, especially electronics.

In specialized suppliers, U.S. industry sharply declined in the 1970s or in the 1980s, accumulating a large decrease in its share of world exports (from 22.8 percent in 1970 to 14.4 percent in 1989) (Table 5) and in its trade surplus (-15.3 points in percentage of total world trade of this sectoral group) (Table 6). The CMSA results demonstrated that these losses can be mostly attributed to a strong deterioration in the competitiveness of U.S. specialized-supplier sectors (see Table 12), to the advantage of Japanese, German, and Italian industries. In the late 1980s, following the dollar's strong depreciation, the U.S. competitive position in specialized suppliers registered a relative improvement, but the notable trade deficit accumulated with Germany and the deficit with Japan decreased only marginally.

In science-based sectors, U.S. industry maintained a positive trade balance even in the 1980s. These sectors, however, manifested a sharp de crease in their share of world exports (from 29.2 percent in 1970 to 20.2 percent in 1989). In this respect, it is in the electronics sector of science-based groups that American firms suffered the heaviest losses, as a consequence of the rapid and strong rise first of Japanese firms and then of those in the Asian newly industrializing countries (NICs).

In the early 1970s, U.S. industry enjoyed a position of relative strength and supremacy in most areas of electronics. Over the past two decades, however, in successive periods of decline affecting first electronic office products, then electronic components and, most recently, data processing equipment, the United States registered a marked deterioration in its competitive position. The notable decrease in market shares (see Table 11), particularly when considered together with the strong decline in trade balances over the past decade (see Figure 4), is clear evidence of the significant loss of competitiveness of U.S. electronics industries as a group.[10] It should be underlined that in the late 1980s the U.S. competitive position despite the dollar's strong devaluation has continued to deteriorate, as shown by trade data. Therefore, although U.S. firms continue to hold a strong competitive position in certain key sectors of electronics (e.g. information technologies), figures for the 1970–1989 period clearly demonstrate that there has been a distinct shift in relative strength in favor of the Japanese industry for the electronics complex as a whole.

In traditional sectors the U.S. economy also experienced a declining market share and a growing trade deficit, primarily in the past decade (see Tables 9–10). At the same time, losses in scale-intensive industries were equal to those registered by the manufacturing sector as a whole (Tables 7–8).

Two sets of contrasting interpretations have emerged to account for this overall negative performance of U.S. industry: (i) a rather optimistic view attributing the decline in competitiveness to cyclical factors, particularly the 1980s appreciation of the dollar; (ii) a more negative view, which sees the decline as the result of long-term and pervasive structural ills of U.S. industry.[11]

The first of these interpretations is supported by the negative U.S. export performance in the first half of the 1980s, which may also be attributed to adverse cyclical trends (for example, the strong and prolonged appreciation of the dollar and the negative domestic growth differentials), and which may partly account for the rise in the U.S. trade deficit in this period.

But the current difficulties of U.S. industries cannot be explained solely by these relatively recent events. As has been shown above, in many cases indicators reveal negative trends dating from the second half of the 1970s and continuing into the late 1980s. Similarly, the sharp decrease in the market shares of U.S. industries, as indicated by CMSA results, is largely attributable, especially in science-based and specialized-supplier sectors, to a loss of competitiveness of U.S. production over the course of the entire 1970–1989 period, rather than to negative cyclical effects of product and market composition (see Table 12).

The foregoing discussion leads to the conclusion that the relative decline of the U.S. competitive position also derives, as the second more negative set of interpretations maintained, from structural disadvantages. These should not be easy to neutralize, even in the presence of a significant reversal of trends in the exchange rate of the dollar, as has been the case. The major structural problems associated with the competitiveness of U.S. firms have been identified elsewhere. They include a decline in many sectors of a formerly uncontested technological leadership; a trend toward decreasing productivity; an inadequate development of process innovations, particularly in the incremental type; and the gradual obsolescence of management and organizational models for production (Cohen and Zysman, 1987; Dertouzos et al., 1989; Teece 1987). These are multifaceted problems requiring complex solutions, the results of which will become evident only in the medium-long term.

Indirect evidence of the above conclusion lies in the evolution of the trade specialization pattern of U.S. industry (see Figure 5). U.S. comparative advantages have been, and are increasingly, concentrated in R&D–intensive (science-based) product groups, most of which are characterized by high growth rates in world demand.[12] The role of science-based exports with respect to total exports of U.S. manufactures is also important and has been rising in the past decade (Table 2). The other strong point of U.S. specialization is food industries, as is demonstrated by its increasing comparative advantage in this area in the 1980s (see Figure 5).

In the scale-intensive industries (particularly automobiles) and traditional industries (especially textiles and clothing) on the other hand, there has been a consolidation of a relative despecialization of the U.S. industry in the past two decades. After sharp fluctuations, including a period of recovery in the 1970s and a subsequent phase of deterioration of equal magnitude in the 1980s, comparative disadvantages in both of these sectors at the end of the period were virtually equal to those at the beginning of the 1970s.

The new element in the evolution of the U.S. pattern of specialization is the sharp decrease in the positive contribution to the trade balance (ICTB) of the specialized-supplier sectors such as machine tools (-9.4 percentage points), although they maintained a comparative advantage position in the late 1980s (see Figure 5). These sectors also experienced a significant decline in their share of total U.S. exports of manufactures (see Table 2).

This trend is indicative of increasing difficulties of U.S. industry in transforming high-level scientific and research capability that continues to be generated in the United States into innovative activities and products with significant commercial value in the other manufacturing sectors. The relationship between the U.S. specialization in R&D-intensive products and the overall negative trade (industrial) performance indirectly demonstrates that the availability of sources of "primary" innovation (high-tech sectors) certainly constitutes a competitive advantage for a country, but it is not a sufficient condition to ensure rapid technological progress in its industry as a whole. If intersectoral technological links play an increasingly important role in the process of development and diffusion of primary innovation throughout the economy, they did not function properly in the United States. The inference that can be drawn tentatively is that ineffective linkages impeded positive technological adjustment in many "user" sectors, such as the specialized suppliers.

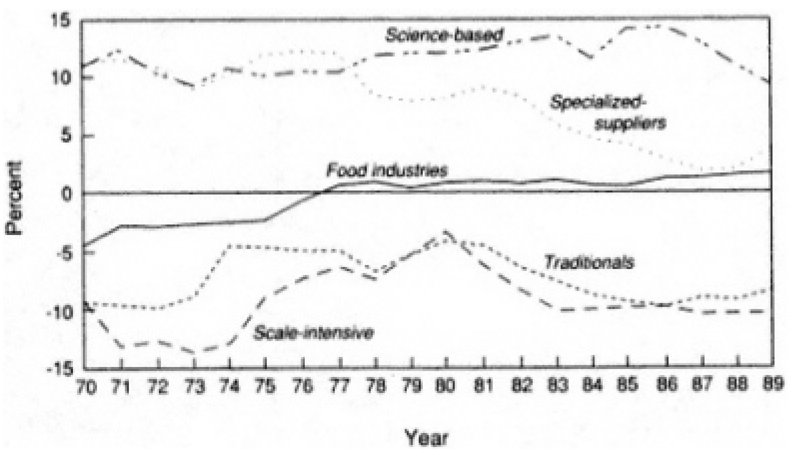

Figure 5 Patterns of trade specialization of the United States. Indicator of comparative advantage (>>0) or disadvantage (<0). For methods and sources, see note 8.

Thus, the patterns of U.S. trade performance and specialization analyzed here demonstrate that it is the combination of adverse cyclical macroeconomic factors and long-standing competitive disadvantages of a structural type that account for the relative deterioration in the international standing of the U.S. economy. Although it is true that the United States maintains a position of relative strength in industrial structure in science-based sectors, its specialization appears increasingly threatened by the rise of Japan and other Asian countries in many important industries, such as electronics and machine tools.

More recently, with the strong depreciation of the dollar, trade performance of U.S. industry has improved especially in export growth. However, the production restructuring necessary to bridge the competitive gaps generated by adverse trends in the past still appears to be a long and difficult process.

THE STABLE PATTERNS OF GERMANY'S TRADE PERFORMANCE

The patterns of trade performance and specialization of West Germany in the past two decades have been more complex than those of the United States and Japan, and do not provide the basis for such clear-cut conclusions. West German market shares have remained rather stable with respect to world exports of manufactures, reabsorbing in the late 1980s the loss suffered over the first half of the same decade. The CMSA reveals that this stability was largely attributable to a positive "structural" effect associated with a favorable commodity export composition, which compensated for both a negative "competitiveness" effect and especially an unfavorable market effect. Trends in Germany's trade balance in total manufactures appear more satisfactory, showing highly positive values throughout the entire period despite significant fluctuations.

This general evolution in Germany's competitiveness, however, is sharply differentiated with respect to the performance in various sectoral groups. First, the competitiveness of German industry in scale-intensive industries, especially automobiles, chemicals, and pharmaceuticals, was very strong in the past and maintained high levels in the 1980s, as demonstrated by fluctuating but high market shares and trade surpluses (see Tables 7–8). It should be underlined, however, that improvements in the trade surplus in the 1980s mostly derived from the net gains attained by Germany in intracommunity trade, which overcompensated the deterioration of German trade balance toward the external areas, and particularly Japan (Guerrieri and Milana, 1990).

The German competitive position has also remained firm in specialized supplier sectors (machine tools) with highly positive trade balances and market shares, which were the highest of all major industrialized countries. It should be noted, however, that German market shares decreased slightly during both the 1970s and the 1980s, and such decrease may be attributable, as shown by the CMSA, to a loss of competitiveness in the same period.

It should be recalled that specialized-supplier industries (especially industrial machinery) have undergone a radical restructuring through renewed production processes in the past decade. In these technical transformations, an important role has been played by technological factors, first through the introduction of high-tech materials and components, especially electronic devices, in production processes. The solid overall competitive position of German industry in these sectors provides clear evidence of both the effec tive production restructuring and the profound technological change that characterized German firms in the past decade.

In traditional products, there was a slight decrease in Germany's market shares together with negative trade balances, although an average stable level was maintained with some fluctuations throughout the 1980s. It should be underlined that German industry has defended its position against the upsurge of exports from Asian NICs in these sectors much better than have other countries in the European Community, such as France and the United Kingdom.

Finally, in science-based sectors Germany's competitive position, which was relatively strong in the early 1970s, experienced a net deterioration in the 1980s. The normalized German trade balance maintained positive and high values by the early 1970s but sharply declined in the 1980s, following an opposite trend with respect to the surplus of Japan in the same period. By the early 1970s, Germany's trade surplus in science-based sectors was significantly higher than that of Japan; by the late 1980s it fell to about one-sixth of the latter. German market shares with respect to world science-based exports also registered a notable decrease (from 17.3 percent in 1973 to 11.8 in 1989). As shown by the results of CMSA, that decrease was caused by a negative structural (market and commodity) effect together with a loss of competitiveness, which was wholly attributable to negative performance in the 1980s.

It must be emphasized that this negative performance is attributable almost entirely to the significant deterioration of the German competitive position in almost all the electronics sectors of science-based group. In fact, in data processing systems, electronic office equipment and electronic components, German industry suffered a significant decrease in its market shares and an increase in trade deficits to the advantage of Japan primarily and of Asian NICs to a lesser extent (Table 11, Figure 4).[13] In the other sectors of science-based (R&D-intensive products) group, on the other hand, German industry maintained or strengthened its competitiveness (such as in chemicals and pharmaceuticals, electrical machinery, and engineering instruments). These trends in the competitive position of Germany are fully confirmed by its patterns of specialization, which remained relatively stable over the 1970–1989 period, as shown in Figure 6.

The strong points of German specialization have always been and remain scale-intensive and specialized-supplier industries, which by the late 1980s gave highly positive contributions to the trade balance (respectively, 9.5 and 8.0 percentage points). The ICTB indicator in scale-intensive sectors in the past two decades shows high and stable levels of specialization in German industry, which maintained sound comparative advantages in this product group, especially in motor vehicles, rubber products, and chemicals and pharmaceuticals.

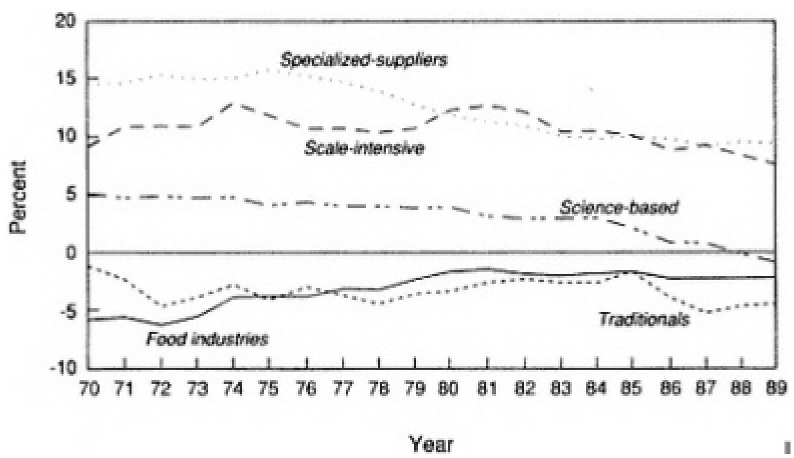

Figure 6 Patterns of trade specialization of the Federal Republic of Germany. Indicator of comparative advantage (>>0) or disadvantage (<0). For methods and sources, see note 8.

The specialized-supplier sectors of mechanical engineering, despite a notable decrease of their indicator ICTB (-5.1 percentage points from 1970 to 1989), have continued to represent the other fundamental pillar of German specialization, as demonstrated by the high comparative advantages maintained by the German industry in machine tools and machinery for specialized industries, which, it must be recalled, are vital investment goods for many manufacturing industries.

The patterns of the German specialization show a remarkable stability also in their weak points. The comparative disadvantages are concentrated, as in the past, in traditional industries and in agro-industrial products. In the latter case the German economy has notably improved its position by virtue of a highly protectionist agricultural policy in the European Community.

In contrast to these areas of stable strength and weakness, the German specialization patterns reveal a declining trend in science-based industries, where the ICTB indicator registered a considerable progressive decrease, declining from the highly positive values in the early 1970s (4.9 percentage points) to negative values in the late 1980s. This negative outcome is mostly attributable to the electronics sectors (data processing systems, electronic components) within the science-based group, confirming the deterioration of the competitive position of the German industry in electronic products that represent vital input in the restructuring of manufacturing currently under way in all major countries.[14]

This consolidated structure of German specialization has favored at least in the 1980s a rapid diffusion of technical progress in the chemical and mechanical branches through a strong and positive interaction between innovation producer sectors and innovation user sectors. The evolution of the competitive position of German industry is thus one of renewed strength with respect to its partners in the European Community. The position of West Germany, however, is similar to that of several other European countries in science-based sectors (Guerrieri, 1991), and especially in sectors of key strategic importance for "primary" innovation such as electronics, where German industry has a wide and increasing disadvantage with respect to Japan and the United States.

CONCLUDING REMARKS

The rapid development of world trade in the past two decades was accompanied by profound changes in the product and market patterns of trade flows. The new shape of the international trade environment, together with the new technological opportunities stemming from accelerated growth of product and process innovations, affected all the major countries and accelerated structural adjustments in their industries.

Most world trade in manufactured products today involves a two-way exchange of fairly similar goods at sectoral levels (intraindustry trade) between countries that are increasingly similar in their classical factor endowments. However, this similarity has not led to a convergence in the pattern of international trade in the industries of the most advanced countries, quite the contrary. As this essay has demonstrated, the process of trade (industrial) adjustment has follow different patterns in the three major economies, and it has met with very different success. Each major country presents a different structure of trade specialization (comparative advantages) and technological trajectories. These national differences increased rather than diminished in the past two decades, bringing about major changes in countries' relative competitive positions.

Among the major countries, Japan undeniably achieved the best trade performance in the past two decades, as all indicators used here demonstrate. This notable progress on international markets may be attributed to the profound changes in the patterns of Japan's trade specialization in the past two decades. It has adapted to the changing dynamics and commodity composition of world demand much more and better than have the specializations of the other two major countries, sharply strengthening both specialized-supplier and R&D-intensive (science-based) sectors, particularly electronics. The case of Japan provides evidence that technological factors can deeply influence the competitive position of a country in the world market. Only Japan among the three leading countries has developed in the past two decades and is now relying on a technological trajectory and specialization pattern based on both science-based and production-intensive sectors, such as scale-intensive and specialized suppliers. Given this domestic coherence, Japanese industry was apparently able to exploit positive intersectoral transmission mechanisms of innovation, as between science-based and specialized-supplier sectors, assuring an adequate functioning of the intersectoral network of generation and dissemination of innovation at the level of the industry as a whole.

The relative decline of the United States is largely parallel to the relative advance of Japan. The United States suffered a marked deterioration in its international competitive position, especially in science-based and specialized-supplier industries. Almost all the indicators provide unequivocal signs of this competitive decline, which may be attributed not only to cyclical factors, but mostly to long-term structural competitive disadvantages that will not be easy to neutralize. The United States still enjoys outstanding comparative advantages in R&D-intensive product groups, but it suffered notable despecialization trends in scale-intensive sectors—consolidating a weak position that was already evident in the 1970s—and in specialized suppliers, which instead suffered heavy losses in the 1980s. These trends seem to show that U.S. industry has increasing difficulties in transforming its high-level research capability into innovative activities and competitive industrial products. Furthermore, the case of the United States demonstrates that the technological capability of a country is a difficult concept to define and quantify, since each major country has a very different pattern of technological and trade competitive advantages, and since no general common pattern exists. A competitive position in sources of "primary" innovation, such as high-tech (science-based) sectors, as in the case of the United States, is not a sufficient condition for assuring a given country a positive trade performance. We can tentatively conclude that the dynamism of the innovation process increasingly depends on the intensity and the quality of the interaction between the innovation-producing sectors and the user sectors. This interaction has been anything but positive in U.S. industry in the past decade. Certainly, it is extremely difficult to define and quantify these interindustry flows of technology, and additional research is needed to demonstrate how it affects the dynamics of innovation in each individual sector, and the overall pattern of technological change in each country.[15]

The patterns of trade performance and specialization of West Germany have been more complex and do not provide the basis for clear-cut conclusions. On the one hand, the competitive position of German industry was sound in the past and strengthened in the 1980s in specialized-supplier and scale-intensive industries; in traditional product and above all in science-based sectors, on the other hand, the West German economy registered negative results on the whole.

The German trade specialization pattern is substantially different from those of Japan and the United States in having technological and trade competitive advantages in production-intensive sectors, such as scale-intensive and specialized-supplier sectors, and in showing a despecialization trend in high-technology goods, especially in electronics. It is true that in the 1980s this established structure led to a rapid diffusion of technological progress in the chemical and mechanical industries, through a favorable interaction between innovation producer and user sectors, as shown by the positive trade performance of the German economy in the above products in the past decade. Yet the capability of Germany to retain the leadership role it now holds seems increasingly to depend on its ability gradually to offset its competitive weakness in electronics.

NOTES

1. Extensive surveys of this literature on innovation and technical change can be found in Dosi et al. (1988), Freeman (1982), Rosenberg (1982), and Scherer (1986), among others.

2. Therefore, the important role played by science-based industries in manufacturing systems does not stem solely from their technological content, since the latter is also high in other sectoral groups using different means to generate innovations; rather it stems from the fact that products of science-based sectors represent sources of "primary" innovation to many other sectors and produce important intersectoral effects.

3. These five classes of products have been formed from the 400 product groups included in the SIE-World Trade data base. The other nonmanufactured traded goods have been grouped in the three broad economic categories: food items and agricultural raw materials, fuels, and other raw materials.

4. Export market share (MS) of country *j* in total world exports with respect to a given group of products *i* is worked out as follows:

$$MS_j = \frac{X_{ij}}{WX_i}$$

where
X_{ij} = total exports of country *j* in product group *i* and
WX_i = total world exports of product group *i*.

5. The standardized trade balance or the indicator of relative competitive position (IRCP) highlights the international distribution over time of trade surpluses and deficits among countries in each group of products. Trade surpluses and deficits are normalized by total world trade in the same group of products (CEPII 1983, 1989). The evolution of trade balance distribution reveals competitiveness patterns of various countries in a certain group of products. For each country *j* the indicator is given by:

$$IRCP_j = \frac{X_{ij} - M_{ij}}{WX_i}$$

where
X_{ij} = total exports of country *j* in the product group *i*
M_{ij} = total imports of country *j* in the product group *i*
WX_i = total world exports in the product group *i*.

6. The constant market shares analysis (CMSA) is an accounting method for breaking down a country's export share (or aggregate export) change to world trade into various effects:

"structural change" effects and "competitiveness" effects. Its usefulness is effectively summarized by Magee (1975, p. 221): "The technique reveals that, even if a country maintains its share of every product in every market, it can still have a decrease in its aggregate market share if it exports to markets that grow more slowly than the world average and/or if it exports products for which demand is growing more slowly than average." The CMSA has been reformulated here so as to overcome the well-known methodological limits linked to the traditional applications of this technique. The version of the CMSA applied in this paper breaks down a country's export share change into the following four effects: (a) competitiveness effect: measures the change of a country's export share resulting from competitiveness factors only, assuming that its trade structure (market and commodity) is constant, (b) market effect: represents the influence of the geographic composition of trade flows on the aggregate export share of a country. It is positive if a country concentrates its exports on market that grow faster than the world average; (c) commodity effect: it represents the influence of the product composition of trade flows on the aggregate export share of a country. It is positive if a country concentrates its exports and products for which demand is growing faster than the world average; (d) specific market-commodity effect: represents the influence on the aggregate export share of a country stemming from specific composition product-markets more (or less) favorable. The sum of (b), (c), and (d) effects represents the overall "structural effect," which measures those changes in a country's aggregate export share resulting only from changes in commodity-market structure in world trade.

The CMSA has been here worked out in the period 1970-1987, since the disaggregated data for the years 1988-1989 are not yet available. For further details on the methodologies of CMSA here used, see Guerrieri and Milana (1990) and Milana (1988).

7. See, among the others, Bremond et al. (1987), Freeman (1987), Saucier (1987).

8. The indicator of the contribution to trade balance (ICTB) of a country *j* with respect to a given group of products *i* is the following:

$$ICTB_{ij} = \frac{(X_{ij} - M_{ij})}{(X_j + M_j)/2} * 100 - \frac{(X_j - M_j)}{(X_j + M_j)/2} * \frac{(X_{ij} + M_{ij})}{(X_j + M_j)} * 100 ,$$

where

X_{ij} = total exports of country *j* in the product group *i*,
M_{ij} = total imports of country *j* in the product group *i*,
X_j = total exports of country *j*, and
M_j = total imports of country *j*.

9. Almost all partners took advantage of the huge U.S. trade deficit; however, Japan and the Asian newly industrializing countries were able to reap the highest benefits.

10. The deterioration in the U.S. competitive position is almost entirely attributable to the rise of Japanese and, more recently, Southeast Asian industries in the U.S. domestic market as well as in other major areas. There is clearly a complementary relationship between the rise of Japan and the Asian NICs in electronics sectors, which has strengthened the capacity of producers in both of these areas to penetrate the U.S. market in particular, and the international market in general.

11. For the first set of interpretations, see, among others, Bergsten (1988) and Lawrence (1984); for the second view, see Cohen and Zysman (1987) and Dertouzos et al. (1989).

12. Among the R&D-intensive sectors, the United States has the highest specialization in aerospace industries, which are characterized by high public procurements.

13. In trade in electronic products, West Germany registered huge and increasing deficits with respect to both Japan and the United States--in the latter case despite the advantage stemming from the appreciation of the dollar in the first half of the 1980s. By the mid-1980s,

even the Asian NICs accumulated significant surpluses with respect to Germany in all major sectors of electronics.

14. This is confirmed by increasing negative values of comparative advantage indicators either in data processing systems or in telecommunications and in electronic components.

15. Recent surveys on the empirical literature on the links between the innovation producer and user sectors and the interindustry technological spillover effects can be found in De Bresson (1988) and Mohnen (1990).

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APPENDIX SIE-WORLD TRADE DATA BASE

The world foreign trade statistics used for the analysis in this paper are taken from a data base developed at Servizi Informativi per l'Estero (SIE) in Rome. The SIE-World Trade data base provides detailed information on exports and imports of 83 countries with respect to 400 product groups, 98 sectors, 25 broad commodity groups, and 5 main product categories.

The data base includes trade statistics for the 24 OECD countries, NICs, other developing countries, and the former CMEA countries, making it possible to examine and analyze the entire world trade matrix. The sources of these statistics are OECD and United Nations publications, provided on magnetic tapes.

The SIE data base is organized in different product group classifications at various levels of disaggregation (400 product groups, 98 sectors, 25 categories, 5 branches) according to the three Standard International Trade Classifications (SITC), *Revised*, and *Revision* 2, and *Revision 3*, defined by the Statistical Office of the United Nations (1961, 1975, 1986) for the periods 1961–1975 and 1978–1987, 1988 on.

The broad product group classification used in this paper is based on the 400 product groups of the SIE-World Trade data base. A summary list of the product groups included in each class is reported in Guerrieri (1991). A complete list of the products included in each group could be provided by the author on request.

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Summary of Panel Discussion

Presentations by Paul Krugman and Paolo Guerrieri (based on the papers in this volume) provide interpretations of high-technology trade statistics over the past 20 years. They document a decline in U.S. preeminence during a period when the value of high-technology exports grew rapidly from $30 billion to almost $300 billion, with Japan as the primary beneficiary.

As Krugman noted in his summary of the discussions that followed the session, the picture one sees looks different at different ranges of the zoom lens. Close up, the lens reveals a shifting comparative advantage at the industry level. In this picture, the declining position of the United States in science-based industries like electronics comes into view (see Guerrieri, in this volume, Figure 2). At the next step out on the zoom lens, one sees that the biggest shift has occurred in the growth of Japan's strength in specialized supplier industries (mechanical engineering, machine tools) and the simultaneous decline of the United States and Germany (see Guerrieri, Table 2). Finally, at the widest field of vision the lens reveals a global perspective in which a variety of factors (cost of capital, quality of management and labor) in addition to a nation's scientific and technological capabilities influence international high-technology trade.

These different vantage points, different ranges of the zoom lens, underscore the contrasting perspectives in the U.S. policy debate over the volume and composition of the nation's high-technology trade as revealed in trade statistics, and raise global questions. Robert Lawrence directed his com

The Panel on Technology and International Trade Competition was chaired by Paul Krugman. Other panelists are Paolo Guerrieri, Robert Lawrence, and Fumitake Yoshida.

ments to the issue of what the United States should do in the face of a decline in U.S. preeminence in high technology trade. A laissez-faire approach, he argued, is no longer viable in a context where the United States is one (perhaps first) among equals. He pointed to innovation policy as one among a number of areas that deserve policy attention. We can no longer afford to take commercial technology development for granted: tax credits and other measures to promote R&D spending, particularly collaboration in precompetitive research, should be considered. Krugman suggested that the U.S. government could provide direct financial support to high-technology industries when it is necessary to buy time for renewal.

Fumitake Yoshida brought another perspective to the discussion by arguing that the reason why imports make up a relatively small percentage of trade in Japan's high-technology markets (Krugman, Table 12) is the significant sales in Japan by foreign-owned firms. Drawing on Japanese government statistics, Yoshida pointed out that sales by U.S.-owned manufacturing firms in Japan amounted $71.9 billion in 1988, while sales by Japanese-owned manufacturing firms in the United States were valued at $19.9 billion. Foreign-owned firms in Japan imported almost the same amount of high-technology goods in 1988 as did foreign-owned firms operating in the United States, according to Yoshida.[1] It will be important to watch how these trends develop in the years ahead.

The audience raised a number of questions about the positive effects of networks and linkages among firms, particularly in Japan. In the Japanese case, linkages among second- and third-tier suppliers and primary producers appear particularly effective. In Italy, strong linkages between producers of consumer goods and investment goods help to explain why the country has retained market share despite gloomy predictions. Paolo Guerrieri called for more studies, at both the micro and macro levels, of industrial linkages and their effects.

Robert Lawrence commented that in the area of trade policy, the United States can no longer tolerate the use of infant industry policies by mature economies. The United States should increase penalties for price-discriminatory dumping. Yoshida cautioned against linking technology and trade policies; he called for attention to production, marketing, and human resources, as well as the macro environment. Comments from the audience, however, highlighted concerns about the perceived negative impacts of foreign industrial targeting practices on the United States.

Competition policy was another area identified for attention. Lawrence cautioned against relaxing antitrust policies. He suggested that "mutual recognition" sometimes works better than harmonization of policies when economic structures are so different in different countries. Ted Moran suggested that we look at foreign investment through an antitrust prism. Answering his own question of whether foreign investment "hurts," he suggested that the answer is yes only if the number of suppliers is concentrated. Fumio Kodama argued for a more sophisticated understanding of the Japanese concept of *keiretsu*, and vertical integration in general. Differences across industries are great, and in some ways General Motors is more integrated than Toyota, he said. Another speaker noted that vertically integrated firms are not necessarily the optimal organizational mode for technological development and overall competitiveness. Harkening back to the discussion of linkages, Daniel Roos suggested that a "loose confederation" of companies that work together (such as the Toyota group of assemblers and suppliers) is a very rich model for building competitiveness.

A number of speakers implicitly agreed with Yoshida's call for attention to macroeconomic factors. Peter Sharfman, Robert Gavin, and Margaret Sharp all pointed in different ways to the importance of capital for technological innovation. Sharp suggested that a genuinely level playing field would involve the formation of a single world financial market with a single interest rate structure but doubted how feasible this was.

Robert Lawrence commented that corporate governance mechanisms in the United States give undue weight to transactional rather than long-term investors and suggested that we may need to change the incentive structure to address this problem. With regard to the benefits and risks of turning to Japanese investment, speakers from Europe commented on a lack of consensus there on this subject. Some countries are actively promoting Japanese investment in the automobile industry, while others doubt that it will ultimately improve the European R&D base.

The panel discussions provided a foundation for the rest of the symposium by examining in some detail the historical changes in high-technology competition. Sharpening understanding of "where we are today and how we got here" led the panelists to questions addressed more fully by the panels that followed: How can we explain what many see as the disappearance of U.S. preeminence in high-technology trade? What should we do about it?

NOTES

1. Yoshida's sales data, drawn from official Japanese government statistics, differ significantly from those published by the U.S. Department of Commerce. The U.S. Department of Commerce estimates 1988 sales of all U.S. manufacturing affiliates in Japan (majority and minority owned) to be $85.4 billion but sales of majority-owned such affiliates to be only $21.5 billion. In the same year, sales by Japanese manufacturing affiliates in the United States are estimated by the Commerce Department to be $27.1 billion by industry of affiliate but $35.4 by industry of sales.

According to Edward M. Graham of the Institute for International Economics, reasons for discrepancies in the Japanese government and U.S. government (Commerce Department) data include: (1) differences in coverage (e.g., what one government classifies as direct investment might be classified as portfolio investment by the other); and (2) differences in industry classi fication (e.g., certain activities classified as "manufacturing" by one government might be classified as "nonmanufacturing" by the other). The data base from which Yoshida's figure on sales in Japan by U.S. manufacturing affiliates is drawn apparently includes all U.S. manufacturing affiliates. Yoshida's $71.9 billion figure, according to Graham, thus exaggerates the true extent of sales of Japanese affiliates of U.S. firms because of the inclusion of sales of minority-owned operations, which as noted above, are substantially greater than those of majority-owned operations. Yoshida's $19.9 billion figure is significantly lower than either of the Commerce Department's estimates for U.S. manufacturing sales of Japanese affiliates, these estimates being based on two different methods of data aggregation. According to Graham, the larger of the two Commerce Department estimates is accepted by most analysts as the one that most accurately depicts such sales.

New Paradigms for Linking Technology and Trade Policies

Managing Trade Conflict in High-Technology Industries

LAURA D'ANDREA TYSON

Trade among nations is traditionally attributed to underlying differences in their resource endowments. Australia exports wool because its climate and terrain are well suited to sheep grazing. Japan is a net exporter of manufactured goods and a net importer of natural resources because of its relative abundance of capital and skilled industrial labor and its relative scarcity of raw materials.

Inherited national differences in resource endowments explain some world trade patterns but not others. Trade among the advanced industrial countries in manufactured goods, which accounts for a large and growing fraction of total world trade, is a glaring exception.[1] Intraindustry trade among these countries in automobiles, computers, sophisticated telecommunications products, and a wide range of other manufactured products cannot be attributed to national differences in availabilities of land, labor, and capital.

Even a more finely grained analysis that distinguishes between different kinds of land, labor, and capital fails to do the trick. What is striking about the advanced industrial countries is their broad similarity in endowments of the kinds of resources required for competitive strength in the production of manufactured goods, not their differences.

If national differences in resource endowments, broadly defined, do not explain intraindustry trade in manufactured goods among the developed countries, what does? At first blush, the reasons for trade in products in which countries have no underlying comparative resource advantage are not

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particularly hard to find. They lie in the advantages of large-scale production—economies of scale, learning, and scope—which lead to an essentially random division of labor in which first-movers in a particular product gain cost advantages over new entrants. They lie in differences in national patterns of demand and subtle product differentiation to meet the desires of different national markets. And they lie in national differences in technological capabilities.

But what determines the kinds of technological capabilities a country fosters, the kinds of demand patterns it develops, or whether its firms are first-movers in scale-intensive industries? Such country-based sources of competitive advantage have something important in common—they are created, not inherited. They can be attributed, at least in part, to salient differences in how national economies are organized and in the economic objectives they pursue.[2]

As intraindustry trade and competition among the developed countries have intensified, the role of such differences in shaping competitive outcomes has drawn increasing attention. Competition among American, European, and Japanese companies has spilled over into competition among the American, European, and Japanese models of capitalism.[3] And trade conflicts, once narrowly focused on allowable national border policies, have spilled over into conflicts about allowable national differences in areas that have traditionally been the domain of domestic policy choice.

Nowhere are systemic competition and friction among the developed countries more heated than in high-technology industries.[4] Such industries are disproportionately concentrated in the developed countries. In 1987, 82 percent of the world's R&D expenditures and 69 percent of the world's R&D personnel were located in five industrial countries—the United States, Japan, France, the United Kingdom, and West Germany. With the addition of five smaller European countries, the shares rise to 91 percent and 84 percent, respectively (Dunning, 1990).

In the 20 years between 1966 and 1986, technology-intensive goods (as measured by the Organization for Economic Cooperation and Development [OECD]) climbed from 14 percent to 22 percent of world manufactured exports (Ostry, 1990a). In 1987, about 42 percent of America's manufactured exports, more than one-third of Japan's manufactured exports, and about one-fifth of Europe's manufactured exports were high-technology products (National Science Board, 1989, Table 7-11, p. 377).

As a result of growing trade and investment, the share of domestic suppliers in the home markets for high-technology products has declined in the United States and even more dramatically throughout Europe. In the United States, products from Japan have accounted for the biggest increase in import penetration. Only in Japan has the import penetration share remained unchanged over the past two decades, with domestic suppliers still account ing for about 94 percent of the Japanese market for high-technology products in 1985. The comparable domestic supplier shares for the United States, France, and West Germany for that year were, respectively, 84 percent, 60 percent and 43 percent (National Science Board, 1989, Table 7-5, p. 374).

Between 1970 and 1989, there were significant changes in the competitive positions of the United States, the European countries, and Japan in high-technology trade (see Tables 1, 2, and 3). The share of Japanese producers in world exports of science-based industries more than doubled from about 8 percent to about 17 percent while the share of American producers declined from about 29 percent to about 20 percent during this period.[5] The erosion of the U.S. share was greatest in electronics, as a consequence of the rapid and strong rise first of Japan and more recently of the East Asian newly industrialized countries (NICs) (see Table 4).

The European Community's share in world exports of science-based sectors also declined from about 45 percent in 1970 to about 37 percent in 1987. The overall European decline reflects a decline in the shares of all of the individual countries in the Community. Like the American decline, the European decline was largely the result of a significant deterioration of the European position in the electronics sector of the science-based group.

Technology-intensive industries have been a source of recurrent trade friction between the United States and its trading partners. Trade in these industries has never really been free in the classical sense. Rather it has been manipulated by a myriad of formal and informal policies. Governments have intervened in these industries—often with a forceful visible hand rather than a velvet touch—because they are perceived to have both military and economic significance. Most of America's high-tech success stories—for example, in semiconductors, computers, and aerospace—have their beginnings in America's endless quest to develop more reliable and sophisticated military equipment.

Japan, the East Asian NICs, and the European countries, in contrast, have emphasized the commercial significance of a high-technology production base. The governments of these nations have accorded high-tech industries special promotional or protectionist treatment in the anticipation of several kinds of economic benefits, including more productive and higher paying jobs, greater exports, and the development of an indigenous technological infrastructure with spillover benefits for other industries.

Despite a general liberalization trend around the world, national governments have not foresworn measures to support their high-technology producers. The visible hand present at their conception is still present long after many of them have reached maturity. While government intervention

TABLE 1 Shares of Selected Countries and Areas in World Trade in Science-Based Sectors* (Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987	1989	1970–89
United States	29.25	25.39	24.41	22.46	25.17	23.87	19.86	20.24	-9.01
Japan	7.81	9.07	9.61	10.37	11.6	14.75	16.16	16.52	8.71
EEC (12)	45.01	47.24	46.78	46.42	42.03	38.06	39.02	37.07	-7.94
Germany, Federal Republic	15.85	17.33	16.19	15.37	13.83	12.04	13.13	11.84	-4.01
France	6.81	7.31	8.61	8.67	7.76	6.73	7.01	6.67	-0.14
United Kingdom	9.87	9.48	8.74	9.72	8.93	8.09	7.23	7.11	-2.76
Italy	4.61	4.07	4.05	3.81	3.69	3.55	3.55	3.4	-1.21
Non-OECD Countries	3.29	4.91	7.26	9.52	11.35	13.35	15.43	16.25	12.96
NICs in Asia	1.04	2.32	3.75	4.76	5.42	7.61	9.29	9.76	8.72

* Ratio of national exports to world exports (percentage).
SOURCE: SIE-World Trade data base.

TABLE 2 Exports of High-Tech Products, by Selected Countries: 1970-86

Exports	All Countries	France	West Germany	Japan	United Kingdom	United States	Other	Europe
	Billions of Dollars							
1970	31.841	2.241	5.127	3.84	3.054	9.02	8.589	17.792
1975	77.942	6.467	12.723	9.487	7.759	20.282	20.864	46.183
1980	185.957	14.425	29.046	31.338	20.168	44.869	46.129	105.414
1982	192.464	15.102	29.612	35.798	18.037	50.234	43.681	101.225
1984	221.521	15.41	28.585	54.1	18.432	56.54	48.454	104.272
1985	237.575	16.556	31.466	55.531	21.333	59.243	53.446	115.981
1986	289.481	20.36	41.937	69.105	25.304	63.483	69.292	149.672

	All Countries	France	West Germany	Japan	United Kingdom	United States	Other	Europe
	Percentage shares *							
Share of total high-tech exports								
1970	100	7	16	12	10	28	27	56
1975	100	8	16	13	10	26	27	59
1980	100	8	16	17	11	24	25	57
1982	100	8	15	19	9	26	23	53
1984	100	7	13	24	8	26	22	47
1985	100	7	13	23	9	25	22	49
1986	100	7	14	24	9	22	24	52

*Includes, in addition to those shown here, Australia, Austria, Belgium, Canada, Denmark, Greece, Iceland, Ireland, Italy, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, Yugoslavia.

NOTE: Uses the Organization for Economic Cooperation and Development definition of high-intensity technology products.

SOURCE: National Science Board. *Science and Engineering Indicators, 1989*.

TABLE 3 Trade Balance of Selected Areas and Countries in Science-Based Sectors*

	1970	1973	1976	1979	1982	1985	1987	1989	1970-1989
United States	18.87	13.79	13.85	10.99	10.91	3.62	1.38	1.45	-17.42
Japan	3.28	4.74	6.19	7.02	8.05	10.99	12.61	12.5	9.22
EEC (12)	5.38	5.05	8.16	5.48	4.96	2.59	0.26	-1.73	-7.11
Germany, Federal Republic	7.82	8.65	7.22	5.01	4.15	3.11	3.53	2.18	-5.64
France	-0.66	-0.67	1.01	1.01	0.81	0.86	0.15	0.21	0.87
United Kingdom	4.03	2.66	2.75	1.83	1.71	0.46	-0.21	-0.51	-4.54
Italy	0.06	-0.68	-0.07	-0.42	-0.32	-0.61	-1.15	-1.04	-1.1
NICs in Asia	-2.14	-2.32	-1.47	-2.02	-1.51	0.08	0.45	-0.91	1.23

* Standardized trade balances expressed as percentage of total world trade in science-based sectors. (For methods see Guerrieri, in this volume, note 5.)
SOURCE: SIE-World Trade data base

TABLE 4 Shares of Selected Countries and Areas in World Trade in High R&D-Intensive Electronic Sectors* (Percentage shares in values)

	1970–1973**	1973–1976	1976–1979	1979–1982	1982–1985	1985–1988	1989	1970–1989
United States	28.48	26.42	24.27	26.05	27.13	21.49	19.51	-13.12
Japan	9.43	10.77	13.06	14.21	17.44	20.22	21.47	13.68
EEC (12)	44.97	42.59	39.89	36.14	30.72	31.30	28.98	-14.62
Germany, Federal Republic	15.03	14.37	12.43	10.43	8.24	8.09	7.09	-6.48
France	7.76	7.48	7.34	6.41	4.96	4.94	4.14	-3.37
United Kingdom	8.02	7.55	7.31	7.18	6.69	7.05	7.08	-0.79
Italy	5.37	4.18	3.91	3.80	3.06	3.21	3.17	-3.06
Non-OECD Countries	5.52	9.19	12.51	14.66	17.13	19.79	23.24	19.31
NICs in Asia	3.36	6.33	8.43	9.20	11.20	13.95	16.21	14.12

* This product group includes data processing equipment, electronic components, and telecommunications equipment.
** Average value in each subperiod.
SOURCE: SIE-World Trade data base.

has been widely discredited in many sectors, there is no presumption that the visible hand of policy will lead to lower economic welfare than the invisible hand of the market in high-technology industries. Indeed, the presumption if anything runs the other way. Increasing returns, substantial learning curve economies, linkage externalities, and technological spillovers are not the stuff of perfect competition and market optimality. As the so-called "strategic" trade literature has demonstrated, policies to protect or promote a national high-technology production base can be welfare-improving under these conditions.[6]

In most countries—including the United States with increasing frequency—the goal of trade policy in high-technology industries is not simply to improve the trade balance, or to improve the terms of trade, or to aid the adjustment of declining industries through temporary protection, or to open foreign markets for their own sake, or to make the world trading system more efficient. Rather the goal is to use trade policy, along with other policy instruments, to secure a national share of world production and the associated spillover benefits of high-technology industries.

The simultaneous pursuit of this goal among the developed countries has been the source of a growing trade conflict. It is easy to see how this goal can be "zero-sum" in nature—more of industry A located in Europe may mean less of industry A located in the United States or Japan. In addition, it is easy to imagine how the policies used in pursuit of this goal—policies such as preferential procurement, aggressive R&D subsidies targeted at commercial technologies but limited to domestic producers, and local content restrictions that require high-technology investment to serve the national market—can be beggar-thy-neighbor or mercantilistic in character. Indeed, some emerging policies that attempt to restrict foreign access to the research activities or results of nationally sponsored R&D programs are nothing short of a kind of technological mercantilism.[7]

Ironically, growing economic nationalism or regionalism in high-technology industries is at odds with the increasing globalization of high-technology companies. The international diffusion of product and process technologies means that these companies can now parcel out separate activities or components on a truly international basis. As a consequence, the competition among the developed countries for high-technology production is becoming more a competition for the activities of high-technology companies regardless of ownership and less a competition among national champions. What matters more and more is not the nationality of a producer or a product, which is increasingly difficult to identify, but its territoriality—where it is produced, not by whom. This trend is most pronounced in Europe, where policies to promote national or regional high-tech champions in electronics have been complemented by policies to attract "high-quality" foreign direct investment by American and Japanese firms.

TRADE BARRIERS, STRUCTURAL IMPEDIMENTS, AND STRUCTURAL DIFFERENCESAS SOURCES OF TRADE CONFLICT IN HIGH-TECHNOLOGY INDUSTRIES

Trade friction among the developed countries in technology-intensive industries takes many forms, including conflicts over such issues as market access, dumping, rules of origin, import quotas, government procurement, industrial subsidies and targeting, standards and testing, and patent protection. Some of these conflicts involve the traditional subject matter of trade disputes—border and nonborder policies that *by intent or design* discriminate between domestic and foreign products, domestic and foreign producers, or foreign products imported from abroad and foreign products produced locally. For want of a better term, such policies will be called trade barriers throughout this discussion. Trade barriers include tariffs, import quotas, dumping laws, rules of origin, preferential procurement policies, subsidies and other forms of industrial targeting. Trade barriers, broadly defined in this way, are important sources of trade friction because they are actively used to build national or regional production bases in high-technology industries.

Other trade conflicts emanate from structural differences among nations in a wide variety of policies and institutions that affect the terms of international competition. At issue in such conflicts are a potpourri of things such as standards and testing, intellectual property protection, health and safety regulations, competition policy, the organization and support of R&D, corporate financial structures and the rights of shareholders, and the nature of business-government relations.

Structural differences in such areas, while not designed to advantage one set of national producers over another, may nevertheless have that effect. Perhaps because of this, such differences have come to be called "structural impediments" to trade—a terminology used by the OECD and by the United States in its recent bilateral negotiations with Japan.

Broad structural differences influence the terms of international competition in global high-technology industries in two ways. First, these differences affect the accessibility of different national markets to foreign competitors. Language is the most obvious example of a structural difference influencing market access. National differences in the extent and organization of regulatory institutions, in antitrust laws and their enforcement, in patent procedures—even national differences in land use policies—may have large but unintended effects on the ability of foreign firms to break into a particular national market. Such differences can act as very real "structural impediments" to foreign market access even though they are not explicitly designed for that purpose.

Second, other kinds of structural differences create different incentive environments and behavioral tendencies for different national firms. National differences in antitrust policies, in the organization of science and technology, in the protection of intellectual property rights, and in the financial system are salient examples.

For example, the long-term vision of Japanese companies is partly an outgrowth of the financial environment in which they operate. The seeming inability of American firms to cooperate with one another in a variety of ways is encouraged—indeed, in some instances, even required—by the antitrust environment in which they function. The relatively open and rapid flow of technological information in the United States is encouraged by the high job turnover of scientific and engineering manpower and by the concentration of the nation's basic research in academic institutions. In Japan, lifetime employment and the concentration of basic research in proprietary laboratories has the opposite effect.[8]

TRADE BARRIERS, STRUCTURAL DIFFERENCES, AND NEW MULTILATERAL RULESFOR TECHNOLOGY TRADE: A LONG-TERM AGENDA

Traditionally, the United States has followed a rules-based approach in its multilateral and bilateral trade negotiations. Even the aggressive unilateralism of the United States in the 1980s usually targeted rules, not outcomes. The nature of trade friction in high-technology industries suggests several conclusions about the rules-based approach.

First, and most obvious, to be effective in reducing trade friction, multilateral rules must be quite precise about the behavior in question. Weak and vague rules are a prime cause of trade disputes that undermine multilateralism.

For example, the 1979 government procurement code attached to the General Agreement on Tariffs and Trade (GATT) had huge loopholes in product coverage and in the specification of bidding procedures. Only about half of worldwide government purchases were open to competitive bidding after the code was negotiated (Jerome, 1990). The remaining purchases were either single-tendered contracts or contracts falling below the code's threshold magnitude. Not surprisingly, the code did not prevent friction between the United States and Japan on "competitive procurement arrangements" in telecommunications equipment and supercomputers, nor did the code preclude the exclusion of telecommunications equipment from national treatment in the 1992 rules proposed by the European Community.

The 1979 Aircraft Code was powerless to prevent substantial European subsidies to Airbus or to head off U.S.-Europe friction in the commercial aircraft industry. And the 1979 GATT Antidumping Code allowed large country differences in what determined dumping, the process by which a dumping decision was realized, and the remedies agreed upon by the alleged dumper and the aggrieved party. Not surprisingly, national antidumping rules became a major route for high-tech trade friction in the 1980s.

Greater precision in rules, although a necessary condition for reducing trade friction, is not enough. Agreements work only when they are monitored, when there is a forum for negotiating disputes among the affected actors, and when there are credible enforcement mechanisms that include credible sanctions for rule violations. The only way to reduce overt nontariff trade barriers is to write explicit rules stating what can and cannot be done, and the only way to be sure that one's trading partners are giving reciprocity—that is, are complying with the rules—is to have an effective, enforceable means of adjudicating claims. At this point and for the foreseeable future, even assuming a successful resolution of the Uruguay Round, GATT will have neither all of the rules nor the necessary means of adjudication (Hudec, 1990).

Moreover, even precise and enforceable rules about overt trade barriers are not sufficient. Rules are also required to reduce impediments to trade caused by structural differences among nations. These differences make a rules-based approach to liberalizing trade a much more complex task, involving multilateral negotiations about business and government practices that, although motivated by domestic economic and political considerations, have unintended but nonetheless wide-reaching effects on trade. Thus, the market-oriented, sector-specific (MOSS) talks between the United States and Japan in the mid-1980s involved negotiations about such nontariff impediments to trade as national testing and certification requirements for telecommunications equipment and Japan's National Health Insurance Reimbursement system, while the Structural Impediments Initiative (SII) talks involved such domestic policy issues as land use, infrastructure spending, and retail distribution systems in Japan and education policy and creditcard use in the United States. The broader the range of policy areas included in trade negotiations, the larger the community of policymakers and interests involved, and the more difficult it is to reach consensus.

In an increasingly interdependent world, significant differences in almost any national policy area can affect trade and hence become the topic of trade negotiations. One of the challenges confronting a rules-based approach is to determine which national policy differences are the appropriate focus of multilateral rules to govern the international trading system and which are not. The answer lies in determining which policy differences are likely to have the biggest effects on competition and hence are most likely to be recurrent sources of friction.

For technology-intensive industries, new international rules are most important in several areas, including government procurement practices, intellectual property protection, antidumping procedures, industrial targeting and subsidies or other forms of infant-industry promotion, foreign direct investment, and competition policies.

Government Procurement Practices

Because government procurement remains an important source of demand for many high-technology products, multilateral disciplines on national procurement practices must be strengthened. The coverage of these disciplines must be broadened, allowable bidding rules must be made more precise, and allowable bidding processes must be made more transparent. Priority in extending coverage should be given to procurement in telecommunications, transport, and electric power and to the provision of services. Ideally, as the European Community has argued, multilateral procurement rules should apply to state, regional, and local governments and "to enterprises, public or private, which have special rights or privileges granted by a public authority."[9] This broad definition would cover national postal, telegraph, and telephone administrations as well as multinational entities, such as the European Space Agency. In addition, the contract threshold above which code rules apply should be reduced as was done bilaterally between the United States and Canada in their free trade agreement.

Intellectual Property Protection[10]

The fundamental problem confronting the development of new international disciplines for intellectual property protection is how to balance the objective of promoting innovation with that of facilitating the diffusion of technology. At the international level, there is an important North-South dimension to this problem, with the developed countries seeking strong protection of intellectual property to safeguard the competitiveness of their high-tech firms, and developing countries arguing that strong international rules would limit their ability to persuade rights holders to transfer technology. Weak international rules, however, along with weak intellectual property protection in developing countries, could actually impede technology transfer. Such transfers are frequently realized through foreign investment, which can be inhibited rather than promoted by weak national property rights that require compulsory licensing of patents and that condone the misappropriation of technology through lax enforcement.

New international rules are needed to supplement existing international treaties, administered primarily under the World Intellectual Property Organization. Stronger rules are required to address two recurrent problems: commercial counterfeiting (the sale of goods with false trademarks) and the misappropriation of technology (involving patent and copyright infringement). These rules should set minimum standards and enforcement proce dures to bolster protection of patents, copyrights, trademarks, and trade secrets. Moreover, such standards should be broad enough to extend to new areas such as patents for biotechnology products, copyright protection for software, and patents for semiconductor chip design.

In the area of patents, a standard term of effective duration dating from the time the patent was granted should be accepted. Compulsory licensing of patents should be restricted, and, where allowed, should accord the rights holder the full value of the license. Trademark protection should derive from use or registration and be renewable.

Finally, enforcement procedures should apply to domestic commerce as well as to international trade, since lack of enforcement in the home market can easily allow infringement of intellectual property rights.[11]

Antidumping Procedures

The appropriate objective for antidumping regulations is the prevention of predatory pricing—a particular type of anticompetitive business behavior that involves short-run price cutting in an effort to exclude rivals and gain or protect market share. Predatory pricing, like other forms of predatory behavior, is harmful irrespective of the nationality of the predator. It is especially irksome, however, when the predator is foreign, since the profits that result from market power do not accrue to domestic residents.

The first-best solution to the problem of predatory pricing—or any other form of predatory behavior for that matter—is a set of supranational rules on competition policy to regulate anticompetitive business practices and a complementary set of enforceable rules to regulate government subsidies, trade barriers, and other government subventions that encourage such practices. Neither set of rules is likely to be developed very quickly. Indeed, for the reasons noted below, the evolution of a supranational competition policy is likely to be a particularly slow process.

For the foreseeable future, therefore, national antidumping laws will remain a legitimate second-best approach that countries can and will apply to prevent the injurious effects of predatory pricing. The challenge is to improve on this second-best solution. To meet this challenge, new international rules are required. Current GATT rules are at once too vague to prohibit the use of national antidumping laws for anticompetitive or protectionist purposes and too lenient to prohibit efforts by predatory sellers to circumvent antidumping duties. The basic objective of new rules should be the adoption of more precise, uniform, and transparent national antidumping procedures that address predatory pricing without restricting other forms of competitive business behavior and that make easy circumvention less feasible.

As a first step, new international rules must encourage tighter criteria for, and greater convergence among, national laws on the conventions used to measure dumping. Currently, GATT law defines dumping simply as the selling of goods in a foreign market at less than fair market value.[12] This definition leaves vague the methods by which the so-called normal value or fair market value (FMV) is to be measured. Often, the FMV is taken to be the price of the foreign seller in its home market. But the price of the seller in some other foreign market can also be used, and with increasing frequency the FMV is taken to be some measure of either actual or constructed production costs.[13]

At a minimum, tighter international regulations should be imposed on national methods for calculating FMVs. Ideally, such methods should be based on actual prices averaged across a wide variety of markets where the product in question is sold rather than on calculations of production costs. In high-technology products, the measurement of production costs is especially hazardous because of the global character of the firms involved and because any estimate of cost is extremely sensitive to the scale of production. Rather than fall back on the false precision of constructed cost and FMV concepts, the application of antidumping rules should be based whenever possible on actual prices.

If production costs continue to be used, however, international conventions are required to control which cost concepts and which profit margins should be applied. These conventions should recognize the sensitivity of costs to scale and should require that, whenever possible, costs at different scales of production be included in FMV calculations.[14]

More effective international rules should also eliminate the use of price undertakings or minimum price commitments by the foreign seller as a method for addressing an antidumping complaint. Price undertakings, which are explicitly allowed under current GATT regulations, encourage price floors and cartel-like arrangements. Ironically, as written, the price undertaking clause often means that the worst punishment for the offender found guilty of dumping behavior is that he must charge higher prices. Moreover, price undertakings often result in much higher prices than would result if an antidumping margin were simply applied in the amount of the difference between the actual price and the FMV.

New international rules are also required to deal with procedural issues in the dumping area. Current GATT regulations allow for large national differences in antidumping procedures. U.S. procedures require extensive judicial review by the International Trade Commission and allow for the disclosure of detailed information to exporters and importers. In contrast, Europe has no system of information disclosure, no separation of responsibilities for dumping and material injury determination, and only limited judicial review, so the system is largely administrative and bureaucratic.[15] Both the U.S. and the European systems, as well as all other national systems, share the obvious defect that national producers appeal to national bodies for a determination of dumping. It is unreasonable to presume that such bodies are impartial judges when it comes to choosing between the interests of domestic and foreign firms. The U.S. system also suffers from the defect that there is no penalty for bringing an unsuccessful dumping case and hence no deterrent to nuisance cases. In contrast, in Europe, an unsuccessful plaintiff must pay court costs.

A primary objective of new multilateral codes for antidumping should be the standardization of national procedures allowing for greater transparency, greater access to information by all interested parties, greater opportunity for judicial review, and more effective deterrence of nuisance cases.[16]

The new international dumping code also needs provisions relating to the effective enforcement of antidumping findings. Foreign sellers found guilty of dumping under allowable national laws should not be allowed to circumvent the charge by screwdriver operations or slight product alterations. The United States and Europe have already experimented with unilateral anticircumvention efforts. The European approach of using de facto local content restrictions has been found in violation of the national treatment principle of GATT. In the absence of international enforcement rules on circumvention, individual nations will continue to devise their own solutions with distorting spillover effects for others.[17]

Finally, if supranational rules on competition policy come into effect, there should be some international mechanism for examining the competitive effects of national antidumping decisions. Selling a product below some measure of cost or selling the same product in two different markets at two different prices is not necessarily predatory or anticompetitive behavior. Predatory pricing can succeed only when markets do not function properly.

To determine whether such pricing decisions have predatory intent, it is necessary to analyze the market situation and the business practices of the producers in question. This requires an antitrust or competition policy perspective. Consequently, as new international codes are developed, the international system should set up some mechanism whereby such a perspective is brought to bear on the use of antidumping laws by individual nations.

One promising line of action against predatory pricing through competition policy is a "two-tier" approach suggested by the OECD. In such an approach, the supranational competition authorities would look first to the market in question and determine whether it is susceptible to successful predation. For the cases that survive the first tier, a multifaceted inquiry would be required, focusing on the relationship between prices and costs, and examining factors behind the observed pricing behavior (Organization for Economic Cooperation and Development, 1989).

Industrial Targeting and Subsidies

The international system needs a procedure akin to that of the European Community—rules on the kinds and the magnitudes of permissible subsidies and targeting programs in high-technology industries. Without strict disciplines on government subventions, it will be difficult to lower border barriers and even harder to dismantle behind-the-border restraints. Suspected subsidization by one government breeds emulation by others.

The basic objective of new disciplines in the targeting and subsidy area should be the restriction of infant-industry support programs for technology-intensive industries by mature industrial economies. The definition of an infant-industry support program is comparable to the definition of industrial targeting suggested by the United States in the Uruguay Round discussions: an infant-industry program is a specific industrial policy for emerging industries, encompassing direct financial support, backed up with collateral measures such as a high level of domestic protection, R&D support, relaxation of competition laws, and export credits.

New international rules are required to restrict such programs, and, when they are allowable, to require that they be made available to foreign firms on the same terms as domestic firms enjoy. The research and development area poses a number of vexing problems for the development of such rules. The presence of externalities has long provided a rationale for government subsidies for basic research. But in Japan and Europe, and increasingly in the United States, government subsidies are extended to precompetitive or generic research that lies somewhere between basic research and proprietary research. As things now stand in the Uruguay Round discussions, R&D subsidies would be allowed, provided they are for "precompetitive" research and provided no other signatory to a subsidy agreement can demonstrate an adverse effect.[18]

To establish binding disciplines on R&D subsidies, it is first necessary to get international agreement on precise distinctions between basic, precompetitive, and applied research.[19] But according to most scientists and technologists, precise distinctions do not exist, so the control of R&D subsidies will require prior agreement on some tough definitional issues.

National R&D support also raises the need for rules about membership in government-sponsored consortia. The dispute over the membership of foreign subsidiaries in the Joint European Semiconductor Silicon Initiative (JESSI) and in Sematech is indicative of the kinds of issues that need to be resolved. As a starting place for new rule development, a rough notion of reciprocity would seem to have merit. As a general principle, each country would make its publicly funded R&D programs available on the same terms to any company regardless of national origin, provided the home countries of any participating foreign company did the same. Moreover, all countries might agree that the funds extended under such programs be spent at home—by both domestic and foreign firms.

When publicly funded R&D programs involve cooperative arrangements among a group of firms, each of which provides some of its own money, additional rules are required to address new issues, such as patent rights and licensing requirements. Moreover, such arrangements also raise some thorny issues of competition policy discussed below.

Finally, an effective international discipline to limit "infant-industry" promotion of high-technology industries probably requires setting quantitative limits on total national spending in permissible subsidy categories. Such categories, no matter how precisely defined, are subject to abuse. The only way to stem that abuse is to restrict its overall magnitude.

Foreign Direct Investment Policy

As flows of investment become ever more important relative to flows of trade, the competition among nations will increasingly take the form of locational competition for shares of the world's high-technology production base regardless of ownership. Under these circumstances, the challenge facing each individual nation is twofold: to make itself an attractive location for both domestic and foreign producers;[20] and to work with its trading partners to restrict "beggar-thy-neighbor" competition for investment by these companies. The second challenge requires the formulation of new multilateral rules in the area of foreign direct investment.

The present GATT Round is likely to make some progress on multilateral rules to limit so-called TRIMS (trade-related investment measures). TRIMS include various kinds of performance measures on foreign direct investment that distort trade. But TRIMS are likely to be less important in the future than a variety of national policies to influence the content or quality of foreign direct investment. Europe's aggressive use of its antidumping clarification to attract semiconductor investment comes immediately to mind.

An effective multilateral investment code for high-technology industries must include regulations delimiting exactly when and how nations can either restrict or encourage foreign direct investment. Of special importance is the harmonization of national practices involving how rules of origin are used and the conventions by which they are enforced. Without multilateral disciplines, each nation will be tempted to act on its own, in beggar-thy-neighbor fashion. Nonetheless, such a code will have to come to terms with the fact that nations or regions are likely to insist that a substantial fraction of the high-technology goods they consume be locally produced, even if the local production facilities are increasingly owned by foreigners. At the very least, if all countries continue to compete for the high-tech production of global companies—an outcome that seems likely—then such competition should be disciplined by an international framework that rules out zero-sum behavior.[21]

Competition Policy

Most technology-intensive industries are global oligopolies consisting of a relatively small number of companies. Each of these companies has substantial market power, and each has a significant presence in all of the major national markets for the products it sells. None of this is terribly surprising—increasing returns to scale and scope and the inherent imperfections associated with technology creation and diffusion tend to produce imperfectly competitive market conditions.

Because most companies in technology-intensive industries are global oligopolist, their competitive position in one part of the global marketplace can have a significant effect on their competitive position elsewhere. It is this interdependence in market outcomes that makes structural differences in national competition policies a source of recurrent trade friction.

If Japanese firms are allowed to engage in certain kinds of business practices at home, they may gain an advantage abroad. Or alternatively, if such practices are an impediment to Japanese market access by American firms, the competitive disadvantages to these firms can reverberate throughout the world. Differences in European and American laws on cooperative research and development can affect the position of European and American firms in the world marketplace. Differences in national regulations on mergers and acquisitions may make one group of national companies vulnerable to takeover attempts by their foreign competitors while another group of national companies is protected from such attempts.

Of all the structural differences among nations, differences in competition policy may have the greatest influence on the terms of global competition in high-technology industries. Yet such differences are likely to be the most difficult to harmonize or to regulate by multilateral rules.

Since the Europeans are already involved in an effort to harmonize their competition policies in the Community, their evolving practices should be the starting point for multilateral negotiations. Also as the European Community experience makes clear, in the area of competition policy, a judicial review system and enforcement mechanism are critical. Since competition policy often involves a complaint of one business actor against another, there must be a judicial system whereby cross-national disputes among corporations of different national origins can be adjudicated. As things now stand, such disputes can be played out in one of two ways—through widely differing national antitrust channels and through trade disputes among national governments that are sometimes forced to represent the interests of their national firms, even when those interests do not conform to the interests of the nation.

What the Europeans are doing to develop a more unified market provides a preview of what the world economy needs in the high-tech area. The Community is developing a precise set of rules to govern business and member government behavior in all of the policy areas discussed here—government procurement, intellectual property protection, antidumping procedures, industrial targeting and subsidies, and competition policy. Moreover, in developing these rules, it has allowed for two approaches—harmonization of policies in some areas and mutual recognition of policy differences in others.[22]

The evolution of policy convergence within the European Community also indicates the critical role of a supranational court system—in the European case, the Court of Justice—to enforce international rules, adjudicate disputes among governments and businesses, and establish legal precedents. Europe 1992 is a regional experiment in "deep integration"—the harmonization of significant structural differences and the development of comprehensive rules in a wide variety of policy areas, both backed by institutions of dispute settlement and enforcement. Unfortunately, for the foreseeable future, the world economy will have to be satisfied with a less ambitious arrangement than deep integration, and so too will U.S. decision makers.

IMPROVEMENTS IN NATIONAL TRADE POLICIES: AN INTERIM POLICY AGENDA

Even the most optimistic free-traders admit that new rules and enforcement mechanisms required to curb trade friction in technology-intensive industries will be a long time coming. Certainly, the long delay in the Uruguay Round caused by the relatively transparent issue of agricultural subsidies indicates how difficult it will be to get agreement on such cloudy issues as differences in national competition policies. In the meantime, the nation's trade laws are its primary mechanism for addressing the harmful effects of foreign trade barriers, structural impediments to foreign markets, and the anticompetitive practices of foreign companies. The challenge is to make these laws work more effectively in the national interest and in the pursuit of a stronger international order.

Antidumping Laws

During the 1980s, recourse to antidumping laws became increasingly popular for American and European companies alike, particularly in their dealings with East Asian competitors.[23] In addition, dumping increasingly became defined not as selling below an actual home market price but selling below a constructed measure of production costs.[24] A dumping determination now often means nothing more than that foreign firms are found to be selling below some artificially defined and constructed measure of full average costs adjusted by an arbitrary 8 percent profit markup.[25]

If a dumping determination has been made, U.S. law calls for a further demonstration of either threatened or actual injury to U.S. companies. Because there are no formal criteria by which threatened or actual injury is assessed, this condition can be met easily, especially if the political and overall trade atmosphere is right. Finally, if injury is established, the law calls for the automatic imposition of dumping duties in the amount of the difference between the dumped price and the FMV. The only way to stop this process is for the dumping suit to be dropped—as it was in the semiconductor case—in preference for another remedy.

At no point in the application of the nation's dumping laws is it necessary to document the structure of the industry in question, the market power of the dumper, the predatory intent or effect of the dumping, or the trade barriers, structural impediments, or other foreign government subventions that might underlie it. In short, there is absolutely nothing in the existing procedures to determine whether dumping is an "unfair" or "predatory" business practice or whether it is supported by the "unfair" behavior of foreign governments. Demonstration of the defensible rationale for national dumping laws under GATT—to deter predatory behavior by foreign firms—is lacking in these procedures. Thus, it is not surprising that they can be used to block "fair" competition by lower-cost, more efficient foreign producers, resulting in a less competitive industry over time.

At a minimum, U.S. dumping laws should be changed to incorporate stricter guidelines on the definition and measurement of the costs and prices used to determine whether dumping has occurred. These changes should be along the lines suggested earlier in the discussion on new international guidelines for dumping—actual prices rather than constructed prices should be used whenever possible, prices and costs should be assessed at different scales of production and in different locations around the world, and the profit markup should be adjusted to different home and industry market conditions. In addition, the law should be changed to incorporate some mechanism for evaluating the market conditions, business practices, trade barriers, and structural impediments affecting competition in the industry in question. Such an evaluation is essential to determining whether dumping is predatory in intent or effect and whether it is supported by foreign government action. It is also essential to determining the appropriate remedy.

Dumping that is injurious, or threatens to be injurious, but is not predatory and not supported by unfair foreign trading practices should be addressed by recourse to the nation's other trade laws. For example, if dumping is supported by foreign subsidies, the appropriate remedy is the countervailing duty (CVD) or countervailing subsidy (CVS) approach discussed below. If dumping is judged to be competitive behavior that is not predatory in intent and there are no foreign subsidies involved, then the appropriate remedy is Section 201—the safeguards section of the U.S. trade law, which is designed to provide import relief, regardless of the underlying case of import damage.

Finally, dumping that occurs under imperfectly competitive market conditions with predatory behavior by foreign companies is likely to require a different remedy than the imposition of dumping margins. At the very least, the remedy should *not* take the form of some kind of negotiated agreement that encourages or compels foreign firms with substantial market power to raise their prices.

At the same time that the nation's dumping laws are tightened along these lines, their enforcement should also be strengthened. As things now work, dumping duties may deter dumping in the future, but they do not undo the effects of dumping in the past. To address this shortcoming, the laws should be revised to include the possibility that all duties, fines, and other revenues generated by a successful antidumping suit be disbursed to the injured domestic industry. In addition, the laws should be modified to allow for the imposition of penalties or damages on foreign firms found guilty of dumping under certain circumstances, such as those in which predatory intent or explicit foreign targeting policies are involved. Finally, the laws should be revised to allow for early monitoring of foreign costs and prices in industries in which there is a strong presumption of predatory capability, based on global industry structure or foreign government policies. An early warning procedure could be a useful deterrent to predatory or preemptive behavior by foreign producers.

Adjusting the nation's dumping laws along the lines suggested here does not mean gutting them. Rather, it means designing them to be used more effectively for their appropriate objective—to deter predatory or anticompetitive behavior by foreign firms and governments. When such behavior is not at issue, but when foreign competition is nonetheless injuring or threatening to injure American companies, the safeguards or CVD clauses of the nation's trade laws, not the dumping laws, are the appropriate remedy.

Countervailing Duties

In accordance with GATT regulations, U.S. trade law allows for the imposition of countervailing duties to offset the injurious effects of foreign subsidies on domestic producers. Under GATT Article VI, injurious subsidization is a form of market distortion recognized as an unfair trade practice. During the first half of the 1980s, there was a rapid expansion in the number of countervailing duty actions brought by U.S. companies against unfair competition (Destler, 1991).

The first-best solution to the problem of trade distortions caused by foreign subsidies would be new international agreements to restrict them. The United States has sought this first-best solution in international negotiations by pushing for stricter multilateral regulations on allowable subsidies—both their kinds and their amounts. The U.S. approach rests on the presumption that it can come to an agreement with its trading partners about allowable subsidies.[26] But this outcome, while laudatory in intent, has proven difficult to realize.

Subsidies reflect fundamental philosophical differences among nations regarding the appropriate role of the government in the economy. In the case of technology-intensive industries, where theory suggests that government intervention may be welfare-increasing, these philosophical differences are even greater than they are in the area of agriculture, where the struggle to negotiate multilateral limits on allowable subsidies has been a long and bitter one.

The imposition of CVDs is the second-best approach currently provided by U.S. trade law for dealing with the distortions caused by foreign subsidies. But there are problems with this second-best approach. Under most market demand conditions, the imposition of a CVD on an imported good raises its domestic price and prevents American consumers from enjoying the short-term benefits of foreign subsidies. Moreover, if such a good is available for purchase elsewhere in the world, a CVD may make the United States a "high-price" island for the good in question, driving consumers to third-country markets. When the good is a productive input and the consumers in question are themselves producers, this can mean driving production to third-country markets as well.

The CVD approach may also not be the best approach for offsetting the injurious effects of foreign subsidies on domestic producers over the long run. In principle, these effects are offset by the duty, which hurts the foreign producers, and by the higher domestic prices of the good in question, which helps the domestic producers. But this approach, even when the demand conditions in the prevailing market cause the full burden of the duty to be borne by the foreign suppliers, does not offset the benefits of sales by subsidized foreign firms in third-country markets. In industries with large economies of scale and learning curve economies, these effects can be substantial and decisive.

Nor does the CVD approach address the effects of foreign subsidies on business expectations and strategies. As the literature on strategic trade theory demonstrates, a credible commitment by a foreign government to target an industry can have profound effects on the strategies of both domestic and foreign firms. U.S. firms competing in an industry that is targeted and subsidized by a foreign government may be able to obtain partial relief in the short run by resorting to the nation's CVD law. But the way the law works, such an approach usually involves a delay, the process of initiating legal action is costly, and the outcome is uncertain.

The uncertainty is even greater when foreign government support is of a kind not easily measured. It is one thing to try to quantify the duty required to offset a specific financial subsidy, but quite another to quantify the duty required to offset other kinds of targeting policies, like protection of the home market or lax antitrust enforcement. And finally there is the uncertainty resulting from circumvention by various means, including shipping intermediate rather than final products into the United States, performing the last manufacturing stage in a third country, or altering the product.

For all of these reasons, a CVD remedy is unlikely to offset the influence of a credible foreign targeting program on the strategies of domestic and foreign companies. In the absence of a similar commitment to the industry by the U.S. government, the result of such a program is likely to make the foreign firms pursue more aggressive strategies than their domestic competitors. The CVD option may moderate, but it is unlikely to eliminate, these effects on strategic behavior and competitive outcomes.

An alternative to the CVD approach is the countervailing subsidy approach —an approach that addresses the deleterious price effects, third-country effects, and strategic effects of the CVD approach. If U.S. policy is predicated on the view that an industry targeted and subsidized by its trading partners is important to the health of the U.S. economy—a view that is defensible in many technology-intensive industries—then a CVS approach may be a defensible and sensible second-best solution.

Section 301 and Super 301

Section 301 and "Super 301" are the major channels within U.S. trade law for addressing foreign trading practices that impede access to foreign markets. Section 301, which was introduced in the 1974 Trade Act, deals with disputes over particular goods, while "Super 301," which was introduced in the 1988 Trade Bill, deals with disputes between individual countries on a broad range of unfair trading practices.[27] The 301 approach has been critized both at home and abroad for its "aggressive unilateralism." In a 301 action, the U.S. government determines what is "fair" and what is not, bypassing GATT at will, and often threatens to retaliate against foreign partners who do not commit to change their ways. As a result, 301 actions can violate three basic GATT principles: reciprocity, because the United States can demand a reduction of a foreign trade barrier without offering a reduction in one of its own; nondiscrimination, because the United States can block or threaten to block imports from a single country; and transparency, because a trade dispute can be settled by some kind of nontariff intervention in trade flows. In addition, the unilateral imposition of retaliatory tariffs or other measures when 301 negotiations fail is a clear violation of GATT's nondiscrimination principle.

Critics of 301 unilateralism also argue that trade concessions granted to the United States under the gun of compulsory negotiations can create negative spillover effects on third parties. So far, however, the United States has been careful to use both 301 and Super 301 to negotiate for nondiscriminatory, most-favored-nation concessions in which benefits are accorded to all suppliers, not just U.S. suppliers. Critics further maintain that U.S. unilateralism will poison the atmosphere for further progress on strengthening the GATT regime. It is equally likely, however, that U.S. unilateralism may help overcome some of the negotiating inertia currently blocking needed reforms.[28]

But the main defense of the 301 approach is that it is essential as an interim measure—the alternative is not a world of free trade unimpeded by overt trade barriers and structural impediments, but a world in which such barriers and impediments can damage national economic interests, especially in imperfectly competitive technology-intensive industries. In such a world, the real policy alternatives are to accept the damage; to try to offset it by subsidy or protection at home; or to negotiate for the removal of the barriers or impediments that cause the damage. The 301 approach chooses the third and most sensible option.

A growing body of evidence, including my case studies of U.S.-Japan trade negotiations in cellular telephones, supercomputers, and semiconductors, indicates that this approach can reduce foreign market barriers and increase market opportunities for American companies.[29] Neither the intent nor the outcome of 301/Super 301 actions in these three cases was protectionist. A similar conclusion applies to recent agreements between the United States and Japan to improve access for American suppliers in Japan's computer and auto-parts markets.

But while bilateral, sector-specific agreements can eventually improve market access, they should not be oversold. The 301 negotiations leading to such agreements are usually long and tortuous, and the results are usually small. The issue of delays reveals a fundamental limitation of this approach—slow resolution of trade policy disputes can be potentially disastrous to American firms or industries, as the 15-year dispute between the United States and Japan on access to the Japanese semiconductor market demonstrates. Even when the companies involved can withstand the delay, as Motorola could in the cellular telephone industry, they pay a heavy price in terms of forgone revenues. Smaller, less prosperous companies may simply write off the prospects of breaking into a sheltered foreign market altogether or may find themselves driven out of business by foreign competitors based in such markets.

Some of the delays in American trade policy have been "internal," reflecting the failure of American policymakers to react to foreign barriers, in part because to do so might threaten broader geopolitical interests and in part because the damaging effects of such barriers were simply discounted. As long as American policymakers believed that it did not matter whether the United States had its own DRAM capabilities, it was difficult to mount a credible response to Japanese policies.

Even with a quick-response approach, such as Super 301, however, American producers can rarely expect a resolution to a trade policy complaint in less than one year, and implementation of a resulting trade agreement can take considerably longer. These unavoidable delays mean that in technology-intensive industries, where one year can destroy a technological advantage, trade policy cannot be an effective substitute for a domestic policy response. If the health of American producers is jeopardized by foreign trading practices, the American government should have the capacity and the will to introduce interim domestic assistance measures while it continues to negotiate with the trading partners.

CONCLUSIONS

As economies become more interdependent and as companies become more global, the world trading system requires new rules and new enforcement mechanisms. GATT may not be dead, as some have argued, but it is certainly in need of a major overhaul. Rules about traditional border policies like tariffs and quotas are no longer enough. Deep interdependence requires deep integration—the harmonization of significant structural differences among nations and the development of comprehensive rules in a variety of "nonborder" policy areas, both backed by multilateral institutions of dispute settlement and enforcement. The blueprint for Europe 1992 provides a model of what will ultimately be required at the international level.

The vision of deep integration should inform U.S. trade policy negotiations at the multilateral level. The goal of U.S. trade policy should remain more and freer trade, safeguarded by new international rules. In pursuing this goal, however, U.S. policymakers must be mindful of the fact that the process of developing such rules will be a slow one.

In the interim period, the United States will continue to face the challenge of preventing further erosion in its relative economic position. To meet this challenge, U.S. policymakers must recognize that trade barriers and structural impediments in foreign markets are harmful to national economic welfare in a variety of ways—they worsen the nation's terms of trade; impose unnecessary adjustment costs on American communities, workers, and companies; eviscerate America's strategic industries; and breed costly protectionist responses. Given the prevalence of such barriers and impediments, free trade in high-technology products is a largely meaningless option. For such products, the real policy choice is not between free trade and protection but between appropriate combinations of liberalization and government intervention that improve national economic welfare in the short run and sustain a more open international trading system in the long run. This real policy agenda requires using the nation's trade laws as they were designed to be used, to offset the negative effects of market distortions abroad.

Even at their best, however, the nation's trade laws cannot substitute for domestic policy initiatives. Ultimately, the fate of America's high-technology industries depends on the choices that Americans make about their macroeconomic policy, about their research and development policy, about their education policy, and about their commitment of today's resources to tomorrow's economic well-being.

NOTES

1. Trade in manufactured products accounts for some 85 percent of total world trade in goods, and most of world trade in manufactured products consists of two-way exchanges of fairly similar goods at the sectoral level.

2. For a recent popular discussion of how differences in the organization of national economics affect their competitive position in international trade see Porter (1990).

3. The same conclusion is reached in Ostry (1990a, b).

4. Any identification of "technology-intensive" or "high-technology" industries is necessarily somewhat arbitrary. In this paper, high-technology products are identified by their R&D intensity, as measured by their R&D spending relative to output and sales indicators, and by the share of scientific and engineering employment in their total employment. This general approach is the one used by both the OECD and the U.S. Department of Commerce to identify and measure trade in "high-technology" products.

The OECD "high-technology" category includes the following sectors with their respective international standard industrial classification codes: drugs and medicine (ISIC 3522); office machinery and computers (ISIC 3825); electrical machinery (ISIC 383 less 3832); electronic components (ISIC 3832); aerospace (ISIC 3845); and scientific instruments (ISIC 385). The DOC "high-technology" category includes the following sectors with their respective SIC codes: guided missiles and spacecraft (SIC 376); communication equipment and electronic components (SIC 365-367); aircraft and parts (SIC 372) office; computing and accounting machines (SIC 367); ordnance and accessories (SIC 348); drugs and medicines (SIC 283); industrial inorganic chemicals (SIC 281); professional and scientific instruments (SIC 38 excluding 3825); engines, turbines, and parts (SIC 351); and plastic materials, synthetic resins, rubber and fibers (SIC 292). OECD data for the United States represented 96 percent and 100 percent of DOC data for the United States in 1980 and 1986, respectively. National Science Board, *Science and Engineering Indicators, 1989* (Washington, D.C.: Government Printing Office, 1989).

5. Science-based industries include industries such as fine chemicals, electronic components, telecommunications equipment, computers, and aerospace, which have high levels of

R&D and which provide capital or intermediate inputs to other industries. This classification is less inclusive than the OECD or DOC classifications of "high-technology" industries. The overall trends in the United States, European, and Japanese positions are similar for both the narrower science-based industry classification and for these broader classifications. For more detail see Tables 1, 2, and 3. The data on the performance of the science-based industries is taken from Guerrieri in this volume.

6. The literature on the new trade theory is large and growing. Several excellent papers are included in Krugman (1986). For a recent summary of the major conclusions of the theory, see Krugman (1987). For a complete technical treatment of the theory, see Helpman and Krugman (1985).
For one of the earlier theoretical pieces that focused on high-technology industries, see Brander and Spencer (1985). Although the literature on strategic trade theory is full of theoretical demonstrations that promotional or protectionist policies can improve economic welfare at home or reduce it abroad, whether such policies work in practice is another matter. The theoretical assumptions behind these demonstrations are usually very restrictive. And the weight of the available evidence, albeit flawed by overly simple models and inadequate data, suggests that such polices often reduce national welfare. See Richardson (1985).

7. The expulsion of Fujitsu-owned ICL from JESSI, Europe's biggest semiconductor research project, funded in part by a number of European governments, comes to mind. See also Mowery (1990).

8. As Porter and others have observed, there are still striking similarities in the capabilities and strategies of individual firms with the same national origin. Many multinational high-tech firms are global in perspective, but they are still significantly national in terms of the behaviors they adopt. Japanese firms do tend to behave differently from American firms in a variety of ways, as do German and French firms. See Porter (1990).

9. For a discussion of the European Community proposal, see *The Financial Times*, August 3, 1990, p. 16.

10. The following discussion of intellectual property protection draws heavily on Schott (1990) and Maskus (1990).

11. The problems of Section 337 of U.S. trade law in GATT reflect a panel ruling that the application of the law conflicted with the principle of national treatment. This ruling reflected the panel's belief that the nation's laws on intellectual property rights were not applied with the same force against domestic companies as they were against foreign companies. The main source of the disparity in national treatment is that the application of Section 337 does not involve the same process of time-consuming patent litigation required to enforce the application of intellectual property rights against a domestic company.

12. According to GATT law, dumping occurs when a good is sold abroad for a lower price than the seller charges for the same good in his home market. The home market price is usually taken to be the "normal value" or FMV. In two circumstances, however, GATT law allows for the construction of an FMV: if there are insufficient sales on the domestic market of the exporter or "whenever there is reasonable ground for believing or suspecting that the price at which a product is actually sold for consumption in the home country is less than the cost of production." The dangers inherent in the vagueness of the second condition are obvious.

13. Under current practice, both the United States and the European Community tend to employ a full average cost standard--dumping is interpreted to occur when price falls below average cost, broadly defined to include both variable and fixed costs, and a profit margin judged high enough to attract investment capital.

14. The concept of using costs measured at different points in the production cycle or different moments of time is behind the idea of "life-cycle costs and pricing" suggested by interested business groups to the American trade negotiators for the Uruguay Round discus

sions. Such a concept, while sensible in intent, is problematic in implementation. It is difficult to come up with measures of life-cycle costs and prices with even the most sophisticated techniques.

15. Some of the procedures used in the application of dumping laws in other nations are even less transparent and more subject to abuse.

16. These objectives are especially important for American export interests. Currently, European and American companies are the most frequent targets of antidumping suits. U.S.-based exporters face less transparent systems abroad than foreign producers face in the United States.

17. To deter repeated dumping by particular producers in a single or related product lines, anticircumvention rules may have to be combined with rules for special penalties for demonstrated recurrent "dumpers." This is the approach suggested by the United States and Europe in the Uruguay Round discussions.

18. Note that the Cortland draft for discussion of subsidies in the Uruguay Round argues that subsidies for the purpose of regional development, precompetitive research and development (R&D), environmental protection, or worker adjustment assistance not be actionable, provided the subsidy is granted for a strictly defined period, not exceeding a specified number of years, and is digressive within this period, provided notification of granting the allowable subsidy is made in advance, and provided no code signatory can demonstrate adverse effects.

19. According to what appears to be the current working definition in U.S. policy circles, R&D is precompetitive when the results of research can be published and used without restriction.

20. For a fascinating discussion of the many factors that influence the attractiveness of a nation for foreign direct investment, see Dunning et al. (1990).

21. For a more complete discussion of the kinds of international rules that may be needed in the area of foreign direct investment, see Bergsten and Graham (1991).

22. As Sylvia Ostry has argued, some national differences cannot and probably should not be harmonized as an act of policy. Instead, such differences should be allowed to converge slowly as the result of competition among producers through trade and cross-border investment. The main challenge is to harmonize differences that impede such competition and therefore impede a healthy competition between different forms of economic organization.

23. For evidence, see Masserlin (1990).

24. For example, according to the U.S. Department of Commerce, approximately two-thirds of antidumping investigations processed in 1987 involved selling below actual or constructed measures of production costs. The cost approach has been used extensively in high-tech products.

25. At least, however, the Commerce Department approach places the evidentiary burden on the petitioners who must be able to demonstrate below-cost sales by providing cost-of-production information and home-market sales data.

26. When international agreements identify certain subsidies as "green-light" or allowable subsidies, the importing country cannot impose a CVD. So to the extent that the United States realizes its objective of limiting certain kinds of subsidies in the Uruguay Round, it correspondingly limits the application of its own CVD law.

27. Super 301 was a temporary measure built into the 1988 trade legislation. It has now expired, but many members of Congress are currently working to extend it. For some critical assessments of both Section 301 and Super 301, see Bhagwati and Patrick (1990).

28. In fact, as Robert Hudec has argued, it is conceivable that U.S. unilateralism may overcome the negotiating inertia currently blocking reforms of the GATT dispute

settlement mechanism—in his words, the U.S. breach of GATT law may actually result in an improvement of this law in the long run. See Hudec (1990).

29. My case studies are contained in Tyson (1992). For an evaluation of the recent 301 actions and their effects, see Bayard and Elliott (1992).

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Summary of Panel Discussion

New approaches to linking trade and technology policy were a major theme in the presentations and in the discussions that followed. Sylvia Ostry made a persuasive case for new approaches by focusing on what she called a new innovation paradigm of continuous process and product improvements. This new paradigm, she argued, has changed the nature of global competition not only because price is less important, but also because systems are competing and some are more "innovation friendly" than others. Competition for market share is not just among firms, but also among national systems.

Because the Japanese approach (of "managed markets") turns out to be more effective than the pluralist approach taken by the United States and Britain, or the German "social market" approach, the new innovation paradigm presents urgent challenges to U.S. policymakers to develop new approaches or risk further deterioration in the U.S. global market position. As Laura Tyson noted in her summary remarks, Japanese companies appear committed to maintaining and expanding their positions in high-technology trade, and there is good evidence that European nations are now intent upon ensuring that a significant share of high valued-added production takes place in Europe. Tyson asked the rhetorical question, Can the United States rest assured that the old policies used in many years past will work in this new context? Ostry answered the question by arguing that neither traditional trade policies nor technology policies provide the tools for formulating the

The Panel on New Paradigms for Linking Technology and Trade Policies was chaired by Laura Tyson. Other panelists were Jean-Claude Derian, Sylvia Ostry, and Clyde Prestowitz, Jr.

needed rules of global competition in the face of the new innovation paradigm.

Jean-Claude Derian's reflections on the "second battle of Poitiers" (the French response to a flood of Japanese-made VCRs) underscored the fact that there are very different approaches to government-business relations in Europe, the United States, and Japan. These different conceptions create trade conflicts. Europe and Japan have embraced industrial and technology policies, while the United States has been reluctant. Clyde Prestowitz went a step further to suggest that the United States manages trade "de facto" because our industrial policies do not work. Derian reminded the audience that there is no one recipe for a successful technology policy—the right mix depends on the traditions and structural features of the system. The growing interest in the United States in technology policy may, he speculated, help to establish common lines of thinking with Europe and ultimately result in an easing of trade conflicts.

There was, however, a great deal of debate (implicit and explicit) over what kind of technology policy is right for the United States. Alexander Flax noted that the Airbus consortium is not a success from the U.S. perspective. Suggesting the need to work with both bilateral and multilateral trade agreements that are sectorally oriented, he called on the United States to do a better job with sectorally oriented policies. Tyson and others noted, however, that there are a variety of forces (such as the American proclivity to buy the lowest priced goods and a presumption that no sector is better than any other) that make this difficult. Claude Barfield strongly disagreed with sectoral approaches, particularly subsidizing industries which he called "throwing money at the problem."

Prestowitz, who argued that the United States manages trade de facto, suggested that the real question is whether we do it well or poorly. Tyson made a case for "second-best approaches" that must be tried "in the meantime"—until new rules of the game can be established to deal adequately with the new style of competition that we see today in high-technology trade. The United States could use a stricter approach to antidumping (with tougher penalties when predatory intent can be proved) and a countervailing subsidy approach that would provide direct benefits to U.S. producers. These and other bilateral approaches to trade problems will not solve all the problems of U.S. high-technology industries, but they can buy some time. According to Tyson, bilateral approaches are justified as a kind of wrench shifting: You either get more competition in the best of all possible worlds, or you at least get some shifting from foreign to U.S. producers.

Ostry provided a counterpoint in arguing for new international rules of the game. These new rules must take into account the fact that systems are structured differently; they must be written to work toward a "mutual balance of benefits" in the face of asymmetries in access to technology and investment. These new rules will not be easy to write, because they will have to deal with a much more complicated environment. Differences in standards, R&D subsidies, intellectual property rights, investment policies, procurement, and competition policies must all be addressed. One problem is that there is no transnational court for things like competition policy—where companies can take their complaints against other companies or where companies can take governments to task. Ostry called for a new supranational authority—not just a simple focus on harmonization of national rules. Work under way at the OECD was mentioned as pushing in this direction.

Bilateral and multilateral approaches can, in the eyes of some, be complementary. Bilateral approaches, however, must be combined with a heavy dose of competition policy, according to Sylvia Ostry and Margaret Sharp. Other speakers held to the view that the only right path is multilateral. Barfield, one of the most articulate proponents of this line of thinking, called for a multilateral approach that features "mutual recognition" and enhances competition even among very different systems. Others more skeptical about the feasibility of such multilateral approaches put stronger emphasis on bilateral trade policies to deal with the urgent problems of high-technology industries faced with a new style of competition from foreign companies and systems.

Technology Challenges to Trade Policy

Technology Challenges to Trade Policy

DAVID B. YOFFIE

The demands for trade intervention in high-technology industries are expanding. Policymakers everywhere seem to believe that the externalities of industries like semiconductors and telecommunications are so great that fewer and fewer want to leave the fate of these businesses open to the vagaries of the "free market." Despite a worldwide movement toward greater conservatism on government policy, trade policies in high-technology sectors have spread beyond Japan, France, and a few newly industrializing countries to North America and the European Community at large. We have witnessed in the 1980s trilateral trade warfare among Europe, the United States, and Japan in sectors such as semiconductors and high-definition television, with numerous bilateral conflicts in sectors such as aircraft (between the United States and Europe), VCRs (between Europe and Japan), and telecommunications (between the United States and Japan).

I will argue in this paper that such conflicts are dangerous and potentially self-defeating. The postwar trading system was developed to solve the problems of the industries of its day—mainly tariffs and quotas in traditional manufacturing industries. Neither the trading system nor trade policies are well suited to deal with the problems posed by high-technology sectors.

I begin by suggesting how high-technology industries are different from the traditional manufacturing sectors and by discussing the consequences of those differences for trade policy in the decade ahead. Perhaps most significant is that high-technology businesses are characterized by huge R&D investments, high risks, and rapid growth. These and other issues pose unique problems for firms and nations. Moreover, the process of making trade policy in mature manufacturing sectors does not fit well the requirements of high-technology industries. U.S. trade law and the dispute-settlement mech anism in the General Agreement on Tariffs and Trade (GATT) are slow, litigious processes designed to inhibit government intervention in international trade. But if a government does intervene in high-technology industries, the lack of a speedy response by other countries can undermine the competitiveness of a firm or nation.

Finally, I will argue that the urge to use trade policy for managing the inflows of goods and services in high-technology sectors should be resisted. The best use for trade policy in the 1990s is to eliminate the vestiges of the past—namely, foreign trade barriers that continue to pervade many countries—and ensure expanded market access. Technology policies, industrial policies, and even military procurement policies are probably better mechanisms by which governments can promote their domestic high-technology sectors. I will use an extended illustration of the U.S.-Japan semiconductor trade agreement to suggest why trade policy is so difficult to fine tune.

WHY IS HIGH TECHNOLOGY DIFFERENT?

First, from a trade policy perspective, why should anyone care about high technology? Or to paraphrase Office of Management and Budget director Richard G. Darman's oft-quoted comment, "potato chips or silicon chips, who cares—they are both chips." How much the national interest depends on silicon versus potatoes will be left to other papers for the conference. However, the efficacy of trade policy does very much depend on the nature of the industry we are discussing.

Most trade law was designed to deal with non-technology-intensive manufacturing businesses, such as steel, textiles, cars, and footwear. Today's higher technology industries did not exist during the formation of the GATT and the creation of most modern trade law; and even agriculture was largely excluded from GATT scrutiny until the most recent Uruguay Round of negotiations. Although these traditional industries were diverse, they were typically characterized by long product life cycles (for example, it took almost 15 years for the textile industry to shift production from cotton materials into synthetics and blends); limited capital mobility (few steel companies, for instance, moved their manufacturing offshore during the 30 years of their relative decline in the industrial countries); and no problems of appropriating the value of their intellectual property (for example, the relatively low level of investment in R&D meant that managers in steel, textiles, cars, and footwear rarely had to worry about the consequences of foreign competitors reverse engineering their products and recouping their investments in design).

Formulating trade policies in such mature manufacturing businesses was a relatively straightforward task. If industries were in distress because of international competition, governments could adjust tariffs and quotas to regulate trade. While short-term profits would suffer if the process was lengthy, the nation would not suffer as a result. Consumers benefited in the short term from low-priced products. And in the longer run, the government's objectives were met because simple tariffs and quotas could effectively raise domestic production and prices. The flip side of this story was that trade liberalization was also a relatively straightforward task: governments, either bilaterally or through the GATT, could negotiate to reduce protectionist tariff and quota barriers and facilitate increased trading activity across national boundaries. Again, if the process of liberalization was slow, it might reduce short-term national welfare, but once trade barriers came down, countries could trade according to their comparative advantage, allowing firms to exploit their "natural" country-based cost advantages or advantages that might be associated with static, scale-based efficiencies.

High-technology sectors create an entirely different problem set for both managers and trade policymakers. Some of the most commonly cited features of technology-intensive industries in the 1990s are (1) high embedded R&D content; (2) difficulty in appropriating the value of the R&D in intellectual property; (3) short and shortening product life cycles (often as quick as two to three years); (4) steep learning curves, which allow prices to decline sharply over time; (5) the role of standards and switching costs; (6) a low ratio of transportation costs to value; and (7) a high degree of capital mobility. These last two items, taken together, allow firms to disperse production and geographically separate research and manufacturing activities.

Each of these features poses challenges for the formulation of trade policy. Perhaps the most obvious problem is that success in high-technology industries comes from *dynamic*, not static, economies. Actions taken or *not* taken today have critical implications for the positions of those industries tomorrow. In sectors with short product life cycles, for instance, firms must not only make heavy up-front investments in intangible assets (R&D), they must find ways to make a return on those investments quickly—before the next generation of product becomes available. Such high R&D content also creates added risk for the firm: unlike the investment in tangible assets, which can often be resold, investment in R&D represents a sunk cost to firms, which have little or no value when the product life cycle is over. This issue is exacerbated in industries where reverse engineering or illegal copying of designs make it difficult for the firms to appropriate the value of their investment. In addition, in some industries, such as commercial aircraft, the up-front intangible investments are so risky that the firm has to bet the company with each new product introduction.

Moreover, dynamic learning economies and the high switching costs associated with many high-technology products create the possibility of "first-mover advantages;" that is, early winners in the marketplace may sustain lower costs for long periods of time, or early winners may be able to make it costly for their customers to switch vendors. Consider two well-known examples: dynamic random access memory chips (DRAMs) and operating system software. For DRAMs, costs generally decline about 30 percent for every doubling of volume. Ever since Japanese manufacturers moved ahead of the U.S. and European manufacturers in production of 64-kilobit DRAMs in the early 1980s, it has been difficult for new vendors (even with high government subsidies) to dislodge the first movers. The leaders in one generation of DRAMs have an advantage in the next generation because learning takes place across products: what counts is not new modern factories or low labor costs, but *cumulative* experience. Regardless of whether a new (country or business) entrant would have a "natural" comparative advantage because of lower wage or capital costs, dynamic learning economies may shut out future competitors.

A different kind of first-mover advantage may emerge when the early winner in a market creates a standard, which ties customers to a particular vendor. The best-known example of first movers creating a standard and high switching costs is the operating systems for personal computers. When IBM set the standard for its personal computers with its choice of Microsoft's disk operating system (MS-DOS), independent software companies wrote applications designed for that system. Over the decade of the 1980s, users of IBM PCs and PC-compatible computers invested more than $30 billion in software written exclusively for MS-DOS-based machines, which made it costly for the average PC customer to switch to machines based on other disk operating systems.

WHY TRADE POLICY IN HIGH TECHNOLOGY IS DIFFERENT

The combination of added risk, short product life cycles, limited appropriability, and first-mover advantages collectively alter the challenge of trade policy for any national government. The most important challenge is posed by speed: slow resolution of trade policy disputes are potentially disastrous to the firm and crippling to certain sectors of a nation. When foreign firms or governments use subsidies, predatory pricing, or other "unfair" practices as defined by the GATT, domestic firms may be seriously weakened or out of business. Although the same is true in traditional sectors, if foreign firms later try to raise prices in mature manufacturing businesses, domestic firms can reenter those businesses and retain national welfare gains from trade.

Not so in high-technology industries. Where first-mover advantages exist, the barriers to reentry may be insurmountably high. Once a firm (or nation) leaves the DRAM business, for instance, and assuming there are no new technological revolutions that obsolete past advantages, the new firm would have to replicate the cumulative learning of its Japanese competitors. Similarly, once Microsoft creates a standard for PC software, in theory it could exercise monopoly power and make it virtually impossible for latecomers to drive down prices.[1]

Yet the very structure of GATT's dispute-settlement mechanism and U.S. trade law, especially the escape clause (Section 201), antidumping and countervailing duties, and unfair trade practices (Section 301), promote slow actions. Even with fast-track provisions under the 1988 trade law, industries in the United States can rarely expect the government to respond in less than a year (see Table 1).[2]

Fast actions against definable trade violations are only part of the trade policy dilemma in high-technology industries. An equally significant issue is the separation of R&D from manufacturing and the potential mobility of production. In traditional sectors, trade policy serves relatively simple objectives that are easy to observe and measure. For example, the United States and Europe protected the textile industry to ensure employment; the Japanese long protected their steel industry to build a domestic production base. Whether these policies were welfare maximizing is a matter for serious debate; nonetheless, trade policy was a viable tool to achieve the state's objectives.

In high-technology sectors, however, the role of trade policy is much more amorphous. Governments typically want to use trade policy to maintain or build certain industries, but the primary objective is not employment or domestic production, per se; rather it is to reap the "externalities" associated with high research and development activities. Countries want to maintain such industries as semiconductors, computers, aircraft, and telecommunications because they see benefits in investing in businesses where knowledge "spills over" into related sectors. The object is to keep high value-added activities within the country in order to foster the broadest base of growth opportunities.

The problem is that high value-added activities and manufacturing are not necessarily the same thing in high-technology businesses. But trade policy is most effective at targeting an industry's production activities—not the other activities that might produce spillovers. Take, for example, the central-office switch business in telecommunications. Physically, a digital, central-office switch consists of arrays of several hundred circuit boards, containing thousands of integrated circuits, wired together in metal cabinets of 400 to 1,000 cubic feet in size. The products are manufactured in high-volume assembly plants around the world. AT&T has factories in the United States, Holland, Spain, Korea, and Taiwan; NEC assembles in Japan, a variety of developing countries, and Texas; Siemens manufactures in Eu

TABLE 1 Summary of Most Commonly Used U.S. Trade Laws

	Escape Clause	National Security Clause	Retaliation	Duties	Antidumping
U.S. Law	Section 201 1974 Trade Act	Section 232 1962 Trade Act	Section 301 1974 Trade Act	Section 303 1930 Tariff Act	Section 731 1930 Tariff Act
Modified	1979, 1984, 1988	1974, 1979, 1988	1984, 1988	1974, 1984, 1988	1974, 1979, 1984
Rule	Increased imports cause or threaten to cause substantial injury	Imports threaten to impair national security by weakening vital domestic industry	Barriers restrict U.S. commerce No injury test	Export subsidy causes or threatens to cause material injury	Price below "fair market value" causes or threatens to cause material injury
Penalty	Duty, quota, orderly marketing agreement or trade adjustment assistance, or other action	At President's discretion	Determined by U.S. Trade Representative, subject to direction of President[a]	Tariff which offsets subsidy or negotiated settlement	Tariff which raised price to fair market value, or negotiated settlement
Investigating Agency	International Trade Commission	Department of Commerce, International Trade Administration	U.S. Trade Representative	Commerce (ITA) and ITC	Commerce (ITA) and ITC
Recommendation due	6 months	270 days[b]	12-18 months[a]	160-300 days	235-420 days
Decision maker	President, based on ITC's proposed remedy	President	USTR, subject to direction of President[a]	Commerce (International Trade Administration)	
Decision due	60 days	No deadline	Included in recommendation, 30 day implementation limit[a]	Upon recommendation	
Congressional override	Yes, within 90 days if President rejects	No	No	No	No

[a] In 1983, penalty was determined by the President, who was the decision maker in 301 cases. The U.S. Trade Representative's recommendation was due in 9 to 14 months, depending on the nature of the unfair practice. The decision was due 21 days after the USTR's report to the President. The OTA of 1988 gave this authority to the USTR.

[b] In 1983, recommendation was due in 12 months.

SOURCE: Yoffie et al. (1987, p. 18).

rope, assembles in developing countries and Florida. Yet the most significant portion of the value (and development costs) of a digital switch is not manufacturing and assembly, but software. Estimates suggest that software might account for as much as 40 or 50 percent of the value of a switch. It costs approximately $1 billion in development costs for each new generation, and annual expenses for software modifications are as much as $200 million per firm. Both AT&T and NEC do all of their significant software development at home; and while Siemens distributes some of its R&D, the bulk of its activities remain in Germany.

The dilemma for trade policy in an industry like telecommunications is precisely this separation of R&D from manufacturing. If the purpose of trade policy is to help build a domestic business in central-office switches, trade policy is a particularly ineffective tool. Even though tariffs or quotas can be used to encourage foreign firms to produce locally and even use local content (e.g., semiconductors and boards), such trade policies will not necessarily promote the "right" value-added activities for a particular geographic location.

Looking at this issue from a firm's perspective, one comes to the same conclusion. The separation of R&D from production makes it easier for a firm to avoid the intent of trade policy. When a government wants to promote its domestic industry through trade policy, it often uses some form of protectionist barrier. The corporate solution is simple: invest around the barrier with assembly or even fully integrated manufacturing. In the past five years, it has been easy for long-term capital to flow across national boundaries (see Figures 1 and 2). Even if some manufacturing economies are lost through such foreign investments, the firm can still maintain its most important economies of scale in R&D at home.

The conundrum that heavy cross-investment creates for trade policy is obvious today in industries like high-definition television (HDTV). Since European and Japanese firms had long established presence in North America in the mature TV business, those same facilities provide platforms for manufacturing new, related businesses, like HDTV. The governments in the European and Japanese blocs have each strategically intervened in their domestic industries by setting of local standards that do not conform to the standards of others. In the meantime, Japanese and European firms are lobbying against American-owned firms to set the standard in the United States. The question one must pose is, What is the value of trade policy to the U.S. government when the American-owned firm, Zenith, produces its TVs in Mexico, Thomson of France own's RCA's production in the United States, and Matsushita of Japan has factories in Chicago?

Perhaps the greatest challenge for trade policy in high-technology businesses is not even the concrete actions taken by governments but the im

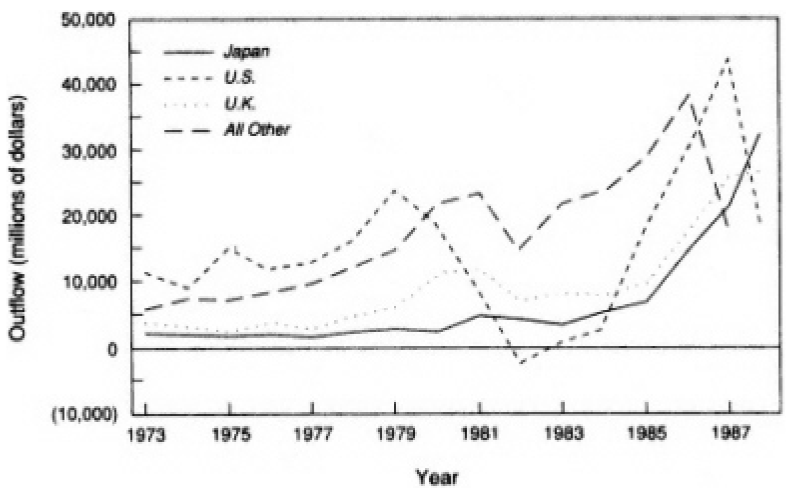

Figure 1 Foreign direct investment outflows. SOURCE: Froot and Yoffie (1991, p. 26).

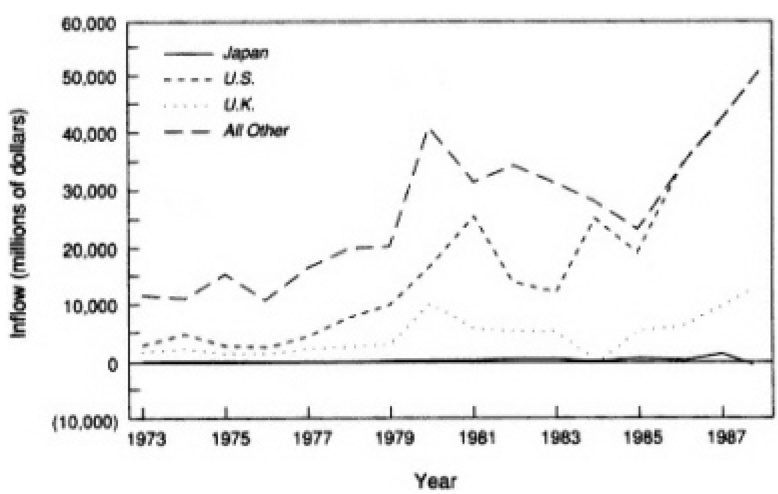

Figure 2 Foreign direct investment inflows. SOURCE: Froot and Yoffie (1991, p. 27).

plicit role that government can play. Just the threat of foreign government intervention in these sectors can undermine domestic firms' investment strategies. When firms must bet their business in order to take advantage of a new technology, they will hesitate to make those investments if foreign governments commit to subsidizing their firms. Even without paying a dollar, when a foreign government says it will underwrite a competitor, a domestic firm will worry that its future profits may disappear. Imagine that Europe announced it planned to subsidize Airbus indefinitely. If U.S. manufacturers of commercial aircraft have no credible commitment of American government trade policy (or subsidies) to countervail actions by the foreign government, then the rational response by American manufacturers would be to underinvest. The risk for a firm like McDonnell Douglas to invest in the next generation of aircraft might outweigh the possible returns.

In sum, high-technology industries place new demands on trade policymaking to act more strategically. Governments not only require knowledge of their domestic industry to be successful, but must also understand the behavior and motives of foreign governments as well. Discipline, judgment, and brinkmanship, skills more typically associated with business than trade policymaking in *any country*, become necessary ingredients for success.

AN ILLUSTRATION: U.S.-JAPAN SEMICONDUCTOR TRADE AGREEMENT

The U.S.-Japan semiconductor trade agreement (SCTA), signed in 1986, is perhaps the best example of why trade policy is a blunt weapon in an age when precision bombing is required. The evolution of the agreement illustrates how speed, capital mobility, technical complexity, and brinkmanship are needed to make trade policy work in high-technology businesses; it also demonstrates how difficult it is to cover all the inevitable contingencies in high-technology sectors.

In many ways, the SCTA is a model for trade policy in high-technology industries. It was the first major U.S. trade agreement motivated by concerns about the loss of competitiveness in a high-tech strategic sector rather than concerns about employment. It was the first U.S. trade agreement dedicated to improving market access abroad rather than restricting market access at home. Unlike previous bilateral trade deals, it attempted to regulate trade not only in the United States and Japan but also in other global markets.

The purpose of the SCTA was to address two nagging issues in U.S.-Japanese high-technology trade: inadequate access by U.S. firms to the Japanese market and dumping by Japanese firms in the U.S. and world markets. Almost one year after the industry association filed an unfair trade practices case (under Section 301 of U.S. trade law) and nine months after dumping suits were filed, the two sides came to agreement: the

United States agreed to suspend dumping and Section 301 retaliation in return for stipulated actions by the Japanese government to improve market access for American companies and for Japanese firms to cease from dumping.

On the market access issue, the official agreement said that the government of Japan would provide sales assistance to help U.S. and other foreign companies sell in Japan and would encourage long-term relationships between Japanese users and foreign suppliers. It also said that both governments anticipated improved opportunities for foreign sales in Japan. In a confidential side-letter to the official agreement, the Japanese government went further and stated that it "understood, welcomed, and would make efforts to assist foreign companies in reaching their goal of a 20 percent market share within five years." The 20 percent figure meant an effective doubling of the foreign share of the Japanese market.

The SCTA suspended investigations of Japanese dumping of DRAM and erasable programmable read-only memory (EPROM) devices without the imposition of duties. As part of the suspension agreement, the Japanese producers agreed not to sell their products at prices below their (average) cost of production, plus an 8 percent profit margin in the U.S. market. The Japanese agreed to have their Ministry of International Trade and Industry monitor export prices on a wide range of semiconductor products, including EPROMs, 256K DRAMs, and 8- and 16-bit microprocessors, to prevent Japanese producers from selling at less than fair market values in the United States or in third countries. The Department of Commerce, in turn, was given the responsibility to calculate foreign market values for each Japanese producer for each product, based on that producer's costs, and to monitor the production costs and prices of all Japanese products covered by the agreement. The United States reserved the right to add or drop products from the monitoring arrangement in the future.

The SCTA tried to deal with many of the problems described above involving trade policy in high-technology industries. For instance, recognizing the need for fast action in dumping suits and the problems of government commitment to facilitate investments, the SCTA allowed for the monitoring of costs and prices on a wide range of products, including several that had not been the subject of the pending dumping investigations. It was anticipated that this arrangement would deter or prevent dumping of such products in the future. It had long been a complaint of the semiconductor industry and other industries that by the time a finding of dumping is actually made, substantial and irreparable harm has been done to American producers. The SCTA tried to address this complaint by heading off dumping before it occurred.

But how did the agreement work? On market access, the quantitative evidence suggests that after the U.S. government retaliated against Japan in

March 1987, market share did rise (see Figure 3). As of the end of 1990, the foreign share of the Japanese market was approximately 13.3 percent, substantially below the ultimate goal of 20 percent but up from 8.5 percent when the agreement was signed, and at its highest level ever.[3]

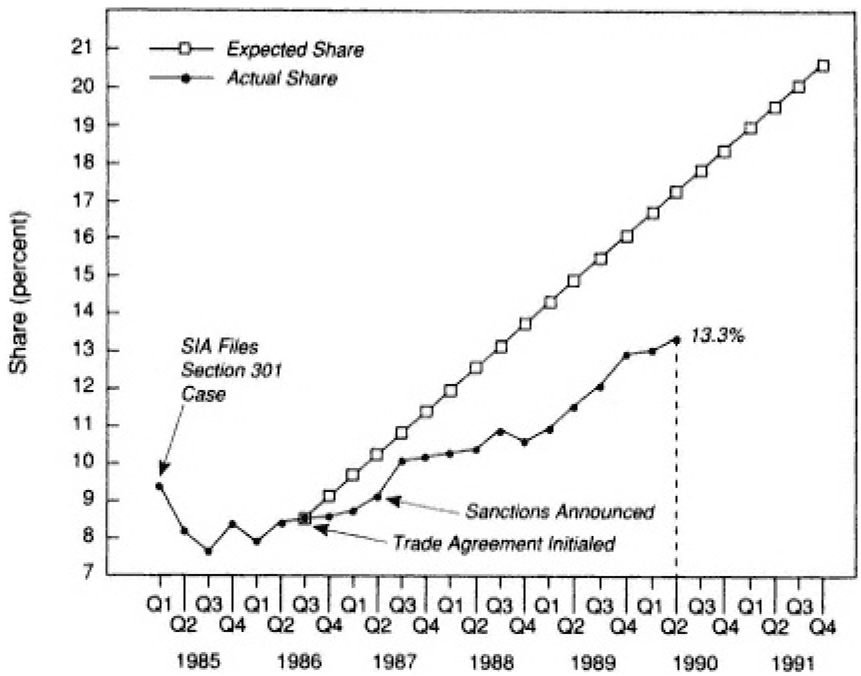

Figure 3 Foreign semiconductor market share in Japan. SOURCE: Yoffie (1989).

The pricing side of the agreement, however, was not such a success. In the first few months after the conclusion of the agreement, prices of semiconductor memory devices exported from Japan jumped sharply. U.S. customers reported that prices of 256K DRAMs had risen anywhere from two to eight times the pre-agreement price. Sustained price increases came after the imposition of sanctions on Japanese companies for failure to comply with the provisions of the agreement. Prices of DRAMs began what was to become a sharp increase lasting through the end of 1988. Spot prices for 256K DRAMs tripled over a four-month period,[4] and American consumers reported significant difficulties in obtaining adequate supplies at any price. The price hikes and supply interruptions caused several U.S. system vendors to ration memory shipments, delay new product introductions, and increase prices. The increase in spot prices for DRAMs was especially severe—spot prices rose three to six times higher than long-term contract prices, with the result that the effective prices paid by consumers depended heavily on the percentage of demand they had to purchase on the spot market.

Since early 1989 there have been adequate supplies, and the gap between spot and large contract prices has disappeared. But Flamm (1990) estimates that higher prices meant about $4 billion of annual profits on approximately $10 billion in global DRAM sales in 1988. Since the Japanese had the lion's share of the DRAM market, they earned the lion's share of these so-called bubble profits.[5]

Although the SCTA did not directly "cause" these higher prices, U.S. trade policy had the perverse effect of helping Japanese companies build a temporary cartel while simultaneously hurting U.S. computer firms.[6] Despite all the safeguards and efforts to deal with the problems of speed, technical complexity, and political discipline, unintended consequences undermined at least half (the pricing side of the agreement) of what the U.S. government and the U.S. semiconductor industry wanted to achieve. The SCTA has also stimulated significant foreign investment by Japanese semiconductor manufacturers into the United States. Future efforts to use trade policy to affect the balance in the United States between Japanese-produced chips versus American-produced chips will verge on the impossible.

LESSONS OF THE SCTA

The lessons of the SCTA may be important for thinking more broadly about the role of trade policy in high-technology sectors. The most successful piece of the SCTA was helping American (and other non-Japanese) firms gain greater access to a formerly closed market. The value of trade policy was that it helped induce Japanese policymakers and private actors to eliminate many of the vestiges of the past that have kept the market implicitly as well as explicitly closed to foreigners. Where trade and other barriers to high-technology trade persist in markets around the world, trade policy remains an appropriate tool. The renewed SCTA that was signed in 1991 recognized this point and focused exclusively on the issue of market access.

But to facilitate a high-technology industry's vitality, to manage production or pricing in such sectors, and to stimulate entry, trade policy is probably obsolete. The dynamics of high-technology products and process, the rapidity of change, the ability of firms to circumvent legal agreement as well as a policy's intent, all suggest trade policy is inappropriate. If a government wishes to assist domestic high-technology firms, the direct approach—subsidies, antitrust exemptions, and other forms of direct intervention—remains the best option.

NOTES

1. Of course, substitutes always exist, and monopoly power will not last forever. However, as we have seen in both DRAMs and operating system software, the lags before new entrants and substitute products become available may be a decade or more.

2. When speed of action is an important criterion, the more administrative approach taken by the Japanese for implementing trade policy is probably superior to the more judicial approach used by the United States and Europe.

3. Note that given the way the Semiconductor Industry Association measures market access, if a Japanese firm sells a packaged and tested product to an American firm, the chip is counted as a Japanese chip regardless of who fabricates the die, whose label is on the package, or who sells the part to the eventual customer. Consequently, any such sale would not be included in the calculation of foreign market share in Japan, even though such a sale brings some benefits to the American supplier. Also note that such transactions in which an American company is involved in the fabrication or sale of a chip in Japan have increased since the agreement as a result of alliances between U.S. and Japanese companies, but such transactions are not counted in measuring U.S. market share.

4. For detailed price information, see Flamm (1990).

5. The two remaining American DRAM producers, Texas Instruments and Micron Technology, also profited substantially from the surge in demand for DRAMs. According to one Wall Street semiconductor analyst, between 30 percent and 40 percent of TI's semiconductor operating profit in 1987, and as much as 60 percent in 1988, was attributable to DRAM sales. Micron, which specified in DRAM production, enjoyed a sixfold rise in revenues between 1986 and 1988 and became profitable that year, for the first time in three years, as a result of DRAM demand. The rough calculations used to estimate these profit figures were derived from the models of Daniel L. Klesken, semiconductor analyst at Prudential-Bache.

6. For a full evaluation of the SCTA, see Tyson and Yoffie (1991).

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Summary of Panel Discussion

The panel discussion indicated general agreement that trade policy is a good tool for dealing with problems of market access. This is the positive side of the U.S.-Japan semiconductor trade agreement, according to David Yoffie. The downside to trade policy becomes clear when the problems relate more to management failures, prolonged trade dispute resolution mechanisms that cannot address the immediate problems of a high-technology industry adversely affected by dumping, or the disincentives associated with foreign government subsidization. The somewhat controversial conclusion that Yoffie drew from this second set of problems was as follows: If governments wish to promote or assist high-technology firms, a "direct" approach is better than trade policy.

Thinking realistically about trade policy requires an appreciation of the integration that is occurring across the boundaries of firms—through alliances, consortia, and other mechanisms. There was a substantial amount of disagreement as to whether these new forms of alliance transcend the power of the nation state. Hans Decker noted that Europe is moving away from policies of state support for protected industry. His presentation focused on new issues such as standards and intellectual property rights that deserve attention at the international level. Decker concluded, however, that although the nation state has been called too small for the big things and too big for the small things that deserve attention, its role is not over. Decker emphasized that the objectives of national strategy (which focus on high

The Panel on Technology Challenges to Trade Policy was chaired by David Yoffie. Other panelists were Han Decker, Henry Lichstein, and William J. Spencer.

technology as integral to national welfare) depend on maintaining of some sort of international system.

Henry Lichstein brought another set of perspectives to the discussion by stressing the need for trade policy to take account of the interests of the users. The service industry, he noted, dominates economic activity in every developed world economy. Services, which make up 77 percent of employment and 85 percent of gross national product, are the major users of high-technology goods. Too often, Lichstein argued, trade policies are made without attention to the users. Based on this line of reasoning, Lichstein argued for the "freest possible" international trade regime as the one most likely to bring low-cost and high-quality goods and services to the users. In contrast to some of the other panelists, Lichstein argued that policies that support individual industries can only distort innovative and competitive capabilities. Instead, policymakers should focus on building up fundamental assets (the "educational and commercial infrastructure") needed by a variety of industries.

William Spencer brought manufacturing into focus as the key ingredient for U.S. competitiveness. He noted that the United States has a "manufacturing lag" in relation to the Pacific Rim countries who, in the 1980s began to manufacture better integrated circuits. Viewed from this angle, the critical issue for the United States is not technology per se but manufacturing. We have plenty of technology, Spencer said. "What we lack is leadership in manufacturing." If we get our manufacturing on track, it will be the horse that will pull the technology policy cart. And if we get our technology strategy together, that will lead naturally to some trade policy steps, he suggested.

The discussion opened up a variety of perspectives on technology policy. In response to a question about whether U.S. government policies could induce Intel to return to the business of manufacturing dynamic random access memory chips (DRAMs), Gordon Moore reiterated the difficulty that U.S. firms face in going head-to-head with the Japanese in fields such as DRAMs. The solutions to our dilemma (focusing on manufacturing and taking the long-term view) will not salvage industries like DRAMs.

There was a good deal of discussion about Sematech as a model for U.S. technology policy. As a direct approach to the management and manufacturing issues, Sematech is more attractive than trade policy tools such as the U.S.-Japan semiconductor trade agreement, which provided a pricing umbrella for Japanese producers. Theodore Moran questioned whether there is adequate analysis to support choices by the U.S. government about which industries to support. Granger Morgan and others expressed concern that the international trading system might disintegrate if we "start subsidizing industries." Alexander Flax reminded the audience that the only way the United States can implement technology policy is to use the "defense fig leaf." Sematech, he argued, is the exception rather than the standard U.S. approach. There is no agreement in the United States on how to proceed.

Gerald Dinneen directed attention to the problems of consensus-building in the United States by asking whether it might be possible to get a trade and technology policy that is more effective and coherent if we learn from the experiences of the large, successful companies. Spencer stressed the need for cooperation among companies and Sematech as an important experiment in that vein. William Whyman called on the symposium participants to examine organizational problems that reflect differences in the technology and trade policy communities. The expertise of these two communities must be combined in order to link technology and trade policies, but in the United States there are different institutional bases, different cultures, and different legal mandates that affect the ability of agencies like the Office of Science and Technology Policy and the Office of the U.S. Trade Representative to work together.

Trade Challenges to Technology Policy

The Challenges of International Trade to U.S. Technology Policy

David C. Mowery

No observer of recent developments in the trade and investment relationships among the industrial and industrializing nations of the world can fail to be struck by the extent to which trade and investment flows, and the foreign and domestic public policies affecting them, now influence the technology development and investment decisions of U.S. firms. International and domestic collaborative ventures; R&D subsidies; technical standards; intellectual property protection; foreign investment decisions; "dual-use" technology development, transfer, and support; technology transfer and "offsets;" and access to offshore sources of technological and scientific research, to name only a few issues, now are linked with trade policy and trade negotiations (both bilateral and multilateral) in complex ways. As this list suggests, technology-related issues now occupy a much more prominent place on the trade policy agenda of the United States and other industrial and industrializing economies.[1]

This paper surveys several aspects of the challenges to domestic technology policy created by greater international economic and technological interdependence. *Technology policy* is difficult to define with great precision, since the innovative performance of an economy is affected by so many policies and influences. For purposes of this paper, it is defined to be the set of public policies that influence the creation, commercialization, and adoption of new technologies within an economy. This survey focuses primarily on the U.S. response to the linkage of trade and technology policies, although I make passing references to similar or contrasting responses in other industrial economies. There are two reasons for this focus: (1) For a number of reasons, these challenges have arisen with greater starkness and suddenness in the United States than in either the European Community

(EC) or Japan; and (2) Because of its large presence within the global scientific and technological (S&T) communities, as well as the size of the U.S. presence in world trade flows, U.S. responses to these challenges will have profound implications for the future of the global S&T and trading systems.

The growth in international trade and investment within the U.S. economy have created at least six issues for technology policy, many of which have also received considerable attention within the EC and Japan:

1. Equality of access to research facilities and results among industrial economies with contrasting domestic systems of research and industrial governance (the finance, ownership, and oversight of corporate organizations).
2. Developing technology policies that promote domestic economic welfare with minimally disruptive effects on trade and investment flows.
3. Improving domestic coordination of the formulation and implementation of trade and technology policies.
4. Adjusting to change in the technological and economic relationships between military and civil applications of "dual-use" technologies.
5. Adjusting to higher levels of foreign ownership of domestic technological assets (high-technology firms, R&D installations, etc.).
6. Adjusting to a "multipolar" world of sources of scientific and technological advances and inputs.

This list is not exhaustive, nor are all of the issues on it equally urgent in all of the industrial economies. Nevertheless, it frames an agenda for discussion at this symposium, and highlights many of the key issues in the U.S. domestic debate.

THE STRUCTURE OF U.S. TECHNOLOGY "POLICY"

U.S. technology "policy" is the outcome of a series of loosely coordinated and often inconsistent decisions made in a broad array of federal agencies and policy areas. The most important characteristic of federal science and technology policy is that it has arisen out of the decisions and effects of policies (including procurement) designed to further the varied missions of numerous individual federal agencies, rather than being designed with any comprehensive economic strategy in mind.

The key elements of this system, many of which are unique among the industrial nations, arose during and after World War II. The loose coordination and weak central oversight characteristic of federal science and technology policy are attributable in part to the failure of Congress and the executive branch to agree on the structure and powers of a federal "science agency" to replace the wartime Committee on Medical Research and the Office of Scientific Research and Development, consistent with the recom mendations of Vannevar Bush's famous report, *Science: The Endless Frontier.* The National Science Foundation (NSF) was established only in 1950, well after the military services, the Atomic Energy Commission, and the National Institutes of Health had begun their own ambitious intramural and extramural science and technology research programs. The NSF budget was and is dwarfed by the research budgets of these other entities. No single agency, office, or committee in either the executive or the legislative branch of the federal government reviews the allocation, costs, and benefits of the entire federal R&D budget (including military R&D) on a regular basis. The interaction between science and technology policies and other policy areas (e.g., antitrust and trade policies) also are not reviewed on any but a sporadic basis.

Other key characteristics of postwar U.S. technology policy and the U.S. innovation system include the following:

1. Dominance of the large federal R&D budget by defense and related agencies: Throughout the postwar period, federal funds have accounted for a large share (45–60%) of total national R&D spending. The federal R&D budget has in turn been dominated by defense-related expenditures, the effects of which on commercial technologies and the firms marketing them were accentuated during the 1950s and 1960s by large-scale military procurement of components and systems in such areas as computers and microelectronics. In many instances, the combined effects of "spillovers" and military procurement supported the development of commercial applications.
2. The prominent role of U.S. universities as performers of research, especially basic research: A large share of the basic research performed in the U.S. economy, more than 50 percent in recent years, is carried out within universities (including federally funded R&D centers, FFRDCs). U.S. universities may well account for a larger share of total national R&D performance than is true of many Western European nations. Comparative statistics suggest that Japanese universities account for a larger share of that nation's total R&D investment (see National Research Council, 1989b), but the quality of these data and the quality of much Japanese university research suggest that the contribution of Japanese universities to basic knowledge is modest in many areas.
3. The role of new firms as agents for the commercialization of new technologies: Another important and unique element of the postwar U.S. research system is the prominent role of new firms as agents of technology commercialization in such technologies as computers, semiconductors, and biotechnology. Although in numerous instances, these firms commercialized technologies that drew on research performed within larger firms, universities, or government laboratories, the fact remains that their role in

this economy was significantly more important than in the postwar Japanese or Western European economies.

4. Minimal assistance for industrial technology adoption: With the significant exception of agriculture, the large federal investment in military and civilian research and technology development devoted virtually no attention or resources to support for the adoption of new technologies. In this respect, as Ergas (1987) has pointed out, postwar U.S. policy resembles that of France and the United Kingdom, both of which supported large defense-related R&D budgets, and contrasts with those of Germany, Sweden, and Japan, where a larger investment of public resources was directed to the support of technology adoption.

Postwar U.S. technology policy relied heavily on federal funding of scientific research, especially basic research, and on federal funding of development or applied research in defense-related areas. This de facto technology policy was further differentiated from those of many other industrial economies by the important role of federal procurement, primarily for defense purposes, and a tough antitrust policy during much of the postwar period. Both of these features contributed to the importance of small startup firms in technology commercialization. The U.S. research system exhibited enormous diversity in funding sources, performers, and objectives, and arguably linked scientific research more closely to postgraduate education than was true of other industrial economies during this period. The structure of the U.S. R&D system, like that of the R&D systems in other industrial economies, also was heavily affected by the structure of U.S. financial markets, firm structure and ownership, and corporate management and oversight.

NEW DEVELOPMENTS AND CHALLENGES

Current challenges to U.S. technology policy are driven by the growing role of international flows of trade, capital, and technology to and from this economy, as well as by other developments. These developments have intensified international competitive pressures on U.S. firms and arguably have reduced the economic payoffs to U.S. firms and citizens from the large federal investment in R&D. Since little of the postwar federal R&D investment was motivated by economic objectives, this result should not be surprising. Nonetheless, growing demands for improvements in U.S. living standards and international competitiveness mean that the value of the federal R&D investment increasingly is being measured in economic terms.

One of the most important of the "other developments" mentioned above is the declining contributions of military-funded R&D and military procurement to civilian applications in many (not all) technologies. The celebrated examples of semiconductors, computers, jet engines, and airframes in the 1950s and 1960s, technologies in which military R&D and procurement yielded important civilian applications, have few contemporary counterparts. Military procurement has declined as a share of total demand in many of these industries, and technologies and applications increasingly flow from civilian to military applications.

This change or reversal in the flow of technological spillovers also has an important economic component. Many U.S. defense suppliers of high-technology components and systems now are economically dependent on their fortunes in the civilian market.[2] This shift in the economic relationship between military and civil technologies contributed to the decision of the Defense Advanced Research Projects Agency (DARPA) to support the Sematech (Semiconductor Manufacturing Technology) and National Center for Manufacturing Sciences (NCMS) initiatives. Both of these research consortia, in which Pentagon research funds supplement contributions from private industry, focus on the development or improvement of civilian, rather than military, technologies and manufacturing processes.

Postwar federal science and technology policies were not designed primarily to aid the competitive capabilities of U.S. firms in civilian technologies.[3] Nevertheless, U.S. firms benefited from the large federal R&D investment, because of the relatively slow pace with which the results of this investment moved across international boundaries and because many foreign firms were not well-equipped to apply these results quickly to commercial applications. Neither of these conditions now applies—scientific and technological knowledge move more quickly within the international economy, and foreign firms have dramatically improved their ability to apply advanced scientific or technological knowledge. In a number of industries, U.S. firms no longer dominate industrial practice or technological performance. As R&D costs and risks rise, access to foreign markets is increasingly important to the viability of many U.S. high-technology firms, even as these firms in many instances now derive a larger share of their components or advanced subassemblies from foreign sources.

Clearly, U.S. technology or trade policies that lead other industrial nations to retaliate by restricting access to their markets may be harmful to U.S. high-technology firms. Existing formal and informal restrictions on U.S. firms' access to foreign markets are equally harmful. As the tariff-based market access barriers of the earlier postwar period have been reduced through successive rounds of multilateral negotiations, they have been replaced by "nontariff barriers," which greatly complicate trade policy-making and link it tightly to technology policy. Nontariff barriers are numerous, difficult to define and measure, and often involve instruments of domestic technology policy. The redefinition of the trade policy agenda during the past 20 years has propelled intellectual property regimes, anti trust policy, technical standards, regional development policies, and a broad array of other policies to a central position in bilateral and multilateral trade negotiations.

The importance of international trade and capital flows has expanded greatly in the U.S. economy during the past 25 years. The share of imports and exports within U.S. gross national product has doubled since 1965, a larger increase than either Japan or Western European economies have experienced during this period. More recently, foreign direct investment in this economy also has grown rapidly, although foreign investment in the U.S. economy remains lower than foreign investment in most Western European economies.[4] The speed with which the U.S. economy has "internationalized" is central to understanding the U.S. domestic debate over technology and trade policies.

Along with a relatively open market for imports and foreign investment (albeit one that has faced significant demands for protection in recent years), the United States maintains a relatively open research system. The structural characteristics of the U.S. R&D system, with its high labor mobility, heavy reliance on university research for basic science and training, and the importance of small firms for technology commercialization, mean that access by foreign firms to U.S. scientific and technological advances is relatively easy. The R&D and industrial governance systems of many other industrial economies, however, differ considerably. The relative importance within many foreign R&D systems of "open" and "closed" research institutions, respectively universities and private firms, contrasts with that of the United States. Moreover, the institutions of industrial finance and governance in many industrial economies may make it difficult for U.S. or other foreign firms to gain access to industrial technologies or innovations through acquisitions of firms or intellectual property. As international economic integration advances, competition among firms increasingly takes the form of competition among different systems for the organization of research, finance, or industry, and these structural differences loom much larger.[5]

Much of this foreign challenge to U.S. economic and technological hegemony, of course, reflects the postwar reconstruction of foreign economies and technological infrastructure that was a central goal of postwar U.S. foreign policy. For much of the 1900–1940 period, one during which the U.S. economy exhibited strong growth in income and productivity, few observers would have characterized U.S. firms as either technologically or scientifically dominant. Nevertheless, the passing of the postwar technological hegemony of U.S. firms has occurred quickly. In many industries, U.S. firms now are first among equals in technological capabilities (or in others, well behind the state of the art), rather than dominant, even as the economic returns from the postwar U.S. R&D system are increasingly available to U.S. and foreign firms alike.

Moreover, for many U.S. firms, access to foreign science and technology is increasingly important to their competitive future. This factor, as well as the need to gain more rapid access to foreign markets and capital, and the political obstacles to market access or investment in many industries, has led U.S., Western European, and Japanese firms to broaden the international reach of their R&D operations.[6] U.S. firms, for example, have formed strategic "alliances" with foreign firms that engage in joint development, manufacture, or marketing of high-technology products. These alliances, which have grown rapidly in number during the past 20 years, now span a wide range of nations and industries, including such high-technology sectors as semiconductors and commercial aircraft, but they have appeared as well in automobiles and steel.[7] Similar alliances have grown between firms within the EC, in many instances with financial support and encouragement from EC technology programs. In many industries, joint ventures between U.S. and foreign firms have expanded simultaneously with growth in domestic research collaboration among U.S. firms and between U.S. firms and universities. These alliances are contributing to the accelerating pace of international technology transfer and to the internationalization of components sourcing, and these trends are in turn intensifying economic and technological interdependence between U.S. and foreign firms.

RESPONSES AND COMPLICATIONS

Although debate over appropriate responses to these new circumstances continues within the U.S. government and private sector, the 1980s witnessed important new developments in U.S. trade and technology policies. Along with other governments, the Reagan administration initiated several policies intended to capture more of the returns of publicly financed research for the U.S. economy. Trade policy became far more salient and politicized during the Reagan administration, as congressional involvement increased significantly. These actions tightened the interdependence of U.S. trade and technology policies, although they did not always result in consistency between trade and technology policies.

The Reagan administration entered the White House in 1981 with a pledge to remove the federal government from a major role in the commercialization of new technologies. In this view, the appropriate federal role in civilian technology development was limited to funding of basic research, commercialization of which was best handled by the market.[8] The contrast between its 1981 posture and the administration's 1987 response to the demonstration of the phenomenon of high-temperature superconductivity or the formation of Sematech (the Semiconductor Manufacturing Technology consortium), is dramatic. In these instances, as well as in the National Science Foundation programs for university-industry cooperation, Engineering and Science Research Centers, and other initiatives, the Reagan administration, with strong bipartisan support, proposed or implemented policies designed to increase the national economic returns to the large federal investment in basic research. Many of these initiatives have been continued by the Bush administration, and Congress has if anything pressed for more far-reaching action.

These developments represented a considerable shift from the rhetoric of 1981, and changed the historic posture of federal policies toward commercial technology development (outside of agriculture). Previous federal initiatives for commercialization generally were modest but, where significant, supported the commercial development of technologies for which market mechanisms and incentives were deemed to be lacking or insufficient. Examples include the commercial supersonic transport, coal liquefaction and synthetic fuels, "Project Breakthrough" in residential housing construction, and the liquid metal fast breeder nuclear reactor. These initiatives of the 1980s, however, indicate some movement in U.S. technology policy to a posture that more closely resembles that of the EC or Japan.

In contrast to the federal commercial technology programs of the 1960s and 1970s, the technology policy initiatives of the 1980s and those of the foreseeable future are designed to accelerate the commercial development of basic research advances for which the private returns are likely to be high, but only in the absence of faster commercialization by foreign firms. As a result, some of these initiatives have attempted to restrict the transfer of research results to foreign enterprises. Efforts were made, for example, to control foreign access to publicly funded research in high-temperature superconductivity in 1987 and 1988. The Sematech and NCMS consortia currently exclude foreign firms, and transfer of NCMS-developed technologies by member firms to their foreign subsidiaries is subject to restrictions.

The EC also inaugurated a series of regional "strategic technology" programs during the 1980s. In many cases, these programs replaced or supplemented the technology policies of member states (primarily France and the United Kingdom) that had relied on "national champions" during the 1960s and 1970s, often attempting to use defense and other public sector procurement policies to bolster these domestic champions.[9] The EC programs of the 1980s, including ESPRIT and others, as well as the EUREKA program, invested large sums of public funds in "precommercial" research in information technologies, microelectronics, etc. With some important exceptions (IBM Europe has been allowed to participate in parts of ESPRIT and EUREKA), these programs have not welcomed foreign firms.[10]

Both the U.S. and European initiatives, of course, were in part responses to the perceived successes of Japanese technology development programs, supported by public and private funds, that produced some successes during the 1960s and 1970s in such technologies as very large-scale integration.

These programs also excluded foreign firms, including Japanese affiliates of non-Japanese multinationals. At least some more recent Japanese research and technology development programs (e.g., in high-temperature superconductivity), however, have been open to foreign participation.

Other U.S. technology policy initiatives during the 1980s strengthened intellectual property protection and reduced antitrust restrictions on collaboration in research. By one count, since 1983 the Congress has passed 14 laws (including the establishment of the Court of Appeals for the Federal Circuit in 1982) increasing protection for intellectual property owners. Improved international protection for intellectual property has also been a central goal of U.S. trade policy in bilateral negotiations, including the use or threat of Section 301, and in the multilateral Uruguay Round of trade negotiations. The 1984 National Cooperative Research Act, another U.S. response to the success of Japanese technology and industrial policies, reduced the antitrust penalties for collaboration among firms in precommercial research. In 1990 the House of Representatives passed a bill that reduced antitrust penalties against consortia that engage in production (the bill excludes from its coverage consortia involving firms with more than 30 percent of their equity owned by foreigners).[11]

Just as U.S. trade policy frequently has been called on to redress the problems created by unbalanced macroeconomic policy,[12] the lack of a coherent U.S. technology policy has placed enormous demands on trade policy. The 1980s witnessed the occasional resort by U.S. policymakers, believers all in free markets, to trade policy to compensate for the absence of a politically unacceptable, "interventionist" U.S. technology policy. The proposal by the Massachusetts Institute of Technology to purchase a supercomputer from the U.S.-based joint venture involving Honeywell and Nippon Electric Company of Japan is an example of this phenomenon (the fact that U.S. policymakers treated the products of this U.S.-based joint venture as Japanese in origin also points out the complexity of determining the national origin of products in a technologically interdependent world).[13] Threatened by the Department of Commerce with an investigation of dumping in supercomputers, MIT elected to postpone the procurement, instead seeking financial support from the National Science Foundation for a supercomputer research center that would involve U.S. firms and U.S.-based technology. MIT Provost John M. Deutch stated that "it became clear important elements of the federal government would prefer to see MIT acquire a supercomputer based on U.S. technology. Since the federal government would ultimately bear nearly all the costs of the machine through research grants to MIT, the preferences of the U.S. government must be seriously addressed" (Massachusetts Institute of Technology [1987]; See also Putka [1987] and Sanger [1987]).

The discovery of the technology policy potential of antidumping policy is not confined to the United States. During the late 1980s and 1990s, the Commission of the European Communities has resorted to increasingly elastic and creative definitions of dumping as a means of inducing foreign-owned firms to locate more of their high-value-added manufacturing activities and R&D within Western Europe (*Economist*, September 9, 1989).

EVALUATING THE U.S. TECHNOLOGY POLICY RESPONSE TO THE TRADE CHALLENGE

Although the increased concern of a number of recent U.S. technology policy initiatives with commercial development of the fruits of basic research investments arguably is a positive development, the mercantilistic flavor of many of them may have unfortunate consequences for U.S. firms. Proposals to restrict scientific and technological cooperation at the water's edge fly in the face of the growing interdependence of national R&D systems. To the extent that U.S. policymakers design technology policies that ignore the growing interdependence of U.S. and foreign scientific and technological research, both U.S. and foreign technological development will be hampered. Similarly, efforts by Western European or Japanese policymakers to restrict foreign access to publicly funded technology projects may have serious negative consequences for their domestic firms.

Proposals to restrict access to U.S. research facilities and findings also overlook the historic futility and ineffectiveness of such restrictions. Indeed, the reality of global technological interdependence is well illustrated by the recent decision of Texas Instruments, a major participant in Sematech, to enter a technology-sharing joint venture with Hitachi of Japan, presumably one of the major technological threats to the firms participating in Sematech.[14] Efforts to impose strict limitations on international transfer or foreign participation attempt to deny the reality of this interdependence.

Restrictions on foreign participation in U.S.-based research consortia that involve significant public funds (in many cases from state, as well as federal, sources), will also complicate U.S. efforts to gain access for U.S. firms to similar consortia in other industrial economies (needless to say, this observation also applies to governments and firms in Western Europe and Japan). Paradoxically, the efforts of the U.S. and foreign governments to establish "closed" national technology development programs are contributing to the development of international alliances among large global firms that partially frustrate the aims of the "national" technology development projects.[15]

The recent Pentagon initiatives for the support of commercial technology development that have been spawned by the change in the civil-military technology relationship also pose a dilemma for U.S. trade policy. These programs undermine the basis for U.S. opposition to large-scale foreign technology development subsidies such as those of the European Airbus program. Admittedly, Airbus (estimated to have consumed $12–15 billion in public subsidies since its foundation) is targeted more precisely on a specific commercial technology (indeed, on a set of commercial aircraft designs) than recent Pentagon programs, and Airbus subsidies support production as well as development.

The fact nevertheless remains that the Airbus program is driven in part by the desire of the participant governments to maintain military aerospace industries by supporting the participation of their national aircraft firms in a major commercial project. This justification is similar to one of the reasons for DARPA support of Sematech and NCMS. The development of similar U.S. programs places this nation's trade policymakers on a very slippery slope. If the difference between U.S. and foreign technology-subsidy programs becomes one of degree, rather than kind, the limits to foreign abuse of subsidies that are imposed by U.S. opposition and persuasion are likely to be eroded still further.

These recent U.S. technology policy initiatives also fail to address a fundamental competitive weakness. Both stronger protection for intellectual property and the relaxation of antitrust restrictions on collaboration in research or in production tend to favor the creation of new commercial technologies. Yet one of the most serious competitive deficiencies of U.S. firms is their slow adoption of new manufacturing technologies, an area in which U.S. firms appear to lag behind their Japanese, German, or Swedish counterparts. Policies supporting commercial technology creation may conflict with those aiding adoption.[16]

Further relaxation of U.S. antitrust policy, for example, could allow domestic consortia to acquire market power in the initial production of innovative technologies and thus discourage rapid adoption. This possibility is unlikely if U.S. markets remain open to imports. Nevertheless, protection of the U.S. domestic market from "unfairly traded" imports combined with antitrust exemption for a domestic production consortium (e.g., in high-definition television) could create a high-cost, noncompetitive domestic producer and severely impede the adoption of its technologically sophisticated products within the U.S. economy.[17] Similarly, intellectual property protection often represents a compromise between the interests of innovators and those of potential adopters.

A similar tension is present in the EC debate over policies to bolster the Western European electronics and information technology industries. The current strategy, which combines large-scale R&D subsidies with formal and informal restrictions on access to the Western European market by foreign producers, has raised the prices and lowered the quality of the information technology and microelectronics products available to Western European firms and consumers, slowing adoption.[18] Throughout the industrial and industrializing economies, policymakers should recognize that while the domestic production of advanced technologies yields important economic benefits, policies that restrict or penalize domestic adoption of these technologies deny an economy the benefits of their application in other industrial sectors. At least some recent U.S. and EC policy initiatives, inspired by the example of postwar Japanese industrial and technology policies, appear to overlook one of the central goals of these Japanese policies: encouragement for domestic technology diffusion.

CONCLUSION: ISSUES FOR THE FUTURE

Within the U.S. government, science and technology policy oversight and coordination within and between Congress and the executive branch are unequal to the task of reviewing strategic technology policy initiatives and coordinating these initiatives with the policy agenda in international trade negotiations. For example, despite the popularity of this claim by interested parties, the executive branch and Congress are not well equipped to evaluate the arguments that one domestic industry or another is "economically strategic" for U.S. living standards, competitiveness, and economic growth. Lists of "critical technologies" proliferate, but few of these lists' authors have analyzed the connection between their critical technologies and U.S. R&D policy, trade policy, or industrial structure. Agreement within the U.S. government on the U.S. position in the Uruguay Round negotiations on subsidies has been difficult to achieve, in large part because of the lack of a consensus among U.S. policymakers and private firms on the appropriate limits for R&D subsidies. During the planning of the Uruguay Round, U.S. government suggestions that a "high-technology" negotiating group be organized also led to naught because the U.S. government could not reach consensus on the mandate for such a negotiating group. The list goes on.

Among other things, as was noted above, the development of a more comprehensive technology policy that included as one of its goals the improvement of U.S. competitive performance could take some of the pressure off of trade policymakers to compensate for a current de facto technology policy that (exaggerating only slightly) in some areas is perverse and in others nonexistent. Nevertheless, technology policy initiatives have important implications for U.S. trade policymakers, as in the case of Sematech, and for policymakers in the EC, who must address the consequences of recent antidumping actions and those of restrictions on foreign participation in EC R&D programs.

Policymakers in the EC, the United States, and Japan are well advised to tilt in favor of technology policy instruments that are less trade-distorting. Some forms of assistance for technology adoption (e.g., industrial exten sion, equipment leasing, cooperative research, or small-scale demonstration projects), for example, are likely to prove less disruptive to the multilateral trading system than targeted subsidies or government procurement policies that exclude foreign firms. Other instruments of technology policy that may be less trade-distorting include tax expenditures and other support for university graduate education and for on-the-job training of production and professional employees.

Efforts to restrict technology transfer from U.S. universities or firms to foreign entities may prove more harmful to the United States in its current position as "first among equals" than would have been the case two decades earlier, during the period of U.S. dominance. U.S. firms now are in a position to gain more from balanced international exchange of technologies and research than at any time in the postwar period. Restricting foreign access to U.S. research is likely to impair U.S. firms' access to foreign technology, ultimately eroding, rather than improving, their competitiveness.

Equality or reciprocity of access nevertheless remains an important issue for the trade and technology policy agenda. This issue involves international differences in systems of finance and corporate governance, as well as differences in the structure of national R&D and innovation systems, and therefore is a difficult problem to resolve. The "structural" origins of this problem also mean that it looms largest on the U.S.-Japan negotiating agenda. The following discussion can only sketch out some issues for further consideration.

As was noted earlier, foreign acquisitions of U.S. firms, specifically small, high-technology firms, are frequently cited as an important source of asymmetry in technology access, since such firms have few analogues in the Japanese or Western European economies. But the view that foreign acquisitions of U.S. start-ups result in a one-way "technology drain" to the foreign buyers may well be based on an unrealistic view of the nature of technological assets and the characteristics of the technology transfer process.

The key technological assets in many high-technology start-up firms are rarely embodied in patent or license agreements, which often convey limited coverage or control of these assets. Instead, the critical knowledge is often "tacit" (e.g., not codified in blueprints or other documents), consisting of know-how and other less easily transferred forms, and this knowledge is embodied in the firm's employees. In the vast majority of acquisitions of U.S. firms by foreign enterprises, these critical human assets do not leave the United States following the acquisition—instead, they frequently leave the firm, transferring their skills and know-how to other U.S. firms. As such, the putative "drain" of U.S. technology through foreign acquisitions of high-technology firms may be exaggerated.[19] Nevertheless, the serious impediments to U.S. acquisition of firms in other industrial economies, particularly in Japan, are not exaggerated, and will continue to create serious tensions until they are reduced or removed. Formal or informal restrictions on foreign investment in the United States, however, are difficult to square with the stated position of the United States in the Uruguay Round and elsewhere that restrictions on foreign investment should be removed.

A second important issue in reciprocal access to research concerns the role of U.S. universities, which play a more prominent role in the United States and global scientific enterprise than do universities in some other industrial economies.[20] Foreign access to U.S. university research raises two separable issues. The first concerns access by foreign firms to U.S. research that has been funded largely or partially by U.S. public funds, for example, through research grants or overhead payments to the academic institution. To the extent that the establishment of cooperative research agreements between U.S. universities and foreign firms allows these firms to gain access to research results without repaying these subsidies, they may be able to "free-ride." Just as U.S. state universities charge higher tuition to nonresident students, however, U.S. universities may be well advised to consider assessing higher overhead charges on foreign firms with whom they negotiate research agreements, in recognition of the substantial contribution of public funds to their research prominence.

The establishment of a multitiered fee structure for university-industry research agreements, however, does not resolve the perceptions of inequity that arise from the fact that the U.S. research system, in which universities play a prominent role and welcome foreign visitors and industrial research agreements, is in many respects a more accessible system. The structural differences between the U.S. and foreign research systems are such that a strict requirement of reciprocity in access to research facilities is either worthless or infeasible. Assurances by the Japanese government of complete access to Japanese universities, for example, may be of limited interest to U.S. firms, in view of the modest amount of world-class research performed in Japanese universities. A "results-oriented" reciprocity requirement that Japanese firms open their industrial research facilities to foreign researchers could impose a similar requirement on U.S. firms, and is scarcely likely to elicit the support of U.S. firms.

The structure of the U.S., Japanese, and Western European research systems may be converging in some respects, as Japanese quasi-public or university-based research institutes become more important performers of high-quality basic research (and as the level and the "spillovers" associated with U.S. military R&D spending decline). If this convergent trend is significant, access to relatively "open" Japanese research institutions may become more attractive to informed U.S. and European firms. This process of institutional change and convergence nevertheless is likely to move so slowly that this issue of reciprocal access will remain very difficult for the foreseeable future.

U.S. technology policies can be criticized for their inconsistency with trade policy, their perverse effects on U.S. competitiveness, and their failure to take into account the realities of international technological interdependence. Nevertheless, the current debate in the United States will be powerfully influenced by evidence that foreign research establishments are being made accessible to U.S. firms and individuals and that markets for U.S. exports are being liberalized, and by agreements in the Uruguay Round that allow U.S. exporters to promote the benefits of multilateral liberalization to an increasingly skeptical domestic polity and Congress. The challenges of trade for technology policy are challenges that must be addressed by the U.S. and foreign governments alike.

NOTES

1. For example, trade negotiators were heavily involved in the 1987-1988 negotiations over renewal of the U.S.-Japan Scientific Cooperation Agreement, an issue formerly of interest primarily to the science and technology policy community.

2. This changing economic and technological relationship also has increased the economic burden imposed on many U.S. firms by national security export controls, as the Panel on the Impact of National Security Controls on International Technology Transfer (1987), pointed out in its report *Balancing the National Interest*.

3. Indeed, the impressive economic performance of the United States during 1990-1940, when scientific research in this nation lagged behind that of a number of European countries, suggests that the link between scientific prowess and national competitiveness may be quite tenuous (see Nelson, 1990).

4. Data in Graham and Krugman (1989) show that measured as a share of national manufacturing employment, direct foreign investment in the United States grew from 3 percent to 7 percent during 1977-1986, compared with declines during this period from 2 percent to 1 percent in Japan, 14 percent to 13 percent in Germany, and 14 percent to 15 percent in Great Britain; the share grew from 18 percent to 21 percent during this period in France. Confirming the statement above concerning the uniqueness and speed of the growth in importance of international trade and investment in the U.S. economy, the authors note that "In 1977, the United States had an exceptionally small amount of inward FDI [foreign direct investment]; much of the rise between then and now can be viewed as a shift to a more typical position. This was a specifically U.S. phenomenon, not part of a global trend toward increased internationalization of business; indeed, there was essentially no trend in the relative importance of foreign firms in the other major countries" (Graham and Krugman, 1989, p. 25).

5. For additional discussion, see Ostry (1990).

6. Consider, for example, the demonstration of high-temperature superconductivity for which the Nobel Prize in physics was awarded in 1988. This scientific discovery, hailed by President Reagan and others in 1987 as a U.S. breakthrough, was in fact demonstrated by a Swiss and German scientist working in a Swiss industrial laboratory owned by a U.S.-based multinational firm (IBM). The "national origins" of this discovery are difficult to identify with precision.

7. For a collection of studies see Mowery (1988).

8. Glenn R. Schleede, executive associate director of the Office of Management and

Budget, commented in 1981 that, "By far the most important change [made in science and technology policies by the Reagan administration) came from this administration's redefinition of the federal role. In the R&D spectrum stretching from the most esoteric basic research out through the actual commercialization of a technology, we have drawn the line for federal intervention and support back much farther toward the basic research end. In the civilian or domestic sector, we do not think the government should be funding demonstration, product development, and commercialization efforts." Quoted in Barfield (1982, p. 41).

9. Nelson (1984) is a valuable survey. The Airbus Industrie consortium is an important forerunner of the EC R&D programs, but differs in its membership, goals, and structure.

10. ESPRIT also has some restrictions on international transfer of research results that were criticized by a senior manager of IBM as, "the discriminatory provision in the Commission research contract that prohibits the dissemination of confidential information into affiliated companies residing outside the European Community, if the parent company is not EC based. . . . It means that Bull can transmit confidential information to Zenith, or Philips to Signetics, but that IBM France cannot transfer information to IBM in the United States, nor can IBM Germany or IBM Italy for that matter" (Jean-Jacques Duby, quoted in National Research Council, 1991, p. 30).

11. Along with change in the economic payoffs from military R&D spending (as well as reductions in its likely future growth rate), these recent policy changes or proposals may significantly change the structure of the U.S. R&D system, removing or reducing some of the elements that formerly distinguished it from those of other industrial nations. In particular, the possibility exists that the small firm could decline in importance within technology commercialization, as a result of the changing antitrust and military R&D and procurement environment.

12. Destler (1986, p. 177) quotes the remarks of Paula Stern at her swearing in as chairwoman of the U.S. International Trade Commission in 1984, when she lamented the fact that economic problems with broader causes were regularly being dumped on the trade system's doorstep. "The Commission," she noted, "does not make macroeconomic policy. But we do deal, one by one, with its industrial victims."

13. Another example is the opposition of Commerce Secretary Baldrige and Defense Secretary Weinberger in 1986 to the efforts of Fujitsu of Japan to acquire Fairchild Semiconductor. Although much of this opposition was couched in terms of the threat to U.S. national security created by foreign ownership of Fairchild, Fujitsu was in fact attempting to acquire the firm from Schlumberger of France. More recently, the Exon-Florio Act created the Committee on Foreign Investment in the United States (CFIUS) to review the national security implications of foreign acquisitions of U.S. firms. CFIUS has been criticized for interpreting its mandate too narrowly, overlooking the long-term, or competition, implications of such acquisitions.

14. According to one account, "Sematech is for manufacturing knowledge and expertise," said Stan Victor, a spokesman for Texas Instruments in Dallas. He added that the purpose of the agreement with Hitachi was different, because it was a 'technology development' program meant to create the most effective designs for the 16-megabit [microprocessor] chip'" (Hayes, 1988). Another Sematech participant, Advanced Micro Devices (AMD), also recently announced an agreement with Sony Corporation that will sell Sony an AMD production plant in exchange for cash and AMD access to Sony's process technology (Pollack, 1990). Sematech participants Motorola and IBM also have technology-sharing alliances with foreign semiconductor producers (respectively, Toshiba and Siemens).

15. Foreign investment flows further complicate these efforts, as in the recent decision to exclude the British computer firm ICL from participation in three key projects of the Joint European Semiconductor Silicon Initiative (JESSI) program following its acquisition by Fujitsu. ICL now participates in JESSI on the same, limited basis as IBM Europe, the only other non-European firm involved in JESSI (Hudson, 1991).

16. For an excellent discussion of this issue, see David (1986).

17. Indeed, the high probability that domestic antitrust exemptions might be combined with protection against imports illustrates the inability to divorce even a carefully formulated, strategic technology policy from trade policy issues and concerns. The development by the United States of a "technology policy" or strategy will complement, but will not replace, the use of trade policy for domestic technological objectives.

18. Commenting on the recent EC Commission paper on future strategies for information technology, the *Financial Times* (March 27, 1991, p. 16) noted that "as IT becomes more deeply-embedded throughout economies, its benefits increasingly accrue from its application rather than from its production. . . . European demand [for advanced IT equipment] is depressed by artificially high prices. Many types of computer equipment and consumer electronics products cost twice as much as in the United States--a difference which cannot be explained simply by higher distribution overheads. In some cases, product prices have been increased as a result of EC anti-dumping actions."

19. Foreign acquisition of U.S. firms may enable a foreign enterprise to acquire a position of significant market power. These possibilities can be controlled, however, through U.S. Justice Department review of the competitive consequences of such acquisitions.

20. Two useful surveys of the "reciprocal access" in the U.S.-Japanese context have been produced by the National Research Council's Office of Japan Affairs (National Research Council, 1989a, b).

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Summary of Panel Discussion

David Mowery's presentation directed attention to the need for coordination between technology and trade policies. Just as trade policy cannot be a substitute for technology policy, an exclusive focus on technology policy obscures some large, international challenges that must be addressed. To develop an effective national technology policy, it is important to take into account the growing importance of technology from foreign sources, the need for expanded access to foreign markets by U.S.-based companies, the comparative openness of the U.S. research system, and the increasing dependence of the defense industry on civilian markets. Pointing to a trend apparent in both Europe and the United States to "emulate" Japanese technology policy of the 1960s and 1970s, Mowery warned that a poorly formulated U.S. technology policy could produce adverse results—a closing off of foreign access to, as well as foreign contributions to, the U.S. research system, and a neglect of policies oriented toward technology diffusion. The lack of consensus about U.S. technology policy, Mowery suggested, hinders effective U.S. trade policy. Witness the absence of a strong U.S. consensus position on R&D subsidies in the General Agreement on Tariffs and Trade (GATT) talks.

Craig Fields and Hajime Karatsu focused on technology as a process of making marketable goods. Fields called attention to the need to bridge the gap between the laboratory and the production line. The primary problem for the United States is not R&D investment, but using technology effec

The Panel on Trade Challenges to Technology Policy was chaired by David Mowery. Other panelists were Craig Fields, Hajime Karatsu, and Margaret Sharp.

tively in manufacturing. Briding the gap means paying attention to the quality of the work force, investment decisions, and building an "information infrastructure" needed to support the U.S. economy.

While Karatsu emphasized the key role of the entrepreneur in the technology process, the examples he chose provided insights into ways in which the government can play a constructive role. The Ministry of International Trade and Industry's program to encourage manufacturing engineers is one example. Another is the Fifth Generation Computer Project, important primarily for building networks among scientists and engineers from competing companies. Karatsu emphasized the importance of "keeping technology in your own hands" even when production is moved offshore. His major message was that American industry should stop complaining and start competing. This means keeping the market constantly in mind. Karatsu emphasized the point that any idea, however innovative, is not technology but "merely knowledge" if we fail to produce marketable goods.

Margaret Sharp brought a European perspective to the panel, reminding the audience that there is no grand strategy in Europe, but rather a search for new approaches. In Britain there is disillusionment with industrial policies developed in years past to support national champion firms. Cooperation and competition are the twin tracks of new policy initiatives in Europe today. ESPRIT embodies the first track—a new model for industrial cooperation, a new confidence in European industry. Through cooperative R&D, the European governments are providing a catalyst for change. The second policy track is reflected in the Single European Act and the role of the Commission in revising public procurement policies that favor national companies. Echoing Mowery's comments, Sharp advocated approaches that "swim with the tide of internationalism, not against it."

A major theme in the discussion was the question of whether the new paradigms provide an adequate basis for action, particularly by the U.S. government. Robert Stern pointed to the lists of critical technologies that have been produced and wondered out loud whether these lists help to set priorities for action. Fields noted that the lists *do* embody priorities, in view of the fact that many technologies are not included. We do not, however, have quantitative data or accepted methodologies for deciding which technologies are most important or for moving technology from the laboratory to production. Many of these judgments must be intuitive.

Laura Tyson called attention to the fundamental differences in thinking between the American and Japanese speakers. Japanese spokesmen are not afraid to say that some industries are important—those that employ highly skilled people, involve mass production, and have developed strategies for using technology to compete globally. In contrast, some U.S. participants criticized the "new paradigms" as incapable of providing a strong analytical base to choose among technologies. According to this view, the U.S. policy process is fundamentally unable to deal with the competing claims of "critical technologies." This deep lack of faith in the government's ability to make effective technology policies contrasts with a perspective from Japan (and Europe): The government does make mistakes, but it can also play a constructive role.

Joseph Gavin and John Odell both called attention to the need for political leadership. Odell asked which industries would be willing to invest the necessary resources to help create a "domestic coalition" for new policy approaches. Mowery responded that much of the U.S. technology policy debate is "distributive politics," the essence of which is competition among industries for shares. Gerald Dinneen pointed to Sematech and MCC as evidence that U.S. industry is ready to act.

The contributions of participants from Europe and Japan helped to bring different perspectives to debates over U.S. policy. The symposium high-lighted significant changes in global competition among high-technology industries and systems. These changes present new challenges to U.S. policymakers in government and industry to bring more coherence between the domestic and international dimensions of economic policy. This will be a difficult task, in view of the ad hoc approach that the United States has taken to technology policy and uncertainties about the future of the multinational trading system under the GATT.

APPENDIXES

A

Biographical Information About the Authors

PAOLO GUERRIERI is professor of economics at the University of Naples and senior research fellow at the Institute for Foreign Affairs in Rome. His academic career also includes an associate professorship of economics at the University of Perugia (1978–1987) and Rome (1987–1990), and visiting fellow at the University of Pennsylvania and Harvard University (1976–1977). Dr. Guerrieri's research activities focus on international trade and trade policy, international political economy, European integration, and economic growth and development. He has authored numerous publications on international economic issues including (in English) *The Political Economy of International Cooperation* (1988) and *The Political Economy of European Integration* (1989).

MARTHA CALDWELL HARRIS is director of the National Research Council's Office of Japan Affairs. She holds M.A. and Ph.D. degrees in political science with a specialization in Asian Studies from the University of Wisconsin (Madison). She was a foreign research associate at the University of Tokyo, taught courses at the University of Washington and George Washington University, and served as project director at the Congressional Office of Technology Assessment before joining the National Research Council staff.

PAUL R. KRUGMAN is professor of economics at Massachusetts Institute of Technology where he has been a member of the faculty since 1979. He also taught at Yale University (1977–1980) and was the senior international economist for the President's Council of Economic Advisers (1982–1983). He is a fellow of the Econometric Society, a research associate of the National Bureau of Economic Research, and a member of the Group of Thirty. He has served as consultant to the Federal Reserve Bank of New

York, the World Bank, the International Monetary Fund, the United Nations, and the European Commission. Dr. Krugman's professional research is focused on international trade and finance. He received his bachelor of arts degree from Yale University in 1974 and his Ph.D. from the Massachusetts Institute of Technology in 1977.

GORDON E. MOORE is chairman of Intel Corporation, a company that he cofounded in 1968. Before that time he was director of research and development for the Semiconductor Division of Fairchild Camera and Instrument Corporation. He was one of the eight founders of Fairchild Semiconductor Corporation in 1957; the organization evolved into the Semiconductor Division. Dr. Moore received a B.S. in chemistry from the University of California, Berkeley, in 1950 and a Ph.D. in chemistry and physics from the California Institute of Technology in 1954. In 1976 he was elected to membership in the National Academy of Engineering.

DAVID C. MOWERY is associate professor of business and public policy at the Walter A. Haas School of Business, University of California, Berkeley, and deputy director of the Consortium on Competitiveness and Cooperation. Before moving to Berkeley in 1988, Dr. Mowery served as assistant and associate professor of economic and social sciences in the Social and Decision Sciences Department at Carnegie Mellon University (1982–1988). During those years, he was also assistant to the counselor at the Office of the U.S. Trade Representative (1987–1988), and study director for the Panel on Technology and Employment, National Academy of Sciences (1986–1987). Dr. Mowery received his A.B., A.M., and Ph.D. degrees in economics from Stanford University. He has received numerous academic honors and fellowships and has published a number of books and papers on the economics of technological change and on U.S. technology policy.

LAURA D'ANDREA TYSON is professor of economics and business administration, research director of the Berkeley Roundtable on the International Economy, and director of the Institute of International Studies at the University of California, Berkeley. During the 1989–1990 academic year, she was the Henry Carroll Thomas Ford Visiting Professor at the Harvard Business School. Dr. Tyson is currently a visiting scholar at the Institute for International Economics in Washington, D.C. She is a member of the Cuomo Commission on Trade and Competitiveness, the advisory board of the Economic Strategy Institute, the Conference Board Economics Colloquium, the Economic Policy Institute Research Council, and the Council on Foreign Relations. Dr. Tyson received a B.A. from Smith College and a Ph.D. in economics from the Massachusetts Institute of Technology.

DAVID B. YOFFIE is a member of the faculty of the Harvard Business School, where he currently teaches competitive strategy in Harvard's International Senior Management Program. His previous teaching assignments included international business; competition and strategy; business, government, and the international economy; and an MBA course he developed, called managing international trade and competition. Before moving to Harvard in 1981, Professor Yoffie was a lecturer in political science for two years at Stanford University. His research and consulting have focused on international trade, competitive strategy, and business-government relations. He was appointed as a member of the board of directors of Intel Corporation in 1989. Dr. Yoffie is the author of two books and numerous articles and case studies on competitive strategy and management issues in international competition. He received his bachelor's degree in political science from Brandeis University and his master's and Ph.D. degrees in political economics from Stanford University.

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Symposium Program

Monday, June 10, 1991

9:00 a.m.	**Welcome**
	Gerald Dinneen Foreign Secretary National Academy of Engineering
	Opening Remarks
	Gordon Moore Symposium Chair, and Chairman, Intel Corporation
9:30 a.m.	***Panel 1: Technology and International Trade Competition—Historical Trends***
	Chair: Paul Krugman Professor Department of Economics Massachusetts Institute of Technology
Panelists:	Robert Lawrence Senior Fellow Economic Studies The Brookings Institution

	Fumitake Yoshida Executive Director Export-Import Bank of Japan
	Paolo Guerrieri Faculty of Economics University of Rome
1:45 p.m.	***Panel 2: New Paradigms for Linking Technology and Trade Policies***
	Chair: Laura Tyson Research Director Berkeley Roundtable on the International Economy University of California, Berkeley
Panelists:	Jean-Claude Derian Former Director of Technology Compagnie Financiere
	Sylvia Ostry Center for International Studies University of Toronto Clyde Prestowitz Jr. President Economic Strategy Institute
Tuesday, June 11, 1991	
9:00 a.m.	***Panel 3: Technology Challenges to Trade Policy***
	Chair: David Yoffie Professor Harvard Business School
Panelists:	Hans Decker Vice Chairman Siemens Corporation
	William J. Spencer President and CEO Sematech, Inc.

	Henry Lichstein Vice President Citibank, N.A.
1:00 p.m.	***Panel 4: Trade Challenges to Technology Policy***
	Chair: David Mowery Associate Professor Haas School of Business University of California, Berkeley
Panelists:	Craig Fields President Microelectronics and Computer Technology Corporation
	Hajime Karatsu Professor R&D Institute Tokai University
	Margaret Sharp Senior Fellow Science Policy Research Unit University of Sussex
3:00 p.m.	**Closing Remarks**
	Gordon Moore Committee Chair

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List of Symposium Attendees

Matthew J. Abrams, President, The Canadian-American Company, Washington, D.C.

David C. Acheson, Director and Consultant, Atlantic Council of the U.S., Washington, D.C.

Michael Aisenberg, Manager, Federal Relations, Digital Equipment Corporation, Washington, D.C.

Joji Arai, Secretary General, International Productivity Services, Washington, D.C.

William T. Archey, Vice President, International, U.S. Chamber of Commerce, Washington, D.C.

Markku A. Auer, Counsellor, Science & Technology, Embassy of Finland, Washington, D.C.

Michael Baker, Research Analyst, Committee for Economic Development, Washington, D.C.

Chen Baosheng, Minister Counselor, Science and Technology, Embassy of China, Washington, D.C.

Claude Barfield, Director, Science and Technology Policy, American Enterprise Institute, Washington, D.C.

Barbara Becker, Administrative Assistant, Office of the Foreign Secretary, National Academy of Engineering, Washington, D.C.

David Beier, Vice President, Government Affairs, Genentech, Inc., Washington, D.C.

Cynthia Beltz, Research Associate, American Enterprise Institute, Washington, D.C.

Sumner Benson, Director, Office of Trade Security Policy, U.S. Department of Defense, Arlington, Va.

Marjory Blumenthal, Staff Director, Computer Science and Telecommunications Board, National Research Council, Washington, D.C.

David L. Bodde, Vice President, Midwest Research Institute, Kansas City, Mo.

Dorothy Bomberger, President, Congress, USA, Northridge, Calif.

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John P. Boright, Acting Deputy Assistant Secretary, Science and Technology Affairs, U.S. Department of State, Washington, D.C.

William M. Borman, Vice President and Director, Global Spectrum Management, Motorola, Inc., Washington, D.C.

John Brighton, Dean of Engineering, Pennsylvania State University, University Park, Pa.

Marc Brodsky, Department of Commerce, Washington, D.C.

Daniel F. Burton, Executive Vice President, Council on Competitiveness, Washington, D.C.

William S. Butcher, Senior Engineering Advisor, Engineering, National Science Foundation, Washington, D.C.

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Hans Decker, Vice Chairman, Siemens Corporation, New York, N.Y.

Jean-Claude Derian, Derian Consultants, Paris, France

John Dimmock, Staff Vice President, Research, McDonnell Douglas Research Laboratories, St. Louis, Mo.

Gerald Dinneen, Foreign Secretary, National Academy of Engineering, Washington, D.C.

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Marcia Dresner, Managing Editor, Chemtech Magazine, American Chemical Society, Washington, D.C.

Alex Fassbender, Manager, Technology Commercialization, Battelle NW, Richland, Wash.

Gilbert Fayl, Delegation of the Commission of the European Communities, Washington, D.C.,, Craig Fields, President, Microelectronics and Computer Technology Corporation, Austin, Tex.

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