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TO: DR. D.A. BROMLEY

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SUBJECT: COPIES OF THE SIX PAPERS THAT WERE MADE AVAILAVLE AT
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"LINKING TECHNOLOGY AND TRADE POLICY: AN
INTERNATIONAL COMPARISON"

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July 12, 1991

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DIRECTOR

Dr. D. Allan Bromley
Assistant to the President for
Science and Technology
Office of Science and Technology Policy
Old Executive Office Building
17th Street and Pennsylvania Avenue
Washington, D.C. 20506

Dear Dr. Bromley:

Last month, the National Academy of Engineering hosted a symposium on "Linking Technology and Trade Policy: An International Comparison," at which a number of provocative and informative presentations were made by a distinguished international roster of speakers. Since you expressed interest in the June 10-11 program, but were unable to attend, I enclose the six papers that were made available at the symposium for your information.

Please note that the Academy expects to publish in edited volume based on the entire symposium proceedings later in the year. If you have any questions concerning the papers or forthcoming proceedings volume, please feel free to call me at (202) 334-2467.

Thank you for your continuing interest in the Academy's programmatic activities.

Sincerely,

Proctor P. Reid
Senior Program Officer

Enclosures

Linking Trade and Technology Policies: An International Comparison

By Invitation
June 10-11, 1991
Washington, D.C.

Lecture Room
National Academy of Sciences
2101 Constitution Avenue, N.W.

The globalization of technology and markets provides new opportunities and challenges for policymakers worldwide who seek to advance their respective national economic growth. Industrial countries have used various domestic and foreign policy instruments to advance their national economic goals during the postwar period. Today, changes in the international market and in technological development highlight the critical interplay of domestic and international policies, and the need for policymakers to achieve greater complementarity between their domestic and international economic policies.

This symposium brings together a group of individuals who work in trade and technology policy to seek a better understanding of how U.S. approaches to such policies differ from those of other industrial countries. Participants from government, industry, and the academic community will explore current trends in trade and technology policies and the consequences for U.S. economic competitiveness.

National Academy of Engineering Preliminary Program

Monday, June 10, 1991

8:00 a.m. **Registration, Continental Breakfast**

9:00 a.m. **Welcome and Opening Remarks**

Gerald P. Dinneen, Foreign Secretary, National Academy of Engineering
Gordon E. Moore, Symposium Chair, and Chairman, Intel Corporation

9:30 a.m. **PANEL 1: Technology and International Trade Competition--Historical Trends**

Panel Chair: Paul Krugman, Professor, Department of Economics,
Massachusetts Institute of Technology

Panelists: Robert Z. Lawrence, Senior Fellow, Economic Studies, Brookings Institution
Fumitake Yoshida, Export-Import Bank of Japan
Paolo Guerrieri, Faculty of Economics, University of Rome

12:15 p.m. **Lunch, Refectory**

1:45 p.m. **PANEL II: New Paradigms for Linking Technology and Trade Policies**

Panel Chair: Laura Tyson, Research Director, Berkeley Roundtable of
International Economics, University of California, Berkeley

Panelists: Jean-Claude Derian, Former Director of Technology, Compagnie Financiere
Sylvia Ostry, Center for International Studies, University of Toronto
Clyde V. Prestowitz Jr., President, Economic Strategy Institute

4:45 p.m. **Adjourn. Reception Buffet following, Great Hall**

Tuesday, June 11, 1991

8:30 a.m. **Continental Breakfast, Lecture Anteroom**

9:00 a.m. **PANEL 3: Technology Challenges to Trade Policy**

Panel Chair: David Yoffie, Professor, Harvard Business School

Panelists: Hans Decker, Vice Chairman, Siemens Corporation
William J. Spencer, President and CEO, Sematech, Inc.

11:30 a.m. **Lunch, Refectory**

1:00 p.m. **PANEL 4: Trade Challenges to Technology Policy**

Panel Chair: David Mowery, Associate Professor, Haas School of Business,
University of California, Berkeley

Panelists: Craig Fields, President, MCC
Hajime Karatsu, Professor, R&D Institute, Tokai University
Margaret Sharp, Fellow, Science Policy Research Unit, University of Sussex

3:00 p.m. **CLOSING REMARKS**

Gordon Moore, Committee Chair

3:45 p.m. **Adjourn**

TECHNOLOGY AND INTERNATIONAL COMPETITION: OVERVIEW

Paul Krugman

Prepared for the
National Academy of Engineering Symposium
"Linking Trade and Technology Policies: An International Comparison"
June 10-11, 1991
National Academy of Sciences
Washington, D.C.

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TECHNOLOGY AND INTERNATIONAL COMPETITION: OVERVIEW

Paul Krugman
April 1991

This is a rough draft prepared for the NAE Symposium on "Linking Trade and Technology Policies", June 10-11. Comments welcome.

In a broad sense, the relationship between technology and trade has been a central theme of international economics since the early 19th 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 US Commerce Department 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.

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

1. 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 US 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 US producers just as directly. Most observers, in other words -- myself included -- feel that there is something special and important about high technology industries.

Essentially, it is widely suspected that high technology industries are particularly likely to generate positive external economies, both within particular high-tech 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-tech sectors, and those for spillovers from high-tech sectors to the economy as a whole, are somewhat different. I will go over the argument for within-sector externalities at some length, then turn 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 feedback¹. Such positive feedback has recently been emphasized as a source of international competitive advantage by Porter (1990); while 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

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

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 spillovers². 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 industry also supports local or domestic suppliers of inputs. In turn, the availability of skilled labor and/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.

² Or, for the economists, pecuniary vs. 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.

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 partly comes 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. I return briefly to this touchy issue in part 3.

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 Boston's Route 128 or Silicon Valley are asked why their firms continue to locate there, the availability of a pool of skilled labor is usually first on the list; 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" 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 US high technology sales in the domestic and foreign markets from 1970 to 1986. While some move toward internationalization is visible, US 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.

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 suggest 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 that 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 tech 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 comparable links for other high-tech 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.

2. Trends in high technology trade

The beginning of the 1990s represents a particularly difficult time to make any assessment of 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 very difficult to detect any underlying trends. For example, from 1980 to 1986 US 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 US 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 offers an illustration of the extent to which that rise and fall affected the competitive position of major competitors. In 1980, German manufacturing workers received an hourly compensation that was xx percent higher than that of their US counterparts. By 1985, the rise of the dollar had shifted that to xx percent less; by 1988 the dollar's plunge had more than restored the German premium, bringing it to xx percent.

The consequence of these huge changes in comparative labor cost has been roller-coaster behavior of trade in manufactures. Table 3 shows US trade balances in high-technology and non-high-

technology manufactures. During the 1980s, the traditional US surplus in high-tech 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-tech surplus over this period that the US 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 US. The conventional wisdom, which one still finds in many popular discussions, sees a US economy that is suffering a progressive process of deindustrialization due to imports of manufactured goods; US 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 US 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 US 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. Deindustrialization, a "hollowing out" of the US manufacturing base by imports, was never a possibility that made sense: given the dominant role of manufactured goods in US trade, one could always count on the dollar eventually to fall to a level that made US production competitive on world markets. And in practice, the negative impact of trade deficits on the overall size of the US manufacturing base has never been massive, and has been diminishing in the last few years. Table 4 shows the US trade deficit 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 13 percent of manufacturing value added; by 1990 it had again fallen to 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 US manufacturing sector in 1990 was only about 5 percent smaller than it would have been had the US economy been closed to foreign competition.

It is widely believed that until the 1980s the stability of the overall US trade balance in manufactures was the result of a simultaneously growing surplus in high technology and 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 US economy. Table 5 shows the relevant trade balances in nominal terms and as a share

of 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 US comparative performance in high technology than in other goods. Table 6 compares the US share of world high technology output with its share of manufactures in general; both shares have declined since 1970 (the apparent rise after 1980 represents valuation effects due to the strong dollar), but the decline has actually been faster in high technology -- or, to put it differently, the distinctive US specialization in high technology has eroded. Table 7 offers a similar form of evidence, comparing the high-tech share of output in the US, Japan, and Europe; this share has risen for all three, but less for the US; again, one sees US distinctiveness eroding. Finally, Table 8 shows measures of US 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 1970 the US has become relatively less oriented toward high technology.

Putting all of this together, one may offer a hypothesis that is pretty much the opposite of the common view that the US is now competitive, if at all, only in high technology industries. In fact US 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 very 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 US, with a dominant position in advanced technology, was able to compete internationally in spite of very high wages relative to other nations. In 1991 the US sells goods that are no more advanced and sometimes less than those produced by other countries; it is able to do this because US wages are not much higher and often less than those of our competitors. In other words, the US remains able to compete; but it has shifted its manufacturing downscale relative to other advanced nations, Japan in particular.

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, US manufacturing has experienced an impressive revival of productivity growth. Table 9 compares US productivity performance with Germany, Japan, and an average of trading partners. Since 1980 the historical trend of US relative decline has slowed or even reversed, thanks to a remarkable burst of productivity improvement in the US. This could represent a one-time gain as US firms have grown leaner and meaner, or it could in part represent a more basic turnaround in the US ability to apply new technology; it is still too early to tell.

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 US 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 US 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 US retained a dominant position in advanced technology, that despite Japanese inroads in a few areas that position remained largely intact. Few would now say that, implying that even if the measured high technology share has remained fairly stable there is a deeper underlying erosion.

3. Sources of trends in high technology trade

I have argued that in a broad sense the picture of high technology trade over the past 20 years is one of gradual erosion of US 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 US 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 US 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 US cost.

The high US cost of capital may, in turn, be explained by low national savings rates. The US has consistently had somewhat lower savings rates than other advanced countries, while Japan has saved more; during the 1980s the US rate plunged to only 3.6 percent of GNP, less than half the OECD average, 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 employed per 10,000 labor force, for the US, Japan, and Germany. The erosion of the distinctive US 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 US 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 in part 1 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 rivals the opportunity to establish the virtuous circles that allow an industry to succeed.

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 supplied by domestic producers for the US, Germany, and Japan. One might have expected that Japan would have a somewhat smaller share of home supply than the still considerably larger US, 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.

4. Summary and conclusions

This brief overview of technology and trade has made three main points.

The first is that the special emphasis placed by many observers 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. Insofar as the economics is concerned, sectors like financial services are as worthy of special concern as microelectronics.

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

Third, the sources of this trend are definitely 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.

REFERENCES

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Lawrence, Robert (1990), "US Current Account Adjustment: An Appraisal", Brookings Papers on Economic Activity 2:1990.

Porter, Michael (1990), The Competitive Advantage of Nations, New York: Free Press.

Table 1: High technology sectors

(Department of Commerce definition)

<u>Sector</u>	<u>1988 exports (\$billion)</u>
Guided missiles and spacecraft	1.1
Comm. eqpt. & elec. components	21.5
Aircraft & parts	25.1
Office, computing, & acctg mach	24.4
Ordnance & accessories	0.7
Drugs & medicines	4.0
Industrial inorganic chemicals	4.1
Prof. & scientific instruments	3.5
Engines, turbines, & parts	3.8
Plastics & synth resins	7.4

Source: US Department of Commerce, United States Trade: Performance
in 1988

Table 2: US market share in high technology

	World market	Domestic market	Foreign market
1970	51	95	10
1980	41	88	12
1986	42	82	11

Source: National Science Board, Science and Engineering Indicators,
1989

Table 3: US trade balances in manufactures

(\$ billion)

	High technology	Low technology
1981	33.0	-22.1
1986	-0.7	-116.4
1987	2.7	-127.5
1988	8.1	-114.5

Source: See Table 1

Table 4: US trade balance in manufacturing
(% 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

Table 5: US trade balances in manufacturing

	\$ billion		% of GNP	
	High tech	Low tech	High tech	Low tech
1970	6.1	-3.8	0.6	-0.4
1981	27.4	-16.5	0.9	-0.5
1988	8.1	-114.5	0.2	-2.3

Source: See Table 1

Table 6: US shares of world output

	High tech	All manufactures	Ratio
1970	51	43	1.19
1980	41	35	1.17
1986	42	38	1.11

Source: See Table 2

Table 7: High technology production as share of total

	US	Japan	Europe
1970	15	15	10
1980	15	15	10
1986	17	19	13

Source: See Table 2

Table 8: Revealed comparative advantage in high technology*

	US	Japan
1970	1.62	1.25
1980	1.59	1.41
1986	1.68	1.50

Source: See Table 2

Table 9: Productivity growth in manufacturing

	US	Japan	Germany	US relative productivity index
1960-70	2.6	10.3	5.7	113.9
1970-80	2.3	6.1	4.2	91.6
1980-88	3.7	4.5	2.8	90.4

Source: Department of Labor, Handbook of Labor Statistics

Table 10: Alternate estimates of the cost of capital

	US	Japan
Hatsopoulos-Brooks	9.7	3.8
McCauley-Zimmer	11.2	7.2
Bernheim-Shoven	11.1	4.1

Source: J. Poterba, "Comparing the cost of capital in the United States and Japan: A Survey of Methods", Federal Reserve Bank of New York Quarterly Review. Winter 1991.

Table 11: Employment of scientists and engineers per 10,000

	Germany	Japan	US
1970	30.8	33.4	64.1
1980	44.3	53.6	60.0
1986	52.3	67.4	66.2

Source: See Table 2

Table 12: Domestic share of home market

	Germany	Japan	US
1970	77	94	95
1980	59	93	89
1985	43	94	84

Source: See Table 2

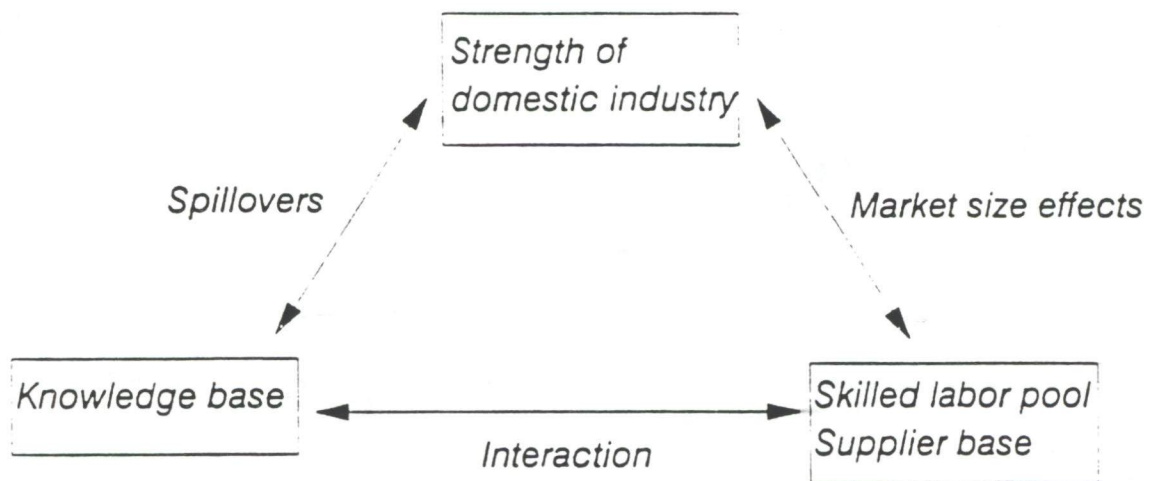
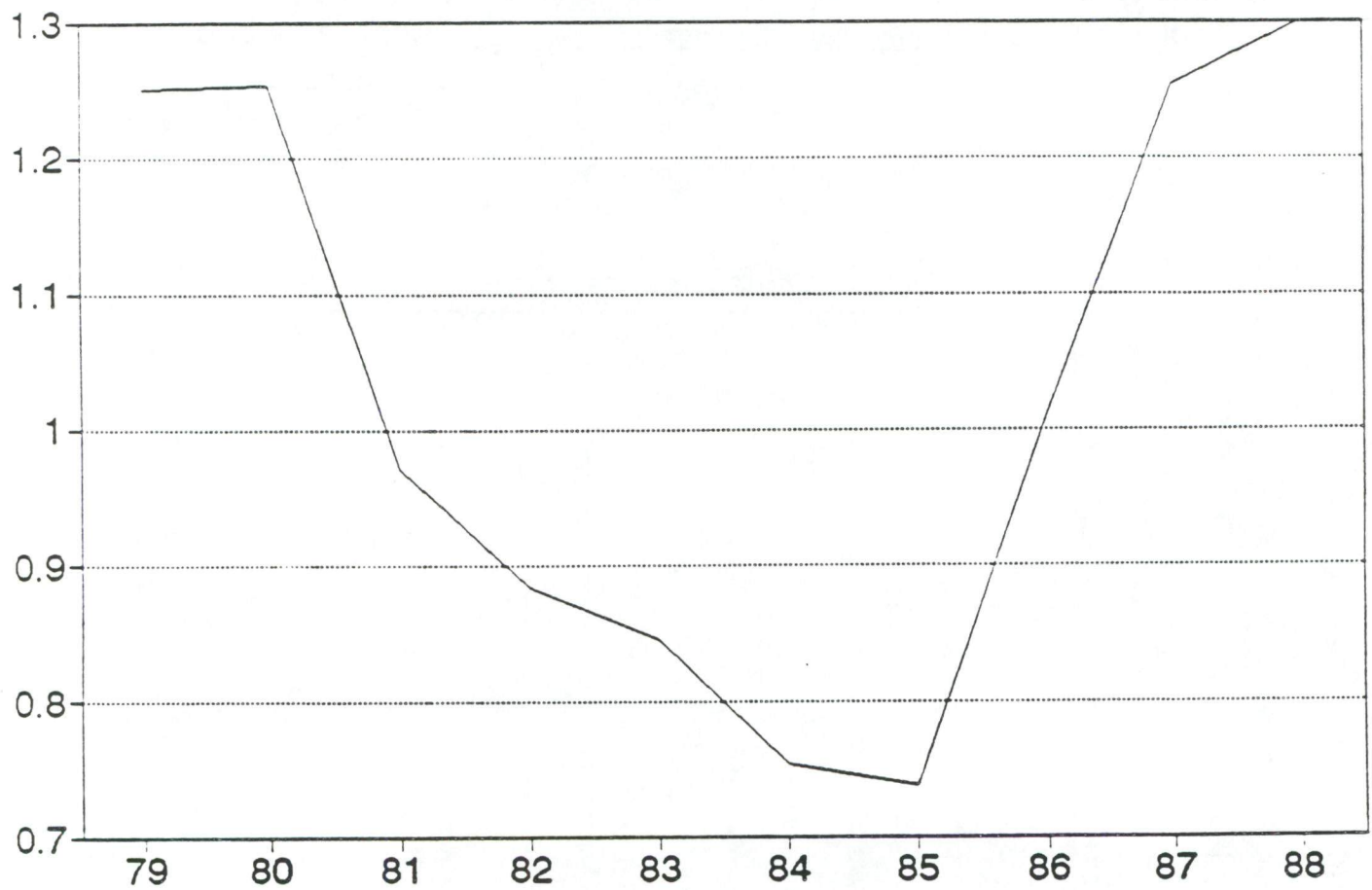


FIGURE 1: Self-reinforcing advantage in high technology

FIGURE 2
Ratio of German to US compensation



TECHNOLOGY AND INTERNATIONAL TRADE PERFORMANCE
OF THE MOST ADVANCED COUNTRIES

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1. Introduction

In the 1980s there was significant growth in trade and production interdependence among the major countries and areas as a result of the remarkable increase of world trade and foreign direct investments.

World trade, despite the proliferation of protectionist measures, has continued to make a substantial contribution to the economic growth of all the major countries. The largest and most rapidly growing part of world trade was in manufactured products, which today accounts for some 85 per cent of total trade in goods.

Most of world trade in manufactures is largely composed of two-way exchanges of fairly similar goods at the sectoral level, so-called 'intraindustry' trade. Industrial countries, which seemed, and were becoming over time, very similar in their factor endowments are the main source of this kind of trade.

Therefore 'intraindustry' trade can not be explained, as a relatively recent and growing literature has shown (1), purely by orthodox trade theory based on national differences in endowments of productive factors. There are other determining factors, such as economies of scale (Dixit and Norman, 1980, ch.9; Krugman, 1981; Ethier, 1982) and product differentiations (Lancaster, 1980; Krugman, 1980; Helpman, 1981).

Another group of contributions has more recently put emphasis on international differences in technological levels and innovative capabilities in order to offer alternative explanations of countries' advantages and specializations in international trade (Krugman 1979, 1986; Soete, 1987; Dosi, Pavitt and Soete, 1989). Such advantages, rather than stemming

from exogenous factor endowments as traditional comparative advantages do, are mostly acquired by different countries according to their different capabilities for generating and diffusing innovations. The international distribution of technological capabilities determines the distribution of comparative (absolute) advantages and produces a hierarchy of national economies which influences the patterns of national trade specializations. At the same time, trade advantages of innovator firms and countries tend to be temporary, as imitators are able to improve their technical capability and narrow the technological gap so as to affect significant changes in the distribution of trade flows between countries and in the patterns of the international division of labor over time.

Such changes have been taking place in the last two decades and have profoundly affected all the major economies. Technological change has forced all the major countries to make wide-ranging domestic adjustments and has continuously modified their relative positions in the world economy. In this respect, the reactions of the major economies followed different patterns and most of all they met with very different success.

To evaluate them, this paper will use a comparative analysis of international trade performance and specialization of all the major countries (US, Japan, EC countries, Asian NICs) in the last two decades, providing some empirical evidence for the international differences in countries' technological levels and innovative capabilities.

The study relies on a new and original data-base allowing to conduct research on the changing pattern of world trade at a rather disaggregated level. The database (SIE - World Trade) is based on United Nations and OECD statistical sources and includes import-export flows from 1970 onwards for more than 80 countries (OECDs, NICs, COMECON and LDCs) at various levels of disaggregation (400 product classes, 98 sectors and 25 commodity groups) [see Appendix]. Unlike previous studies on the same topic based on partial trade data referring only to the 24 OECD countries, the database used here makes it possible to examine the entire world trade matrix and to extend analysis to new,

important competitors on the world trade scene, i.e. the South-East Asian NICs.

To carry out this kind of analysis, one must first briefly examine the empirical and methodological issues associated with the former, particularly with respect to the relationship between a given country's technological capability and its international trade performance.

2. Technology and International Competitiveness: Some Methodological and Empirical Problems.

Technological capabilities are widely recognized as a key factor driving countries' international trade performance and competitiveness. Many methodological and empirical problems, however, are associated with the definition and quantification of such technological levels and innovative capabilities. They arise from the difficulties both of determining sources and effects of technology, and, more generally, of mapping the relations between technological change, trade specialization and international competitiveness of a given country.

A suitable starting point for such an investigation is the result of the considerable volume of theoretical and empirical research on the nature, determinants and effects of innovative activities that has been carried out over the past fifteen years (2).

In very general terms, technology may be defined as a stock of knowledge (technical or managerial) which allows for the introduction of new products or production processes. Innovative activity is thus viewed as the result of a long and complex process of accumulation and appropriation of this knowledge. The means and channels, however, by which this accumulation and appropriation take place, as well as the output of the stock of knowledge which is formed, are not the same for all firms and product groups; technology is a cumulative process and has firm-specific nature, since it is differentiated in both its technical characteristics and its market application (Teece, 1986; Pavitt 1988; Cantwell 1989). Processes of technological accumulation

tend to assume varying sectoral features, in terms of differences in technological opportunities, sources and appropriability conditions (Levin, 1984; Scherer, 1986). Another peculiarity of each sector is the different specific weight that innovation assumes in affecting sectoral profitability and competitiveness relative to all other factors.

It follows that the technological content of various product groups can be differently defined and quantified according to the different typologies and sources of technology which are being considered.

In this respect, the linkages between various industrial sectors assume great importance (Schmookler, 1966; Scherer 1982; Pavitt, 1984). The industrial system of a country should, in effect, be considered not as an ideal portfolio of sectors which are independent of one another, but rather as a structure with its own internal hierarchy, defined by a complex technical interdependence between its various component sectors. Technological change also affects these structural linkages and, through them, affects competitiveness of each sector and hence of the industrial system as a whole (Chesnais, 1986).

These features of technology have important implications for a comparative analysis of international trade specializations and performances of various countries. Particularly, one should take into consideration the main features of technology and innovation briefly mentioned above when developing a taxonomy of industrial sectors with respect to their technological content which aims at synthetically modelling the different national industrial systems for the purpose of comparison.

In this respect, more traditional taxonomies which divide the various industrial sectors into high, medium and low technology-intensity groups of products on the basis of indicators of both technological input (R & D expenditures) and output (patents) are unsatisfactory for an evaluation of a country's technological capabilities and international trade performance (3).

According to such classifications, a country's international trade specialization is considered more suitable for improving

its domestic and external competitiveness the greater the concentration of its export in "high technology" industrial sectors. This latter category should include all those production activities characterized by high demand growth, low price elasticity and high barriers to market entry for newly industrializing countries (NICs). An opposite conclusion is drawn when a country's export specialization is mainly based on 'medium-low technology' industrial sectors.

These classification schemes can be criticized not only because they use technological indicators of little and ambiguous meaning, but, more importantly, because they actually ignore those prominent differences with respect to the mechanisms of introducing and diffusing technologies, already mentioned, between various industrial sectors. Therefore, they tend to reduce technological change to a physiological alternation of "growth" industries (high-tech sectors) and "decline" industries (low-tech sectors).

In this respect, a sectoral taxonomy developed at the Science Policy Research Unit of the University of Sussex by Pavitt (1984) appears more adequate to represent the differences in the opportunities and appropriability mechanisms of technological innovations characterizing various industrial sectors. In Pavitt's taxonomy, industries are divided into four major groups mainly according to a combination of technology sources, user requirements and means of appropriation.

The first group of sectors, so called 'science-based', 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 spill-over effects on the whole economic system, and a large number of other sectors heavily rely on them as capital or intermediate inputs (4).

A second group of sectors - 'scale-intensive' - includes typical oligopolistic large firm industries, with high capital intensity, wide economies of scale and learning, high technical or managerial complexity and significant in-house production

engineering activities, such as automobiles, certain consumer electronics and consumer durables, the rubber and steel industries.

The third group of industries - 'specialized-suppliers' - includes most producers of investment goods in mechanical and instrument engineering, such as the machinery for specialized industries (i.e. machine-tools), and is characterized by a high diversification of supply, high "economies of scope", relatively medium 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 encompasses the more traditional consumer and non-consumer goods industries which are net purchasers of process innovations and innovative intermediate inputs from other suppliers of productive equipment and materials (specialized-supplier and scale-intensive sectors); these sectors are notably sensitive to price competition, but are also influenced by 'non-price factors' such as product design and quality. This group includes textiles, clothing, wood and furniture, leather and shoes, ceramics, the simplest metal products.

Pavitt's classification of industrial sectors, 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; nevertheless, it 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 interdependences are of great importance since they affect the competitiveness of the manufacturing system as a whole. Such interdependencies, as shown below, are also very important to achieving a proper understanding of the links between technological capabilities and international competitiveness at the country level.

On the basis of the foregoing considerations, Pavitt's classification scheme for industrial sectors seems more suitable than the traditional ones to deal with innovative capabilities of different countries. It has therefore been used in this paper to carry out a comparative analysis of major countries' international trade performance and specialization.

For this purpose all traded-industrial products, at a highly disaggregated level, have been classified into four groups, science-based, specialized-suppliers, scale-intensive and supplier-dominated, plus the group of the food industries which is considered separately (5). All the other non-industrial products have been grouped into three broad economic categories (6), for a total of nine product groups here considered (see Appendix).

3. The notable rise of Japan in international markets

This and subsequent sections will deal with the major shifts in the world division of labor by analyzing the trade performance and specialization patterns of the United States, Japan, EC countries and the Southeast Asian NICs in the last two decades.

It should be noted that in the present phase of increasing globalization of markets and internationalization of production competition among countries and firms takes place on many different grounds, i.e. trade, foreign direct investment, etc. International trade, however, as demonstrated below, has continued to play a relevant role in the increasing interdependence among countries and therefore provides a privileged look-out post for evaluating changing competitive patterns of various countries.

The present analysis uses a long-term approach (1970-87) for a clear overall appraisal of the major changes in trade (industrial) structures. 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.

Among the major countries, Japan undoubtedly achieved the best trade performance in the last two decades. To evaluate it, the first two sets of indicators employed are both more directly tied to the competitive position of a country and 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 a country exports in world exports with reference to each group of products (7). The performance of market share will be considered over a long period (1970-87), 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 consists of 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 (8).

In trade of manufactured products, Japan's share in world exports has been increasing continuously (+40 per cent) over the period considered (see Table 1), and standardized trade balances have been growing even more impressively (from 4.7 percentage points in 1970 to 7.4 percentage points in 1987 with respect to world trade in manufactures, see Table 2).

In the case of single sectoral groups, both sets of indicators show a huge rise of the Japanese industry: first, in science-based sectors, with more than a doubling of market shares (from 7.8 per cent in 1970 to 16.2 in 1987, see Table 3) and a sharp increase in trade surpluses (+9.3 points in percentage of world trade for this product group, see Table 4): second, in specialized-suppliers (mechanical engineering), with considerable gains in Japan's shares in world exports (from 6.4 per cent in 1970 to 14.6 in 1987, see Table 5) and rapidly increasing positive trade balances (see Table 6). In the scale-intensive sector the Japanese industry has further consolidated its

competitive position that was already strong in the early seventies (see Tables 7-8). On the contrary, in traditional sectors - such as textile, clothing, leather and footwear - the halving of export shares (Table 9) and the shift from high surpluses to slight but significant deficits in the mid-1980s (Table 10) show that the Japanese industry has carried out a relative disengagement from these productions, investing heavily abroad and reducing its export propensity.

Using the "Constant Market Shares Analysis", applied here with a new method of calculation, the changes in Japan's market share of manufacturing sector and various sectoral groups in the period 1970-87 has been broken down into two groups of components: 'structural effect' and 'competitiveness effect', each of which represents a different set of determinants of Japan's trade performance (9).

The 'structural effect' refers to the geographic and commodity structure of a country's export relative to the structure and the dynamics of world demand. The structural effect will be positive (negative) if a country concentrates its export on markets and/or commodities that grow faster (slower) than the world average (world demand). This structural effect can be further divided into three elements: the "market effect", due to the export's structure of a country by geographical destination; the "commodity effect", due to the export's structure of a country by products ; 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 ('price' and 'non price').

The results of CMSA (see Table 12) confirm that the 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 underway after the second oil shock.

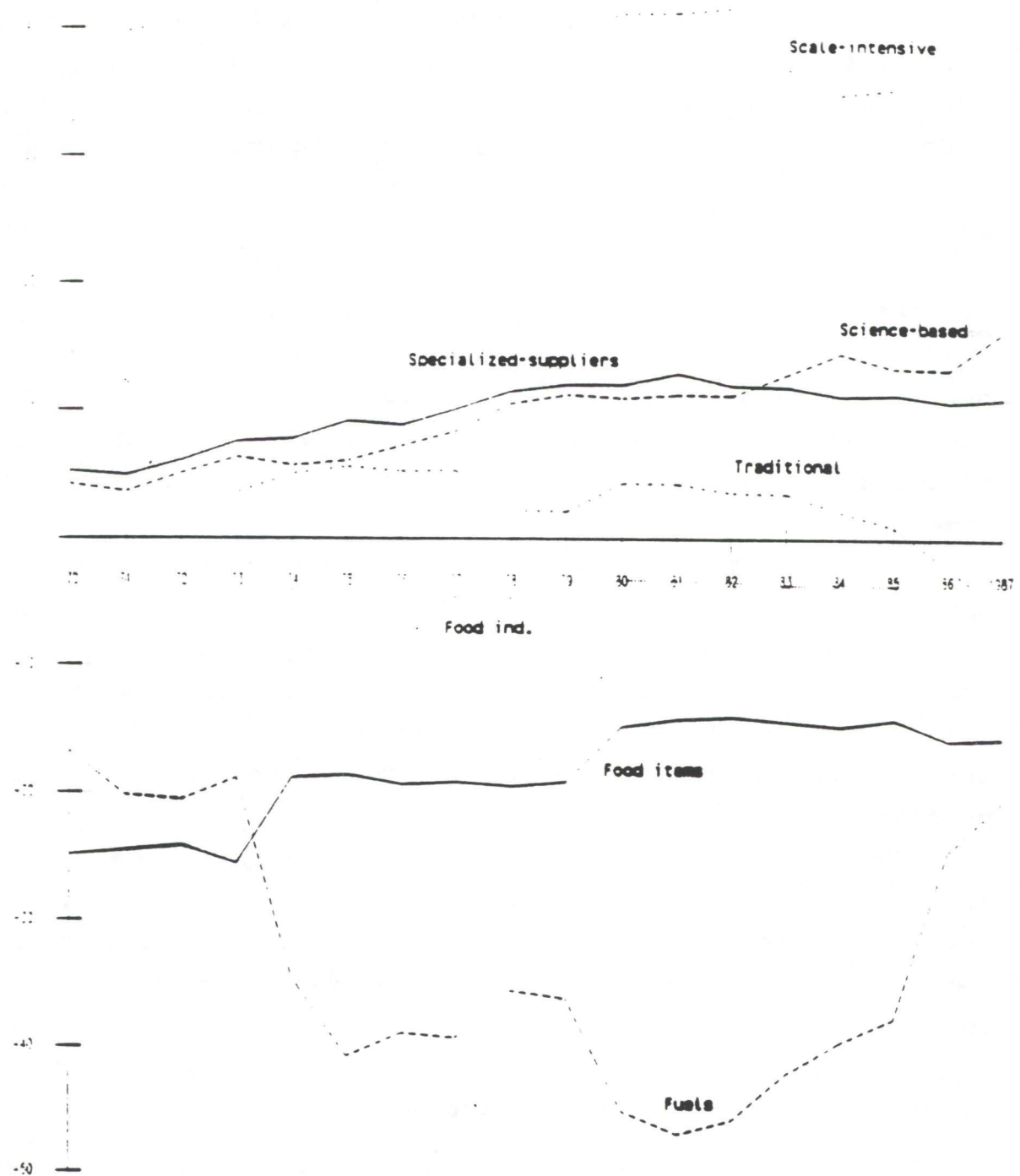
Certainly, this sharp strengthening of the competitiveness of Japanese productions may be attributed to many and heterogeneous factors. It is far from easy to identify them, and can not be attempted within the limits of this paper. In general, however, it may be said that a set of macroeconomic and socio-institutional factors, together with a peculiar strategy of industrial development, contributed to the success of Japanese industry. In this respect, a relevant role, as many studies have pointed out (10), was played by structural competitiveness factors, such as a particularly rapid technological change.

These structural factors may be connected with the profound changes which have taken place in the patterns of Japan's trade specialization in the last two decades. It 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, an indicator has been worked out that measures the relative contributions to a country's trade balance (ICTB) of the various groups of sectors in consideration (CEPII, 1983), see Figure 1. 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 advantage in trade specialization of a given country. Opposite considerations are associated with negative ICTB values. They identify those commodity groups for which a country more or less greatly depends on other countries (comparative disadvantages) and which generate a relatively high trade deficit (11). The ICTB indicator has been worked out for each year in the period from 1970 to 1987.

In the case of Japan, in the early 1970s, the scale-intensive and traditional sectors represented the strong points

Figure 1. PATTERNS OF TRADE SPECIALIZATION OF JAPAN *



(comparative advantages) of the Japanese industry's specialization pattern (see Figure 1). But since 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 trade balance strongly increased: (i) in the case of the R&D-intensity sectors (science-based), by a quadruplication of their indicator ICTB (+ 12 percentage points); (ii) for the specialized-supplier sectors, by a doubling of their ICTB (+5.7 percentage points).

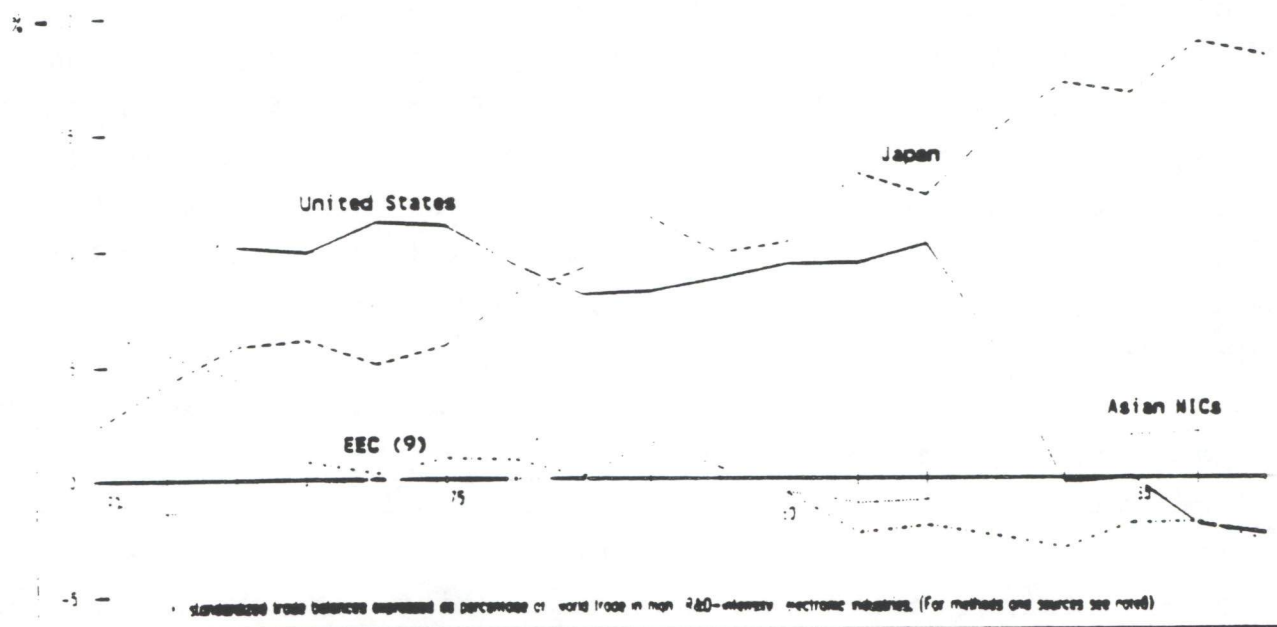
The strengthening of Japanese specialization in high R&D-intensity products (science-based) may be largely attributed to the notable gains of Japanese industry in electronics, and particularly in those sectors with the highest technological content (12). In the latter sectors, such as data processing systems, electronic components, telecommunications, the increase in market shares since the early 1970s was impressive such that by 1986-87 Japan became the world largest exporter of electronic products (see Table 11). In terms of trade balance, Japanese performance was even more successful, with huge and increasing trade surpluses, which confirmed its supremacy, quite sharply in most electronic sectors, with respect to other partner countries (see Chart 1).

The adoption of the most advanced product and process innovations, mostly imported by the US, the lower costs linked to large scale production processes, the aggressive industrial and trade policies have all contributed to the rapid rise of Japanese electronic industry in international markets, which severely penalized, as shown below, most of the US and European productions.

The use of new electronic technologies, on the other hand, also sustained the strengthening of Japanese specialization in specialized-supplier sectors (Figure 1), and particularly in industrial machinery, such as numerically controlled machine-tools.

Together with the increase in comparative advantage in science-based and specialized-suppliers, the evolution of

Chart 1. TRADE BALANCE IN HIGH R&D-INTENSITY ELECTRONIC INDUSTRIES *



* The R&D intensity electronic industries are those sectors in the electronics that are characterized by a relatively high R&D spending in relation to output and are therefore included in the Science Based group (see Appendix)

Japanese specialization patterns reveals that the scale-intensive sectors significantly decreased their contribution to trade balance since the second half of the 1970s (-14.3 percentage points), even though its value is still the highest in absolute terms (see Figure 1).

A new element has been the great reduction in the role of traditional sectors, which registered negative values of the ICTB indicator in the second half of the 1980s, following a decrease of over 19 percentage points since the early 1970s (Figure 1). Also the share of exports of traditional goods in total Japanese manufacturing exports has significantly declined in the last two decades, to less than half, while there has been a symmetrical doubling of the share of the R&D-intensity group, see Table 13 (13).

Thus, the evolution of Japan's trade specialization pattern has been characterized by a dynamic reallocation of the productive resources, oriented towards a sharply strengthening of the special-supplier and science-based sectors in the 1980s. Given that technological progress is increasingly dependent, as already noted, on the quality and intensity of interaction between innovative and user sectors (Lundvall, 1988), in the case of Japan these intersectoral transmission mechanisms of innovation functioned properly and to a large degree explain the strengthening of the Japanese competitive position in the period considered.

To sum up, Japan's performance seems to show very clear-cut patterns: a rapid growth of manufactures exports strongly concentrated in a restricted number of sectors (14) and a substantial shift in specialization patterns, both based on high and growing technological capability in terms of high intersectoral dynamics of the generation and dissemination of innovations, have led the Japanese industry to achieve the best results of the most advanced countries with respect to nearly all the 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 of manufactures

imports and especially an upsurge of direct investments abroad, particularly into US market. Hence Japan is now undergoing a changing growth pattern, bound also to modify its domestic economic structure. But it is too early for any sound forecast in this regard.

4. The emergence of the Asian NICs as new competitors

In addition to Japan, it is important to note the remarkable performances of South-East Asian countries - Hong Kong, Singapore, South Korea and Taiwan (Asian NICs) - over the entire period (1970-87), in terms of both rapidly increasing market shares and trade surpluses in manufacturing activity. In the early 1970s Asian NICs market shares accounted for a little more than two percentage points of world manufactures exports. By the late 1970s this figure had doubled and throughout the 1980s increased so much that by the end of the period under consideration it was four times higher than it had been initially (see Table 1).

The CMSA reveals that this export market share increase was largely attributable to a positive 'competitiveness' effect; however, 'structural' effects associated with a favourable market and commodity export composition also greatly contributed, particularly in the 1980s, to the Asian NICs upsurge in world market (see Table 12).

Even in terms of trade balances, Asian NICs achieved substantial gains in the period under consideration. From trade deficits in the 1970s they shifted to increasing surpluses in the 1980s, registering an overall increase in the period 1970-87 almost equal to that in Japan (2.7 percentage points of total world trade in manufactures (Table 2) (15).

Such remarkable trade performance may be connected with the export-led growth strategies followed by Asian NICs countries since the end of the 1960s. A massive allocation of productive resources in those industrial sectors with highest export

potential was the main goal of these strategies. To this end either state interventions or incentive and subsidy policies were used on a large scale and in different forms (Bradford and Branson 1987).

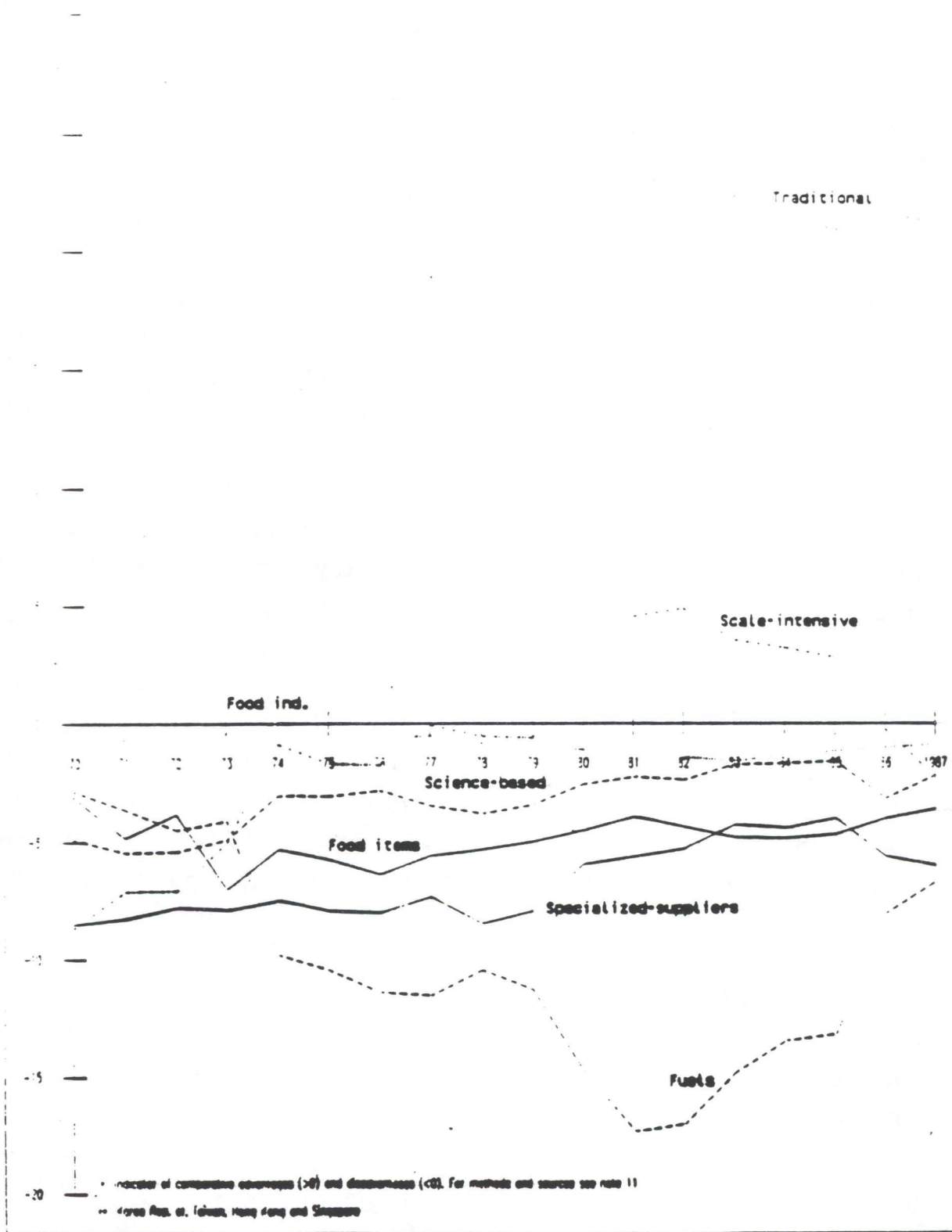
The industrial development of Asian NICs has thus been initially supported by production and export of consumer goods requiring large amounts of unskilled labor, for which they benefitted by the highest comparative (and absolute) advantages. The specialization pattern clearly shows the key role played in the past and even today by traditional industrial sectors for export growth of Asian NICs (see Figure 2). Of the various sectoral groups, only traditional industries maintained consistently positive and relatively high values of comparative advantage indicators (ICTB) over the entire period under consideration. However, the contribution of traditional goods to the trade balance, after increasing consistently until the end of the 1970s, has shown a significantly decreasing trend throughout the 1980s (-6.14 percentage points) (16).

This trend stems from the diversification process of manufacturing output that Asian NICs have been carrying out since the second half of the 1970s, greatly decreasing their import dependence on science-based and scale-intensive sectors, as shown by substantial improvements of trade balance contribution indicators of these two sectoral groups (see Figure 2). In specialized-suppliers sectors, conversely, Asian NICs still registered notable comparative disadvantage in the 1980s (Figure 2).

Further evidence of Asian NICs position in world trade can be drawn from their competitive patterns, measured, as has been done in the preceding section, by the share of world exports and standardized trade balance in various sectoral groups.

Competitiveness indicators show a sharp strengthening of NICs traditional industries on international markets both in terms of a rapidly rising share in world exports (from 6.1 per cent in 1970 to 17 per cent in 1987) (Table 9) and significantly increasing trade surplus (in 1987 equal to 10,3 percentage points of total world trade in traditional goods) (Table 10). This

Figure 2. PATTERNS OF TRADE SPECIALIZATION OF ASIAN NICs * **



continued export success of the four Asian NICs, concentrated in sectors such as textiles, clothing, leather and footwear, severely penalized the industries of most European countries and of Japan in the 1970s, while in the 1980s the US industry in particular suffered the most severe losses.

In addition, the four Asian NICs were also able to improve their competitive position in scale-intensive sectors (iron and steel, shipbuilding and petrochemicals) and most of all in science-based sectors (electronics) (17), in both cases considerably increasing their share of world exports and shifting their trade balance from a deficit to a moderate but significant surplus (Tables 3-4, 7-8).

Such gains confirm that the development strategies of the Asian NICs, based initially on poles of competitiveness comprising labor-intensive consumer good exports, gradually put into effect a process of diversification of industrial structure leading toward a strengthening of higher capital-intensive and most of all technology-intensive productions.

In this respect, the achievements of the Asian NICs in electronics is emblematic. In the first half of the 1970s, they succeeded in expanding their share of world export and trade surplus in consumer electronics. Such advances were later used to develop up-stream more technologically sophisticated electronic sectors, such as electronic components and telecommunications, through an import substitution process (most of all in South Korea) that was both complementary to the export-led growth path followed and centered on an 'à la filière' approach which turned out highly effective. This is demonstrated by the increasing trend in the 1980s of world export share and positive trade balances of the East Asia NICs - particularly South Korea - in data processing machines, telecommunications and electronic components (Table 11, Chart 1). Their standardized trade surplus increased considerably in the last decade, surpassed only by the huge Japanese one (18).

Finally, in specialized-supplier sectors, and particularly in mechanical engineering (i.e. machinery for specialized industries), Asian NICs rising share (Table 5) was not followed by

an improvement of trade balances, which, on the contrary, were negative and quite high throughout the entire period under consideration (Table 6), confirming that the Asian NICs diversification process of industrial structure required increasing imports in these sectors.

To sum up, the pattern of international trade specialization of the Asian NICs was characterized by profound and rapid changes in the period under consideration. It initially centered on labor-intensive consumer products (traditional sectors) and intensively diversified towards both scale-intensive sectors and most of all the electronic industry, with a sharp strengthening in the latter in recent years.

Clearly these countries can no longer be considered only export platforms connected with the redeployment strategies of multinational firms of the major industrial countries. The Asian NICs are at present a sound productive reality and are going to play an increasingly relevant role in world trade in the 1990s.

5. The deterioration of the US competitive position

Against the rise of the Asian countries, there was a relative decline in the US international competitive position throughout the period under consideration. The evolution of aggregate trade flows show a changing pattern of the US industry's competitiveness, especially since the late 1970s, diametrically opposed to the one characterizing Japan.

The US share in world manufactures exports experienced a sharp decline from 1970 to 1987, 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 US industry competitiveness both in the 1970s and 1980s since structural effects, comprising a positive commodity effect and a negative market one, on the whole played only a marginal role.

Further evidence that the US trade performance in the last two decades was anything but positive stems from trade balance

patterns, showing a persistent deficit since the mid-1970s and which has grown enormously in the last decade, mostly a consequence of the increasingly large trade deficit in manufactured products (Table 2). After the first oil shock, the US economy, unlike all other more advanced economies, was not able to counterbalance growing oil deficits, however moderated by positive net exports in food products, through adequate trade surpluses in manufactures. Despite the depreciation of the dollar in the second half of the 1970s, the manufacturing trade balance only partially improved, while an appreciation of the exchange rate until 1985 led to an enormous increase in the US deficit (9.4 percentage points of world manufactures trade) only partially decreased in the most recent years (19).

This overall deterioration is confirmed by the evolution of US competitiveness in various sectoral groups, though it has followed quite different patterns.

The most negative results have been those in specialized-supplier sectors (mechanical engineering, i.e. machine tools), in which the US industry sharply declined either in the 1970s or in the 1980s, accumulating a large decrease in its share in world exports (from 22.8 per cent in 1970 to 11.0 in 1987) (Table 5) and a huge increase in its trade deficit (-19.7 point in percentage of total world trade of this sectoral group) (Table 6) (20). The CMSA results demonstrated that these losses can be mostly attributed to a strong deterioration in the competitiveness of US mechanical engineering sectors (specialized suppliers) (see Table 12), to the advantage of Japan and European (German and Italian) industries.

In traditional sectors the US economy also experienced a declining market share and a growing trade deficit, primarily in the last decade (see Tables 9-10) (21), while in scale-intensive industries the losses were equal to those registered by the manufacturing sector as a whole (Tables 7-8).

Only in science-based sectors the US industry maintained a positive trade balance even in the 1980s, but also in this case manifested a sharp decrease either of its share in world exports (from 29.2 per cent in 1970 to 19.8 per cent in 1987) or of its

surpluses in the last two decades (see Tables 3-4). In this respect, it is in the electronic sectors of science-based groups that the American firms suffered the heaviest losses, as a consequence of the rapid and strong rise first of Japanese firms and then of Asian NICS ones.

In the early 1970s, US industry enjoyed a position of relative strength and supremacy in most areas of electronics. Over the last two decades, however, in successive periods of decline affecting first electronic office products, then electronic components and , most recently, data processing equipment, the US registered a marked deterioration in its competitive position. The notable decrease in market shares, particularly when considered together with the strong decline in trade balances over the last decade, is a clear evidence of the significant loss of competitiveness of US electronic industries as a group (see Table 11, Chart 1)(22). Therefore, although US firms continue to hold a strong competitive position in certain key sectors of electronics (e.g. information technologies), figures for the period considered here 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.

Two sets of contrasting interpretations have emerged to account for this overall negative performance of US 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 ills of the US industry due to structural factors (23).

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

But the current difficulties of US 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. Similarly, the sharp decrease in the market shares of US industries, as indicated by USMA results, is largely attributable in all the sectoral groups to a loss of competitiveness of US productions over the course of the entire period considered here, rather than to negative effects of product and market composition (see Table 12).

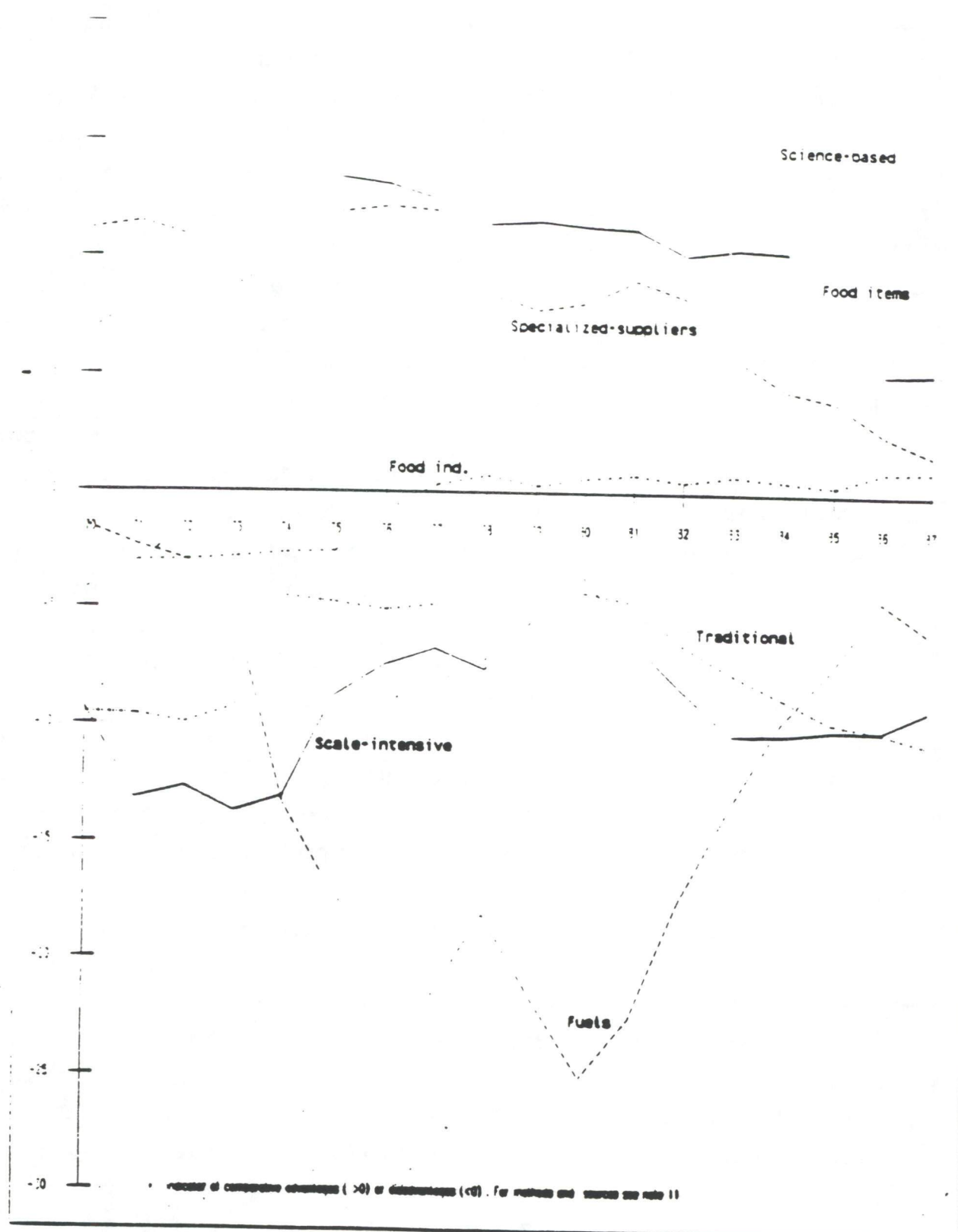
The foregoing leads to the conclusion that the relative decline of the US competitive position also derives, as the second more negative set of interpretations maintained, from structural disadvantages that should not be easy to neutralize, even in the presence of a significant reversal of trends in the exchange rate of the dollar, as has been the case. The major structural problems associated with the competitiveness of US firms include (Cohen and Zysman, 1987; Teece 1987; Dertouzos et al., 1989): 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; the gradual obsolescence of management and organizational models for production. These are multi-faced problems requiring complex solutions, the results of which will only become evident in the medium-long term.

Indirect evidence of the above lies in the evolution of the trade specialization pattern of US industry (see Figure 3). US comparative advantages have been and are increasingly concentrated in R&D-intensive product groups (science-based), most of which are characterized by high growth rates in world demand (24). The weight of science-based exports with respect to total US manufactures exports is also very high and has been rising in recent years (Table, 13) (25).

The other strong point of US specialization is food items and industries, as is demonstrated by its comparative advantage in this area until the first half of the 1980s, despite a slight decrease in recent years (see Figure 3).

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 US industry in the last two decades.

Figure 3. PATTERNS OF TRADE SPECIALIZATION OF THE UNITED STATES*



Following 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 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 US pattern of specialization is the sharp decrease in the positive contribution to trade balance (ICTB) of the specialized-supplier sectors such as mechanical engineering (-9.4 percentage points), although they maintained a slight comparative advantage by the mid-1980s (see Figure 3). These sectors also experienced a significant decline in terms of their share in the US total manufactures exports (26).

This trend is indicative of increasing difficulties of US industry in transforming high-level scientific research that continues to be generated in the US into innovative activities and products with significant commercial value in the other manufacturing sectors. The inverse correlation existing between the strengthening of US 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 assure the technological progress of its industry as a whole. Intersectoral technological links play an increasing role in the process of development and diffusion of 'primary' innovation throughout the economy and in the case of US they did not function properly, impeding a positive technological adjustment in many 'user' sectors, such as the specialized-suppliers.

To sum up, the patterns of US 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 which accounts for the relative deterioration in the international standing of the US economy. While it is true that the US still maintains a position of relative strength in terms of 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 mechanical engineering.

More recently, with the strong depreciation of the dollar, trade performance, especially in terms of export growth, of US industry has improved. 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 to accomplish.

6. The European Community's international competitiveness: widely differing patterns

Unlike the relatively well-defined trends emerging from indicators of trade performance in Japan and in the United States, the pattern generated for the European Community (EC) is more complex and not as clearly delineated. The market shares of EC countries as a group with respect to world manufactures exports registered a relative decrease from the early 1970s to the second half of the 1980s (-7.4 per cent), with greater losses (-14.5 per cent) if intra-Community trade is not taken into account (Table 1). This decrease, however, occurred almost entirely within the first half of the 1980s, and losses have been partly reabsorbed since 1985.

Trends in the Community's trade balance appear more satisfactory. In fact, manufactures trade balance was highly positive throughout the entire period, despite notable fluctuations (see Table 2). A high surplus was maintained until the end of the 1970s, largely as a result of the significant positive net exports with respect to developing countries. In the 1980s, the net decrease in imports of manufactures by developing countries, resulted in a marked reduction in the European surplus in manufactures trade, which was only partially compensated by the positive trade balance with respect to the US, while the

deficit towards Japan has recently increased considerably (27).

This general evolution in European competitiveness has been sharply differentiated with respect to both the performance of its individual member states and trends in various sectoral groups.

First, competitiveness of EC countries in specialized-supplier sectors (mechanical engineering) was very strong in the past and had maintained high levels in the 1980s, with market shares only slightly decreasing and highly positive trade balances (see Tables 5-6). This was the result of the positive performance, on the one hand, of the Federal Republic of Germany, which had maintained a highly competitive position in terms of market shares and trade surpluses, which were the highest of all major industrialized countries; and, on the other hand, of Italy, the only European country which increased both its world market shares (+22.8 per cent) and its positive trade balances (+1.8 points in percentage of world trade of this product group). On the contrary, the competitiveness of France and particularly of the United Kingdom deteriorated sharply, especially with regard to extra-Community trade.

The EC competitive position has also remained firm in scale-intensive industries, despite a slight decrease in market shares (see Tables 7-8). Once again, this may be attributed to the highly differentiated performance of the major EC countries. Germany, in particular, continued to be highly competitive in these sectors, as demonstrated by its increase in market shares following a drop in the early 1980s and by a recent net gain in what had already been a high surplus. France also maintained a trade surplus during much of the period considered here, but it registered a declining trend over the last decade. The competitiveness of Great Britain and Italy, on the other hand, clearly deteriorated, with a considerable increase in their trade deficits in scale-intensive industries.

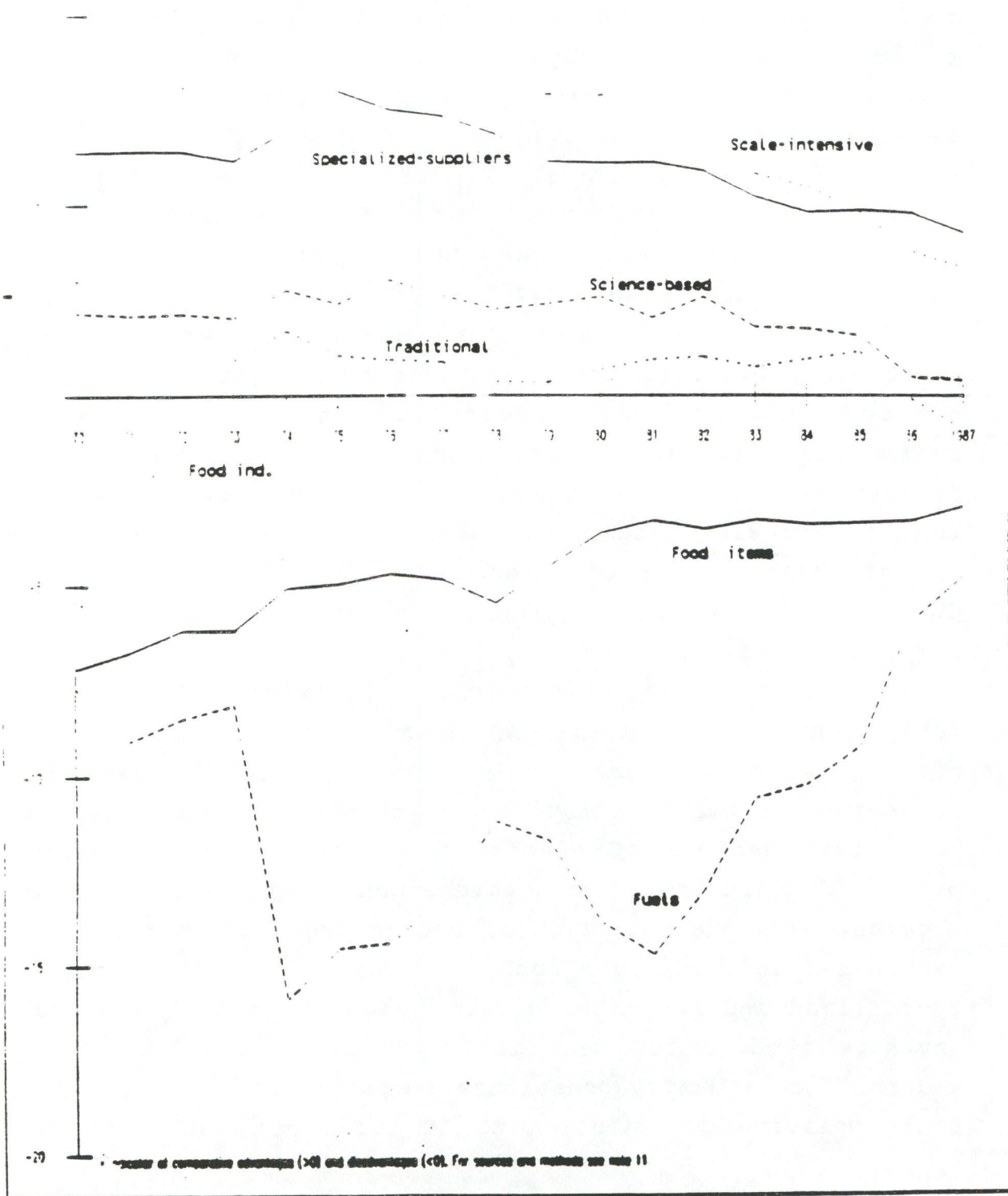
In traditional products, there was a notable decrease in EC market shares, particularly in intra-Community trade in the 1980s and mostly to the advantage of the newly industrializing Asian countries (see Table 9). It may be attributed to

significant deterioration in competitiveness in United Kingdom, France, and, to a considerably lesser extent, of Germany (Table 10). Italy was the only major country in the Community that did not follow this trend, as it had strengthened its competitive position in traditional industries during the 1970s and was able to maintain its advantage in this area during the last decade, though with some difficulty in recent years (28).

Finally, in science-based sectors EC countries registered a more uniform performance (Table 3-4). The EC competitive position, which was relatively strong in the early 1970s, experienced a net deterioration in the 1980s. EC normalized trade balance maintained positive and high values by the late 1970s but sharply declined in the 1980s (29). This negative performance affected all EC countries, including Germany. It must be underlined, however, that this negative performance is attributable almost entirely to the significant deterioration of the EC competitive position in all electronic sectors of science-based group. In effect, in data processing systems, in electronic office equipment and electronic components, EC countries registered significant reductions in their market shares and increasing trade deficits to the advantage primarily of Japan and, to a lesser extent, of Asian NICs (30) (Table 11, Chart 1). In the other sectors of science-based group, on the other hand, European industries maintained or strengthened their competitiveness (31).

These trends in the competitive position of EC countries are fully confirmed by their patterns of specialization over the period considered here (see Figure 4). The European industry maintained sound comparative advantages in many chemical and mechanical sectors of specialized-supplier and scale-intensive groups. In fact there was a strengthening of EC specialization in chemicals and pharmaceuticals, rubber products, basic metals and mechanical engineering - such as machine-tools and machinery for specialized industries - which, it must be recalled, are vital investment goods for many manufacturing industries. Food items and the food industry constitute a special case as they increased their positive contribution to EC trade balance in virtue of a

Figure 4. PATTERNS OF TRADE SPECIALIZATION OF THE EEC (9) *



highly protectionist Community agricultural policy.

In contrast to these areas of relative strength, EC specialization patterns reveal a declining trend in traditional sectors and above all in science-based electronic industries, particularly those in the 'information technology' area (32). This latter weakness must not be underestimated, as electronic products represent vital inputs in manufacturing restructuring currently underway in all major countries.

These overall trends, however, mask the sharp differences that have characterized, as has already been shown, the trade performances of individual EC countries, particularly the four major ones.

Germany retained its position of competitive strength, maintaining stable market shares at the end of the period considered here and reabsorbing the losses suffered in the first half of the 1980s largely thanks to gains on the European internal market at the expense of its EC partners. This positive German performance may be attributed to a relatively stable patterns of specialization, strong points of which have always been scale-intensive industries (especially automobiles, chemicals and pharmaceuticals) and specialized-suppliers (particularly industrial machinery and mechanical components) (see Figure 5) (33). This consolidated 'coherence' of German specialization also favored a rapid diffusion of technical progress into the entire production system through a strong and positive interaction between innovation production sectors and user sectors. The evolution of the competitive position of German industry is thus one of renewed strength with respect to its EC partners. If other more industrialized countries, such as Japan, are also considered, however, the German position appears less strong, because of the relatively poor performance of German exports in sectors of key strategic importance for 'primary' innovation such as electronics.

The United Kingdom, on the other hand, has had a distinctly negative trade performance. The deterioration in competitiveness that has characterized the position of British industry on international markets over the last two decades (34) is clearly

Figure 5. PATTERNS OF TRADE SPECIALIZATION OF GERMANY (Fed. Rep.)*

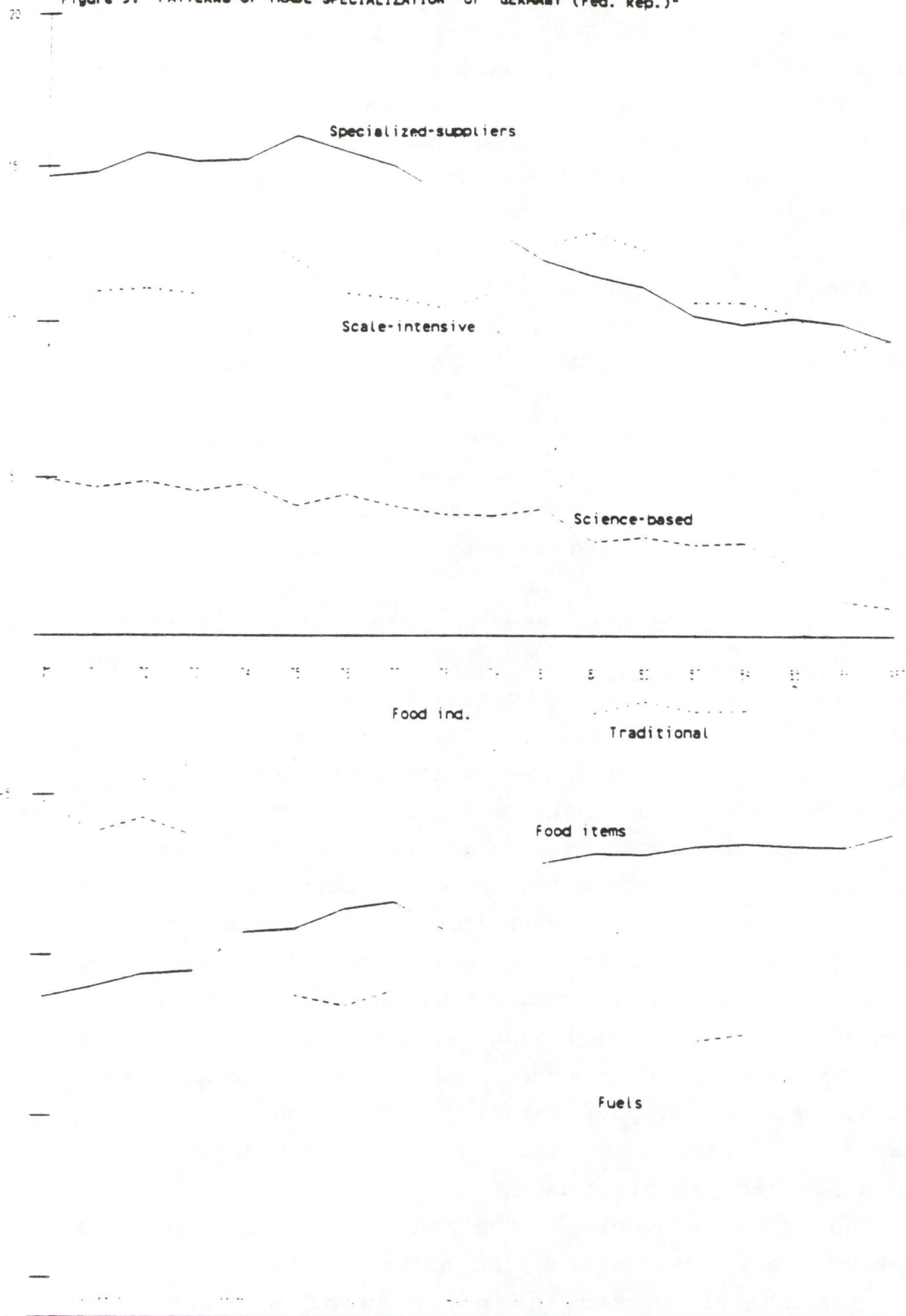


Figure 5. PATTERNS OF TRADE SPECIALIZATION OF THE UNITED KINGDOM *

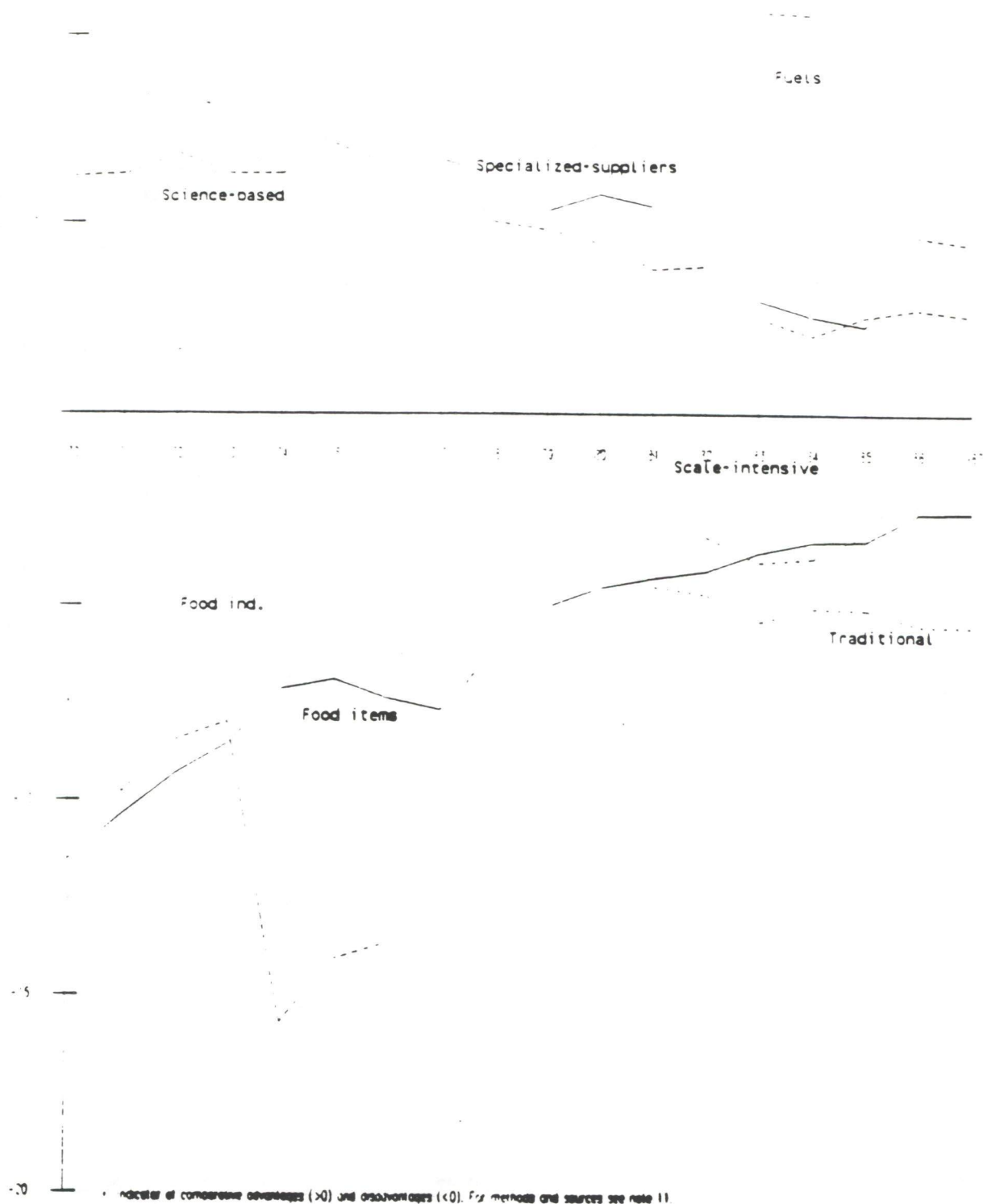
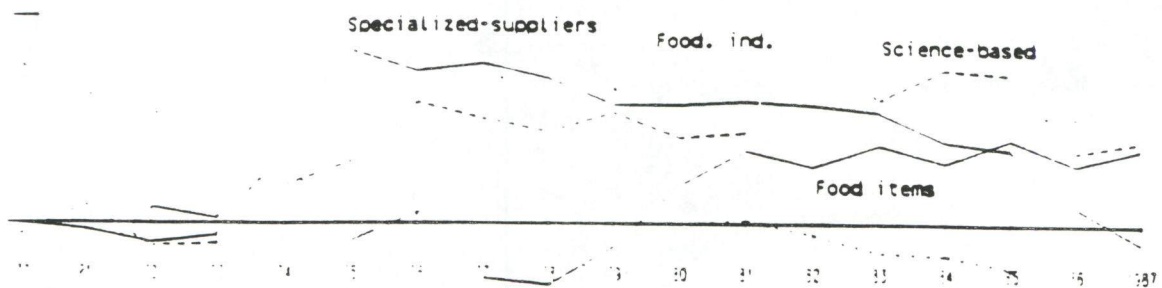


Figure 7. PATTERNS OF TRADE SPECIALIZATION OF FRANCE *

Scale-intensive



Traditional

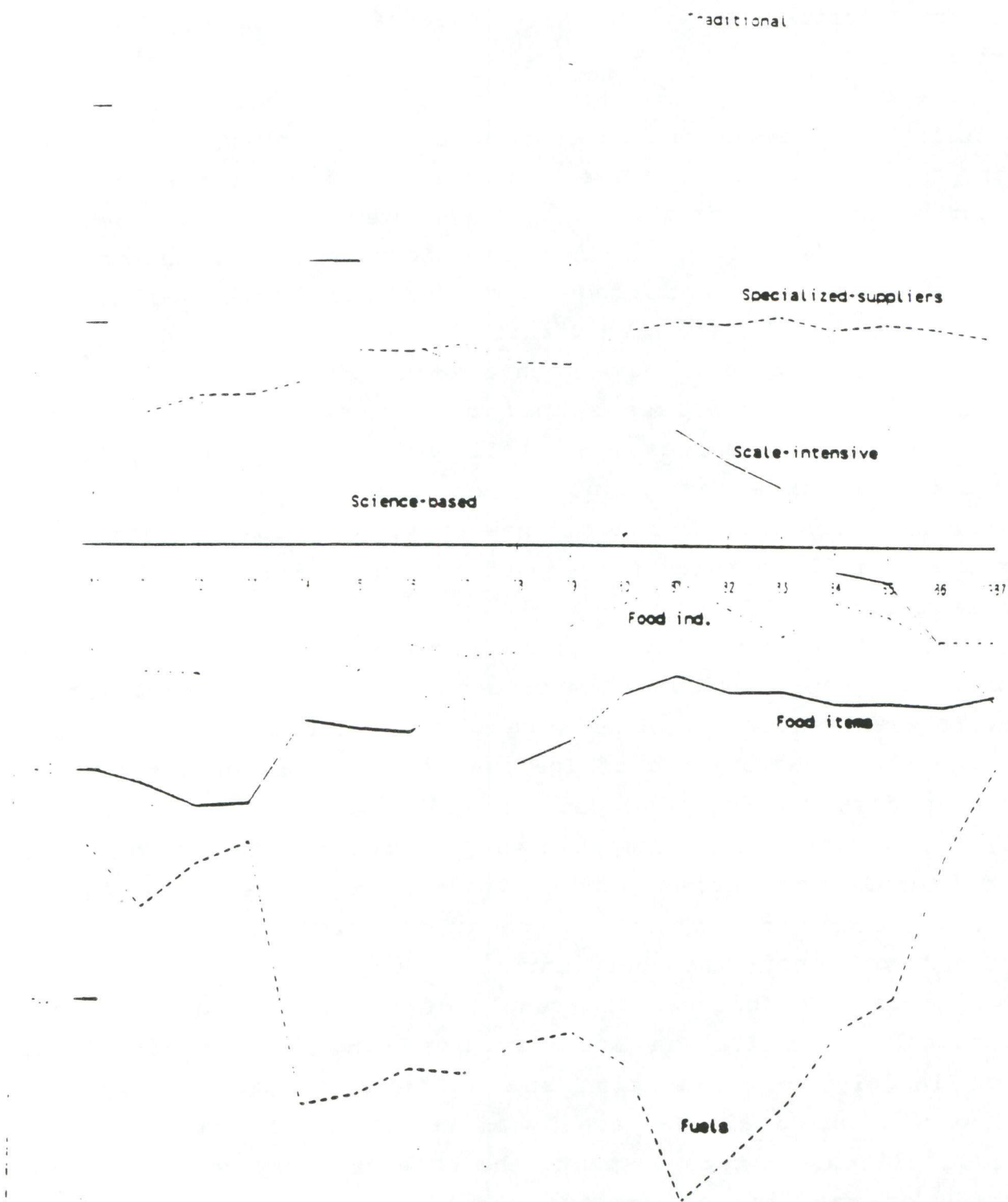
Fuels

reflected in its decidedly unfavorable specialization pattern in the same period (see Figure 6). Comparative advantage indicators registered considerable decreases in all four groups of industrial products (35), while there were increases only in agricultural products and foodstuffs, and especially in the energy sector. A slight reversal in trends in the last few years has not modified these overall negative results of UK trade performance.

French industry, unlike German one, is characterized by generally low levels of trade specialization, though there have been significant qualitative and quantitative changes in the structure of its comparative advantages over the last two decades (see Figure 7). High R&D-intensity industries (science-based) have emerged as new strong points, while there has been a relative despecialization in the traditional sectors (36). At the same time, recent years have seen a weak specialization position of France in specialized-supplier sectors, as in the early seventies. These changes are still at work and have not yet yielded the expected results, in terms of replacing old comparative advantages with the new ones, thus mostly accounting for the overall negative trade performance of French industry in the last decade (37).

Finally, Italy distinguishes its position in the world economy by the increasing heterogeneity of its specialization pattern with respect to other more advanced countries (see Figure 8). The trade performance of Italian industry has been decidedly positive over the last two decades (38) and is attributable not only to the the strong competitive position of Italian firms in traditional industries but also to the strengthening in specialization and competitiveness in the sectors of mechanical engineering (specialized-suppliers), such as industrial machinery (machine-tools). This was the result of the process of extensive restructuring in Italian industry beginning in the mid-1970s, based largely on application and diffusion of mostly imported technology, which also allowed some so-called mature sectors to be revitalised. In this respect, the case of Italy shows that the concept of maturity of sectors should be treated with extreme

Figure 3. PATTERNS OF TRADE SPECIALIZATION OF ITALY *



caution, since technological change may remove the ageing symptoms of the more traditional industries.

In the case of Italy, this external acquisition of technological input, however, also resulted in increased deficits and despecialization in many science-based sectors and in certain scale-intensive product groups (such as chemicals), with disturbing implications for the future position of Italian industry in world economy.

In sum, the figures in the previous analysis are indicative of complex trends in the EC, which cannot be unequivocally interpreted. In an effort to compensate for the relative loss of competitiveness experienced particularly in high-tech sectors in the early 1980s, the EC initiated moves toward the 1992 Single Market in an attempt to eliminate excessive rigidities and constraints on their economies. The renewed growth and recovery in investments in Europe in the last two years are indicative of the beginning of an economic revival of European countries, which seems destined to be reinforced by the new opportunities for integration offered by Eastern European countries. It must be emphasized, however, that the major EC countries have been characterized by significant different patterns of specialization and competitiveness in the past decade, and these differences are bound to be of particular importance once the 1992 internal market is completed.

7. Concluding remarks

The rapid development of world trade in the last 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 speeded up structural adjustments in their industries.

This paper concentrated on relative trade performance of different countries and on their trade (industrial) specialization, that is, on the degree to which their structural changes were consistent with the international competitive environment. In effect, trade performance and specialization provide a relatively objective and convenient test of comparative efficiency in each industry for each country.

Most world trade in manufactures products is today composed of a two-way exchange of fairly similar goods at sectoral level (intra-industry trade) between countries which are increasingly similar in their 'classical' factor endowments; however, this has not led toward a convergence in the pattern of international trade of the industries of the most advanced countries, quite the contrary. As this paper has demonstrated, the process of trade (industrial) adjustment followed different patterns in the major economies and most of all it met with very different success. Each major country presents a different structure of trade specialization and comparative advantages and these national differences increased rather than diminished in the last two decades, bringing about major changes in countries' relative competitive positions.

Among the major countries, Japan undeniably achieved the best trade performance in the last 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 last two decades. It has adapted to the changing dynamic and commodity composition of world demand much more and better than have the specializations

of the other major countries, sharply strengthening both specialized-supplier and high R&D-intensity sectors (science-based), particularly electronics. The case of Japan shows that factors of a technological order deeply influence the competitive position of a country in world market, mostly through the proper functioning of the intersectoral network of generation and dissemination of innovation at the level of the industry as a whole.

Together with the notable rise of Japan, the emergence of the South-east Asian countries as new strong competitors on international markets should be underlined. As has been shown by using the new data base on world trade, the continued export success of the Asian NICs, based initially on products with a high content of unskilled labor, was subsequently the results of more capital-intensive and most of all technology-intensive products, such as electronic goods and equipment. The Asian NICs thus now hold a prominent position on international markets and they seem destined to play a first-rate role together with other major industrialized areas in the 1990s.

The rising competition of Asian countries has increasingly affected the other advanced countries, and primarily the US and European area.

The United States suffered a marked deterioration of its international competitive position on the whole. 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 US still enjoys outstanding comparative advantages in R&D-intensity product groups, but it has been increasingly difficult to transform its high-level research capability into competitive industrial products, as evidenced by negative trends in many other manufacturing sectors. The US case shows that technological capability of a country is a difficult concept to define and quantify. This stems from the fact that each country has a very different pattern of technological and trade competitive advantages and no general common pattern exists. A sound competitive position in sources of 'primary'

innovation, such as high-tech (science-based) sectors, as in the case of the US, is not a sufficient condition for assuring a given country a positive trade performance. The dynamism of the innovation process increasingly depends on the intensity and the quality of the interaction between innovation production sectors and user sectors, which has been anything but positive in the US case in the last decade.

The patterns of trade performance and specialization of the EC countries was more complex and do not provide clear-cut indications. On one hand, the competitiveness of EC countries was very 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 electronic sectors, on the other hand, the EC registered rather negative results on the whole. It should be underlined, however, that these general trends have been sharply differentiated with respect to individual member states. The rather positive trade performances of Germany and Italy, that are both due, although in different manner, to a favorable intersectoral dynamics of the dissemination and application of innovations, contrast with the more uncertain outcomes in the case of France and, especially, with the negative trade patterns of the United Kingdom.

In an effort to compensate for the relative loss of competitiveness experienced particularly in the high-tech sectors, the EC launched the 1992 Single Market initiative. The renewed growth and recovery in investment in Europe in recent years could be indicative of the beginning of a long-run economic revival of European countries; however, it will depend, among other things, on the Europe's ability to overcome its competitive weakness in electronics.

Table 1. SHARES OF SELECTED COUNTRIES AND AREAS IN WORLD TRADE IN TOTAL MANUFACTURERS *
(Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987
OECD	35.91	34.49	34.27	32.29	30.32	29.06	29.59
United States	15.64	12.62	13.22	11.38	13.01	12.18	10.73
Canada	5.46	4.34	4.01	3.53	3.81	4.65	3.77
Japan	3.37	3.79	10.14	9.04	11.06	12.48	11.75
EEC (9)	46.02	47.21	45.96	47.11	42.11	39.52	42.62
Germany	14.51	15.78	14.93	14.67	13.56	12.69	14.55
France	7.05	7.61	7.62	7.99	6.76	6.28	6.64
United Kingdom	3.12	7.36	6.67	7.15	6.16	5.71	5.81
Italy	5.46	5.11	5.31	6.15	5.67	5.41	5.79
Other EEC (9)	10.88	11.65	11.45	11.14	9.96	9.42	9.94
Greece, Port., Spain	1.41	1.72	1.69	1.96	2.04	2.21	2.25
EFTA	3.16	8.08	7.94	7.62	7.01	6.78	7.41
Non-OECD Countries	13.33	14.71	15.51	16.76	19.19	20.46	19.91
MIDDLE EAST	0.81	0.78	1.06	1.05	1.12	1.27	1.11
NICs in ASIA	2.25	3.35	3.95	4.61	6.05	7.48	8.42
China	0.38	0.59	0.47	0.62	1.03	1.19	1.61
OTHER ASIAN C.	1.38	1.64	1.94	2.17	2.29	2.58	2.58
NORTH AFRICA	0.31	0.31	0.29	0.35	0.61	0.59	0.51
LATIN AMERICA	3.39	3.56	3.35	3.55	3.98	3.67	2.84
NICs in Latin America	1.17	1.72	1.32	1.54	1.76	2.31	1.93
COMECON	2.34	2.41	2.54	2.51	2.32	2.09	1.71
Soviet Union	0.74	0.82	0.96	1.02	1.07	0.91	0.66
Comecon Europe	1.49	1.51	1.51	1.44	1.21	1.16	1.03

(*) Ratio of national exports to world exports (percentage)

Source: SIE-World Trade data base

Table 2. TRADE BALANCE OF SELECTED AREAS AND COUNTRIES IN TOTAL MANUFACTURERS *

	1970	1973	1976	1979	1982	1985	1987	87-70
United States	0.41	-1.42	0.45	-1.24	-1.81	-9.43	-8.01	-8.42
Canada	0.25	-0.63	-0.79	-0.38	0.18	-0.21	-0.24	-0.49
Japan	4.73	4.71	6.88	5.34	7.46	8.72	7.36	2.63
EEC (9)	7.51	7.67	8.77	7.26	7.07	5.87	4.96	-2.55
Germany, Fed. Rep.	4.59	5.71	5.21	4.15	4.56	4.03	4.81	0.22
France	0.76	0.78	0.91	1.21	0.21	0.52	-0.25	-1.01
United Kingdom	1.08	-0.19	0.51	-0.21	-0.35	-0.86	-1.21	-2.29
Italy	1.01	0.54	1.36	1.81	1.52	1.15	0.83	-0.18
Greece, Port., Spain	-1.35	-1.08	-0.86	-0.26	-0.21	0.23	-0.71	0.64
EFTA	-0.81	-0.38	-0.29	-0.11	0.03	0.16	-0.23	0.58
NICs in Asia	-0.71	-0.07	0.49	0.34	1.04	2.05	2.01	2.72
NICs in Latin America	-1.47	-0.89	-1.15	-0.85	-0.32	0.66	0.31	1.78

* Standardized trade balances expressed as percentage of world trade in total manufacturers (For methods see note 8)

Source: SIE-World Trade data base

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
OECD	96.25	94.63	92.3	88.63	87.33	85.03	83.81
United States	29.25	25.39	24.41	22.46	25.17	23.87	19.86
Canada	4.87	3.63	3.09	2.06	2.39	2.53	2.15
Japan	7.81	9.07	9.61	10.37	11.6	14.75	16.16
EEC (9)	44.61	46.66	46.15	45.69	41.15	37.14	38.15
(a)	31.62	32.49	32.67	31.45	27.83	24.58	23.83
Germany, Fed. Rep.	15.85	17.33	16.19	15.37	13.83	12.04	13.13
(a)	11.08	12.04	11.28	10.01	8.82	7.62	8.21
France	6.81	7.31	8.61	8.67	7.76	6.73	7.01
(a)	4.41	4.65	6.39	6.15	5.79	4.81	4.58
United Kingdom	9.87	9.48	8.74	9.72	8.93	8.09	7.23
(a)	8.61	8.16	7.23	8.15	7.17	6.01	5.28
Italy	4.61	4.07	4.05	3.81	3.69	3.55	3.55
(a)	2.95	2.89	2.97	2.73	2.72	2.58	2.16
Other EEC (9)	7.48	8.47	8.56	8.12	6.94	6.72	7.22
Greece, Port., Spain	0.41	0.58	0.63	0.73	0.88	0.92	0.97
EFTA	9.12	8.91	8.17	7.09	5.88	5.58	6.26
Non-OECD Countries	3.29	4.91	7.26	9.52	11.35	13.35	15.43
MIDDLE EAST	0.21	0.27	0.42	0.44	0.78	0.79	0.68
NICs in ASIA	1.04	2.32	3.75	4.76	5.42	7.61	9.29
China	0.04	0.07	0.11	0.11	0.16	0.24	0.47
OTHER ASIAN C.	0.22	0.31	0.72	1.25	1.61	1.72	2.15
NORTH AFRICA	0.01	0.03	0.02	0.03	0.07	0.06	0.05
NICs in LATIN AMERICA	0.44	0.59	0.57	0.66	0.82	1.58	1.69
COMECON	0.74	0.76	0.98	1.25	0.64	0.47	0.47

(*) Ratio of national exports to world exports (percentage)

(a) excluding intra-Community trade

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	87-70
United States	18.87	13.79	13.85	10.99	10.91	3.62	1.38	-17.49
Canada	-2.35	-3.47	-2.47	-2.48	-2.19	-2.58	-1.89	0.46
Japan	3.28	4.74	6.19	7.02	8.05	10.99	12.61	9.33
EEC (9)	8.27	8.35	10.63	7.02	6.42	3.72	2.06	-6.21
Germany, Fed. Rep.	7.82	8.65	7.22	5.01	4.15	3.11	3.53	-4.29
France	-0.66	-0.67	1.01	1.01	0.81	0.86	0.15	0.81
United Kingdom	4.03	2.66	2.75	1.83	1.71	0.46	-0.21	-4.24
Italy	0.06	-0.68	-0.07	-0.42	-0.32	-0.61	-1.15	-1.21
Greece, Port., Spain	-2.89	-3.29	-2.47	-1.54	-1.45	-1.13	-1.81	1.08
EFTA	0.49	0.64	0.43	0.13	-0.17	-0.33	-0.28	-0.77
NICs in Asia	-2.14	-2.32	-1.47	-2.02	-1.51	0.08	0.45	2.59
NICs in Latin America	-3.52	-3.54	-2.96	-2.12	-1.69	-0.48	-0.45	3.07

* Standardized trade balances expressed as percentage of total world trade in science-based sectors (For methods see note 8)

Source: SIE-World Trade data base

Table 5. SHARES OF SELECTED COUNTRIES AND AREAS IN WORLD TRADE IN SPECIALIZED-SUPP. SECTORS*
(Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987
OECD	96.74	95.47	95.34	94.54	91.41	91.37	91.21
United States	22.79	19.17	21.06	16.67	19.06	15.26	11.01
Canada	2.21	1.83	1.85	1.99	2.07	2.09	1.68
Japan	6.36	7.45	8.15	10.29	12.35	15.61	14.6
EEC (9)	55.31	56.25	53.51	53.61	46.62	46.53	50.65
(a)	42.65	43.41	42.72	41.88	36.28	35.46	37.91
Germany, Fed. Rep.	24.01	26.55	23.81	22.96	19.02	19.31	22.19
(a)	17.78	20.59	19.31	18.62	14.84	15.02	17.06
France	6.83	7.44	7.99	7.81	6.49	6.14	5.94
(a)	5.15	5.54	6.53	6.19	5.25	4.73	4.33
United Kingdom	10.54	8.63	8.22	8.32	7.71	6.98	6.67
(a)	9.79	8.02	7.34	7.09	6.69	5.94	5.51
Italy	7.14	6.28	6.23	7.24	7.22	7.72	8.77
(a)	5.99	5.14	5.23	5.81	5.91	6.09	6.98
Other EEC (9)	6.78	7.35	7.25	7.27	6.19	6.38	7.08
Greece, Port., Spain	0.67	0.82	0.96	1.34	1.28	1.23	1.39
EFTA	9.09	9.51	9.47	10.31	9.64	10.11	11.25
Non-OECD Countries	3.24	4.51	4.58	5.33	8.43	8.37	8.52
MIDDLE EAST	0.08	0.09	0.12	0.16	0.26	0.32	0.28
NICs in ASIA	0.77	1.52	1.22	1.62	2.44	3.71	4.02
China	0.05	0.07	0.08	0.11	0.21	0.18	0.28
OTHER ASIAN C.	0.21	0.39	0.48	0.49	0.58	0.84	0.87
NORTH AFRICA	0.02	0.02	0.01	0.02	0.03	0.03	0.04
NICs in LATIN AMERICA	0.32	0.48	0.58	0.82	0.88	1.21	1.35
COMECON	1.31	1.41	1.38	1.28	1.12	0.96	0.81

(*) Ratio of national exports to world exports (percentage)

(a) excluding intra-Community trade

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	87-90
United States	14.97	11.13	14.11	7.59	8.99	-1.86	-4.73	-19.7
Canada	-4.34	-3.99	-3.81	-3.34	-2.61	-3.68	-3.09	1.25
Japan	3.14	4.85	6.34	8.35	10.41	13.36	12.43	9.29
EEC (9)	20.52	22.34	24.44	22.87	20.37	18.2	17.44	-3.08
Germany, Fed. Rep.	16.45	19.93	17.79	15.92	13.11	12.67	14.23	-2.22
France	-0.46	-0.47	1.24	1.41	0.44	0.57	-0.89	-0.43
United Kingdom	4.71	2.78	2.96	2.66	2.58	1.01	0.57	-4.14
Italy	2.68	1.81	2.97	3.95	4.24	4.57	4.47	1.79
Greece, Port., Spain	-3.06	-3.59	-2.34	-1.58	-1.61	-1.09	-2.48	0.58
EFTA	-0.21	0.74	1.45	2.49	2.24	2.18	1.81	2.02
NICs in Asia	-2.64	-2.86	-2.77	-3.72	-3.06	-2.12	-3.18	-0.54
NICs in Latin America	-4.12	-4.09	-3.93	-3.55	-3.21	-1.87	-1.43	2.69

* Standardized trade balances expressed as percentage of total world trade in specialized-supplier sectors (For methods see note 8)

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
OECD	36.31	36.51	35.51	33.51	30.81	29.97	32.84
United States	13.21	10.66	10.85	9.77	9.83	9.35	8.47
Canada	8.34	6.42	5.97	5.17	5.71	7.19	6.09
Japan	10.23	12.05	14.18	11.9	14.62	15.71	14.61
EEC (9)	43.94	46.26	43.89	46.29	40.44	37.31	42.43
(a)	28.56	29.5	27.61	28.63	24.79	22.38	25.48
Germany, Fed. Rep.	14.29	16.11	14.38	14.95	13.69	12.77	15.71
(a)	10.09	11.41	10.24	10.32	9.36	8.63	10.47
France	7.13	7.56	7.53	8.51	6.65	6.21	6.94
(a)	4.23	4.43	4.71	5.21	4.26	3.83	4.21
United Kingdom	7.14	6.01	5.62	5.92	5.15	4.77	5.42
(a)	6.54	5.33	4.48	4.43	3.66	3.18	3.84
Italy	4.42	4.53	4.54	5.21	4.52	3.92	4.16
(a)	2.98	3.11	3.31	3.92	3.44	2.85	2.76
Other EEC (9)	10.97	12.05	11.83	11.71	10.42	9.64	10.21
Greece, Port., Spain	1.04	1.43	1.44	1.85	2.08	2.42	2.36
EFTA	8.46	8.39	7.99	7.77	7.15	6.95	7.89
Non-OECD Countries	13.35	13.17	14.29	16.12	18.72	19.63	16.57
MIDDLE EAST	1.06	0.91	1.54	1.5	1.57	1.86	1.59
NICs in ASIA	1.11	1.89	2.39	2.96	4.59	5.46	5.38
China	0.15	0.21	0.19	0.32	0.68	0.62	0.74
OTHER ASIAN C.	0.96	0.85	1.01	1.1	0.96	1.2	1.03
NORTH AFRICA	0.14	0.22	0.28	0.47	1.09	1.09	0.78
NICs in LATIN AMERICA	0.61	0.86	0.71	1.01	1.59	2.29	1.76
COMECON	2.51	2.67	2.91	3.34	3.51	3.19	2.46

(*) Ratio of national exports to world exports (percentage)

(a) excluding intra-Community trade

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	87-70
United States	-2.92	-5.28	-3.88	-4.89	-6.21	-13.44	-11.58	-8.66
Canada	3.33	1.22	1.17	1.13	2.23	1.78	1.46	-1.87
Japan	6.39	8.63	11.1	8.21	10.92	11.9	10.24	3.85
EEC (9)	7.14	9.25	8.88	7.71	5.91	4.71	5.03	-2.11
Germany, Fed. Rep.	4.58	6.48	5.25	4.72	5.22	4.47	6.34	1.76
France	1.21	1.13	1.32	2.21	0.27	0.72	0.14	-1.07
United Kingdom	1.27	0.17	0.47	-0.42	-0.72	-0.94	-1.04	-2.31
Italy	-0.25	0.21	0.61	0.48	-0.04	-0.71	-1.27	-1.02
Greece, Port., Spain	-1.85	-1.15	-1.22	-0.59	-0.31	0.31	-0.81	1.04
EFTA	-0.91	-0.64	-0.58	-0.27	-0.01	0.52	0.33	1.24
NICs in Asia	-1.26	-0.87	-0.42	-0.48	0.41	0.97	0.33	1.59
NICs in Latin America	-2.17	-1.97	-1.94	-1.64	-0.53	0.62	0.08	2.25

* Standardized trade balances expressed as percentage of total world trade in scale-intensive sectors (For methods see note 8)

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
OECD	79.81	74.41	73.84	71.61	68.6	65.1	62.25
United States	7.43	6.66	7.33	6.43	6.71	5.21	4.42
Canada	3.09	3.25	2.51	2.63	2.31	2.91	2.41
Japan	9.29	6.33	6.23	4.63	6.03	5.53	4.01
EEC (9)	48.42	46.22	45.34	45.69	40.94	38.96	39.19
(a)	30.62	27.38	26.41	26.77	24.09	23.41	22.21
Germany, Fed. Rep.	12.06	12.04	12.07	11.07	10.51	10.12	10.69
(a)	7.83	7.59	7.39	6.84	6.52	6.38	6.59
France	7.06	7.27	6.55	6.27	5.74	5.34	5.17
(a)	4.41	4.08	3.94	3.62	3.58	3.28	3.02
United Kingdom	8.51	7.63	7.06	7.76	5.14	4.62	4.39
(a)	7.98	7.07	6.08	6.48	3.89	3.39	2.98
Italy	9.01	7.68	8.81	10.81	10.63	10.51	10.33
(a)	5.65	4.34	4.79	6.03	6.46	6.53	5.91
Other EEC (9)	11.79	11.59	10.85	9.79	8.92	8.38	8.62
Greece, Port., Spain	2.48	2.89	3.11	3.25	3.49	3.52	3.62
EFTA	8.54	8.34	8.61	8.34	7.95	7.41	7.27
Non-OECD Countries	18.24	23.35	25.95	25.77	30.5	33.97	36.82
MIDDLE EAST	1.27	1.48	1.37	1.41	1.29	1.25	1.28
NICs in ASIA	6.13	8.67	10.7	10.64	13.8	15.86	17.01
China	1.11	1.71	1.34	1.69	2.92	3.86	4.97
OTHER ASIAN C.	2.74	3.76	3.97	4.41	4.81	5.72	6.49
NORTH AFRICA	0.57	0.46	0.51	0.46	0.45	0.45	0.76
NICs in LATIN AMERICA	1.02	1.81	1.41	1.53	1.34	1.92	1.68
COMECON	2.82	2.81	3.26	2.58	2.23	2.01	2.01

(*) Ratio of national exports to world exports (percentage)

(a) excluding intra-Community trade

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	87-70
United States	-8.46	-7.56	-5.66	-6.99	-8.98	-19.07	-15.57	-7.11
Canada	-1.46	-0.63	-1.85	-0.48	-0.78	-0.78	-0.58	0.88
Japan	6.62	1.39	3.05	0.75	2.48	2.04	-0.61	-7.23
EEC (9)	6.53	1.54	0.43	-1.01	1.37	2.69	-0.79	-7.32
Germany, Fed. Rep.	0.82	-0.31	-0.35	-1.68	-0.16	0.45	-0.47	-1.29
France	1.21	0.77	-0.88	-1.27	-1.56	-1.01	-2.03	-3.24
United Kingdom	0.66	-1.18	-0.45	-1.53	-2.24	-2.59	-2.95	-3.61
Italy	5.51	3.94	5.38	7.13	7.16	7.12	6.47	0.96
Greece, Port., Spain	0.73	1.25	1.51	1.82	1.84	2.08	1.39	0.66
EFTA	-1.66	-0.82	-1.17	-1.18	-1.01	-1.13	-2.13	-0.47
NICs in Asia	2.21	4.65	6.88	6.57	8.24	9.81	10.3	8.09
NICs in Latin America	-0.18	0.91	0.66	0.69	0.47	1.16	0.97	1.15

* Standardized trade balances expressed as percentage of total world trade in 'traditional' sectors (For methods see note 8)

Source: SIE-World Trade data base

Table 11. SHARES OF SELECTED COUNTRIES AND AREAS IN WORLD TRADE
IN HIGH R&D-INTENSITY ELECTRONIC INDUSTRIES

(Percentage shares in values)

	1970	1973	1976	1979	1982	1985	1987
United States	35.4	29.3	27.2	29.7	34.5	28.2	22.8
Japan	11.1	15.4	16.1	17.4	19.3	23.8	26.1
Asian NICs	2.1	5.4	8.7	9.3	9.1	12.3	15.8
EEC (9)	31.1	30.4	29.1	26.6	20.9	19.8	19.1

(*) Ratio of national exports to world exports (percentage),
excluding intra-Community trade

Source: SIE-World Trade data base

Table 12. Results of the Constant-Market-Shares-Analysis of the exports in single group of sectors (*)
1970-1987 (percentage values)

	Market share changes (c) = (d) + (e)	Effect competi- tiveness (d)	Total (e) = (f) + (g) + (h)	Structural Market Effect (f)	Commo- dity Effect (g)	Effect Specific (h)
UNITED STATES, 1970-87:						
Total	-4.86	-4.31	-0.55	-1.12	1.02	-0.45
Food Ind.	-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, 1970-87:						
Total	3.38	1.07	2.31	1.97	0.55	-0.21
Food Ind.	-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, 1970-87:						
Total	6.17	3.85	2.32	0.93	1.04	0.35
Food Ind.	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 (Fed.Rep.), 1970-87:						
Total	0.04	-0.23	0.27	-0.56	0.22	0.61
Food Ind.	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
FRANCE, 1970-87:						
Total	-0.41	-0.07	-0.34	-0.72	0.01	0.37
Food Ind.	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, 1970-87:						
Total	-2.32	-2.25	-0.07	-0.32	0.24	0.01
Food Ind.	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, 1970-87:						
Total	0.33	-0.05	0.38	-0.26	0.34	0.3
Food Ind.	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 CRSA was carried out within each single group of sectors

Source: Guerrieri-Milane (1990)

Table 13. WEIGHTS OF THE SECTORAL GROUPS IN TOTAL EXPORTS BY MANUFACTURING INDUSTRY *

Country	Food Ind.		Traditional		Spec. Suppl.		Scale-Intens.		Science-based	
	70-73	84-87	70-73	84-87	70-73	84-87	70-73	84-87	70-73	84-87**
United States	5.2	5.6	10.2	3.5	22.1	14.2	37.8	34.3	23.6	37.4
Japan	1.7	0.6	18.2	7.5	11.1	15.1	57.6	53.1	11.3	23.9
EEC (9)	3.5	3.6	20.4	18.5	17.3	14.5	42.4	41.2	11.4	17.1
Germany, Fed. Rep.	3.1	4.6	15.9	14.9	24.1	18.7	44.1	44.4	12.7	17.4
France	11.9	10.7	19.4	15.7	13.9	11.2	43.6	42.7	11.1	19.6
United Kingdom	6.1	6.6	21.1	14.8	18.8	15.1	38.5	38.6	15.3	24.8
Italy	4.7	4.9	31.2	35.8	17.6	17.6	37.1	30.1	9.4	11.6
NICs in Asia	6.8	3.1	56.2	41.5	5.9	5.9	24.2	29.1	6.7	20.3
World	9.6	6.9	20.1	19.5	14.5	12.3	43.9	42.4	11.8	18.8

* (the sum of the five sectoral groups = 100)

** average value in each sub-period

Source: SIE-World Trade data base

NOTES

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(1) For a survey of this kind of literature see Greenaway and Milner (1986), Grimwade (1989).

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

(3) For such kind of studies using sectoral taxonomies of the traditional type referred above see OECD (1985), Kremp and Larroumets (1985), Koekkoek (1987).

(4) Therefore, the important role played by science-base industries in manufacturing system does not rely so much on their technological content, since this latter is also high in other sectoral groups using different means to generate innovations; rather it depends on the fact that their products represent sources of 'primary' innovation to many other sectors and produce important intersectoral effects.

(5) These five classes of products have been formed from the 400 product groups comprised in the database SIE-World Trade (see Appendix).

(6) The three broad economic categories are the followings: food items and agricultural raw materials, fuels, other raw materials.

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

$$MS = \frac{jXi}{\sum jXi}$$

jXi = total exports of country (j) in product group (i)
 $\sum jXi$ = total world exports of product group (i)

(8) 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, CEPII 1989). The evolution of trade balance distribution permits to highlight competitiveness patterns of various countries in a certain group of products. For each country (j) the indicator is given by:

$$IRCP = \frac{Xi - Mi}{\sum (Xi - Mi)}$$

Xi = total exports of country (j) in the product group (i)
 Mi = total imports of country (j) in the product group (i)
 $\sum (Xi - Mi)$ = total world trade in the product group (i).

(9) The Constant-market-shares-analysis (CMSA) is an accounting method for decomposing a country's export share (or aggregate export) change in 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 here reformulated in a more convenient way in order to overcome the well known methodological limits linked to the traditional applications of this technique. The version of the CMSA applied in this paper decomposes a country's export share change into the following four effects:

a) competitiveness effect: it measures the change of a country's export share due only to competitiveness factors assuming that its trade structure (market and commodity) is constant

b) market effect: it represents the influence of the geographic composition of trade flows upon the aggregate export share of a country. It is positive (negative) if a country concentrate its exports on market that grow faster (more slowly) than the world average

c) commodity effect: it represents the influence of the product composition of trade flows upon the aggregate export share of a country. It is positive (negative) if a country concentrates its exports on products for which demand is growing faster (more slowly) than the world average

d) specific market-commodity effect: it represents the influence on the aggregate export share of a country stemming from specific composition product-markets more (or less) favourable.

The sum of b), c) and d) effects represents the overall 'structural effect', which measures those changes in aggregate export share of a country due only to changes in commodity-market structure in world trade.

For further details on the methodologies of CMSA here used see Milana (1988) and Guerrieri-Milana (1990).

(10) See, among the others, Bremond [1987], Freeman [1987], Saucier [1987].

(11) 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:

$$ICS_i = \frac{(X_i - M_i)}{(X + M) / 2} * 100 - \frac{(X - M)}{(X + M) / 2} * \frac{(X_i + M_i)}{(X + M)} * 100$$

X_i = total exports of country (j) in the product group (i)

M_i = total imports of country (j) in the product group (i)

X = total exports of country (j)

M = total imports of country (j)

If the contribution (positive or negative) of each group of products to 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 products is equal to zero. Hence, positive ICTB values indicate those product groups whose positive contribution to trade balance is greater than their weight in total trade. Symmetrical considerations are associated with negative ICS values.

The sum of the indicators with respect to the various product groups (i) in which the total trade of a country is disaggregated, is equal to zero (see CEPIL, 1983). This indicator has been here worked out with respect to the 9 groups of products in which total trade has been disaggregated for each country.

(12) For a study on world trade patterns in these R&D-intensive electronic products see Guerrieri-Milana (1989)

(12) The share of Japanese traditional exports in total manufacturing exports decreased from 18,2 per cent in the early 1970s to 7,5 per cent in the late 1980s, while the share of science-based exports increased from 11,3 per cent to 23,9 per cent in the same period, see Table 13.

(14) The increase in market share and trade surplus has been mostly concentrated in three sectors: automobiles, machinery for specialized industries, data processing systems.

(15) The Asian NICs registered the highest trade surplus with respect to the US, which also represented the most important outlet for their exports. Slight trade surplus has been registered by Asian NICs also toward EC countries, while high deficits characterized their trade relations with Japan.

(16) The share of traditional goods in Asian NICs total manufactures exports has also significantly decreased over the last decade, though it is still quite high (41,5%), see Table 13.

(17) The CMSA reveals that the gains achieved by Asian NICs in science-based sectors can be mostly attributed to positive structural effects, particularly to a favorable export commodity composition, while increase in market share in scale-intensive industries largely derive from positive competitiveness effects, (Table 12).

(18) The strategies for strenghtening the electronix complex sharply differed for each Asian country, particularly as regard to foreign participation in developing the domestic industrial base in these sectors, see Guerrieri-Milana (1990)

(19) Almost all countries partners took advantage from the huge US trade deficit; however, Japan and the Asian NICs were able to reap the highest benefits.

(20) In the case of machine-tools and other machinery for specialized industries, the most negative results have been those in export performance of the US industry in the 1980s, which to a large degree explain the increase in trade deficit in these sectors.

(21) In the textile and clothing industries the US firms were able to maintain their position in international markets in the 1970s; in the first half of the 1980s, with the appreciation of the dollar, the competitive position of US firms sharply deteriorated, with a strong increase in foreign penetration of the US domestic market, particularly by the Asian NICs.

(22) The deterioration in the US competitive position is almost entirely attributable to the rise of Japanese and, more recently, Southeast Asian industries in the US domestic market as well as in other major areas. In telecommunications and electronic office

equipment, the US deficit was largely a result of trade exchanges with Japan, while 70 per cent of the deficit in electronic components originated from the Asian NICs. There is clearly a complementary relationship between the rise of Japan and the Asian NICs in electronic sectors, which has strengthened the capacity of both these producers to penetrate the US market in particular, and the international market in general.

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

(24) Among the R&D-intensity sectors, the US has the highest specialization in aerospace industries, which is characterized, as well known, by high public procurements.

(25) The weight of science based (R&D-intensity) exports in total US exports in manufactures was equal to 37,4 per cent in 1987 (23,6 per cent in 1970) and it is the highest of the most advanced countries.

(26) Their weight declined from 22,1 per cent in 1970 to 14,2 per cent in 1987, see Table 13.

(27) Japan is the only country with respect to which the EEC had registered a trade deficit since the early 1970s

(28) In traditional sectors the strong competitive position of Italian industry is confirmed by its positive trade balance patterns (standardized by total world trade in traditional sectors), which reveals an increasing trend despite cyclical fluctuations. Its value by the end of the period considered was higher than it had been in the early seventies. The evolution of Italian export share in world exports in traditional sectors was also very positive, with notable increase in the 1970s (+20 per cent from 1970 to 1979) and a slight decrease in the 1980s (-4.4 per cent)(Table 9).

(29) By the late 1970s, EC trade surplus in science-based sectors was almost equal to that of Japan; by the mid-1980s it fell to one third of the latter (Table 4).

(30) In trade in electronic products, EC registered huge and increasing deficits with respect to both Japan and the US, in the latter case despite the advantage stemming from the appreciation of the dollar in the first half of the 1980. By the mid-1980s even the Asian NICs accumulated significant surpluses with respect to the EC countries in all major sectors of electronics.

(31) The sectoral indicators reveal a positive evolution and a maintenance of the competitive position of European industry in many science-based (R&D-intensity) product groups over the 1980s, such as chemical-pharmaceuticals, electrical machinery, engineering instruments and more recently aerospace, see Guerrieri-Milana (1990)

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

(33) The scale-intensive and specialized-supplier industries gave positive and almost equal contributions to German trade balance by the mid-1980s (+9,4 percentage points).

(34) The U.K. registered the highest decrease in market share of the four EC major countries (-29,4%), with losses spread over the entire period (Table 1). Its magnitude is able to explain most of that overall deterioration of EC countries market share noted above.

(35) It is mostly in the scale-intensive sectors that U.K. industry registered the major change in its competitive position: its high specialization in the early 1970s (+9,9 percentage point) shifted into a notable despecialization by the mid-1980s (-3,1 percentage point), with only a slight improvement in recent years. In this respect, had been the huge loss in the automobile industry (-13,6 percentage point) emblematic and the main cause of this pattern.

(36) As to science-based industries, the indicator of their contribution to French trade balance registered a positive and notable increase (+2,8 percentage point from 1970 to 1987). The role of traditional sectors, on the other hand, suffered a great reduction since the early 1970s, when they represented a strong point of French specialization. The indicator of the contribution to trade balance of all traditional sectors diminished more than 7 percentage point and registered increasing negative values in recent years.

(37) France registered an overall slight loss in market share over the entire period here considered; however, it was the result of highly differentiated patterns in the last two decades, with a notable increase in market share in the 1970s and a sharp decrease in the 1980s (Table 1).

(38) The Italian share in world manufactures exports registered a significant increase in the second half of the 1970s, suffering a loss of equal size in the first half of the 1980s, followed by a partial recovery from 1985 to 1987, such that at the end of the period its level was slightly higher than it had been in the early 1970s (+5,1 per cent) (Table 1). The Italian trade performance may be evaluated rather positive on the whole with respect, on one hand, to those of other major European countries, and if one considers, on the other hand, the huge rise in international markets of Japan and the Asian NICs in that period.

APPENDIX : SIE-World Trade Data Base

The world foreign trade statistics used for the analysis in this paper stem from the SIE-World Trade data base.

The network of trade data worked out by the SIE (Servizi Informativi per l'Estero) provides detailed information on export and import 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 with respect to the 24 OECD countries, the newly industrializing countries (NICs), the other developing countries and the Comecon countries, and makes it possible to examine and analyze the entire world trade matrix. The source for the basic trade statistics of the SIE-World Trade is the publications of the OECD and the United Nations provided on magnetic tapes.

The SIE data-base is organized in different product group classification at various levels of disaggregation (400 product groups, 98 sectors, 25 categories, 5 branches) according to the two Standard International Trade Classifications (SITC), Revised and Revision 2, defined by the Statistical Office of the UN (1961, 1975) as to the periods 1961-75, 1978-87.

The broad product groups classification used in this paper is based on the 400 product groups of the SIE-World Trade. A summary list of the product groups included in each of the nine classes of products is below provided:

1) Food items and Agricultural raw materials (41 product groups)

Food - Live animals - Animal oil and fats - Natural rubber - Vegetable and animal textile fibres - Cork and Wood - Skins

2) Fuels (4 product groups)

Coal - Petroleum oil - Gas

3) Other raw materials (17 product groups)

Iron ore - Ores of base metals - Other crude minerals

4) Food industry (36 product groups)

Meat and meat preparations - Dairy products - Vegetables and fruit preparations - Cereal preparations - Sugar preparations - Other edible products

5) Science Based (59 product groups)

Synthetic organic dyestuffs - Radio-active and associated materials - Polymerization and copolymerization products - Antibiotics and other pharmaceutical products - Nuclear reactors - Automatic data processing machines & Units - Telecommunications equipment - Semiconductor devices - Electronic microcircuits - Electronic measuring instruments - Electric power machinery and apparatus - Internal combustion piston engines - Aircraft & associated equipment - Medical instruments - Optical instruments - Photographic apparatus and equipment

6) Scale Intensive (106 product groups)

Paper and paperboard - Organic chemicals - Inorganic chemical products - Other chemical materials and products - Medicinal and pharmaceutical products - Petroleum products - Rubber manufactures - Non-metallic mineral manufactures - Iron and steel - Non-ferrous metal products - Television, radio, other image-sound recorder and reproducers - Household type electrical equipment - Ships and boats - Railway vehicles & equipment - Road vehicles

7) Specialized Suppliers (43 product groups)

Agricultural machinery - Machine tools for working metals - Metal working machinery - Other machine tools for specialized particular industries - Construction and mining machinery - Textile and leather machinery - Paper and paperboard machinery - Other machinery for specialized particular industries - Other general industrial machinery & equipment - Electrical equipment and components - Measuring, checking, analysing instruments - Optical goods - Other miscellaneous products

8) Traditionals or Supplier dominated (76 product groups)

Textile products - Articles of apparel and clothing accessories - Leather manufactures - Footwear - Wood manufactures - Furniture - Paper and printed products - Article of ceramic materials - Glass products - Miscellaneous manufactures of metal (structures, tools, cutlery and other articles) - Jewellery, goldsmiths - Imitation jewellery - Musical instruments - Sporting goods - Toys & games - Other miscellaneous products

9) Residuals (18 product groups)

Other product groups n.e.s.

A complete list of the products included in each group could be provided on request by the author.

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MANAGING TRADE CONFLICT IN HIGH-TECHNOLOGY INDUSTRIES

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Managing Trade Conflict in High-Technology Industries

by

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This paper contains excerpts from a book entitled Managed and Mismanaged Trade in High-Technology Industries: Lessons for US Policy in the 1990s to be published by the Institute for International Economics in the fall of 1991. The author is grateful to the Institute and to the Sloan Foundation for financial support.

I. Trends in High-Tech Competition Among the Developed Countries

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 Intra-industry 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 which 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 intra-industry 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 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

¹Trade in manufactured products accounts for some 85% 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.

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 intra-industry 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% of the world's R&D expenditures and 69% of the world's R&D personnel were located in five industrial countries--the U.S., Japan, France, the United Kingdom, and West Germany. With the addition of five smaller European countries the shares rise to 91% and 84% respectively.⁵

In the twenty years between 1966 and 1986, technology-intensive goods (as measured by the

²For a recent popular discussion of how differences in the organization of national economies affect their competitive position in international trade see Michael Porter, The Competitive Advantage of Nations, (New York, NY: The Free Press, 1990).

³The same conclusion is reached in a recent paper by Sylvia Osury entitled "Beyond the Border: The New International Policy Arena," prepared for the OECD Forum for the Future, (Paris, France: OECD, October 1990) and in her earlier book Governments and Corporations in a Shrinking World, (New York, NY: Council on Foreign Relations, 1990).

⁴Any 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 US 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 medicines (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 282). OECD data for the US represented 96% and 100% of DOC data for the US in 1980 and 1986 respectively. National Science Board, Science and Engineering Indicators, 1989 (Washington, DC: Government Printing Office, 1989).

⁵John H. Dunning, "Multinational Enterprises and the Globalization of Innovative Activities." Discussion Paper in International Investment and Business Studies B, III, 143, Department of Economics, University of Reading, 1990.

OECD) climbed from 14% to 22% of world manufactured exports.⁶ In 1987, about 42% 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.⁷

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 accounting for about 94% of the Japanese market for high-technology products in 1985. The comparable domestic supplier shares for the U.S., France and West Germany for that year were 84%, 60% and 43%.⁸

Between 1970 and 1987, there were significant changes in the competitive positions of the US, the European countries, and Japan in high-technology trade. (Tables 1, 2, and 3). The share of Japanese producers in world exports of science-based industries more than doubled from about 8% to about 16% while the share of American producers declined from about 29% to about 20% during this period.⁹ The erosion of the US share was greatest in electronics, as a consequence of the rapid and strong rise first of Japan and more recently of the East Asian NICs. (Table 4)

The European Community's share in world exports of science-based sectors also declined from about 45% in 1970 to about 38% 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

⁶Sylvia Ostry, "Beyond the Border: The New International Policy Arena," OECD Forum for the Future, (Paris, France: OECD, October 1990).

⁷These numbers are taken from National Science Board, Science and Engineering Indicators, 1989 (Washington, DC: Government Printing Office, 1989), Table 7-11, p. 377.

⁸National Science Board, Science and Engineering Indicators, 1989 (Washington, DC: Government Printing Office, 1989), Table 7-5, p. 374.

⁹Science-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 US, 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 Paolo Guerrieri, "Technology and International Trade Performance of the Most Advanced Countries." Forthcoming BRIE Working Paper, University of California, Berkeley, 1991.

sector of the science-based group.

Technology-intensive industries have been a source of recurrent trade friction between the US 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 and/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 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.¹⁰

¹⁰The literature on the new trade theory is large and growing. Several excellent papers are included in Paul R. Krugman, ed., Strategic Policy and the New International Economics (Boston, MA: MIT Press, 1986). For a recent summary of the major conclusions of the theory, see Krugman, "Is Free Trade Passe?" Journal of Economic Perspectives 1 (Fall 1987): 131-44. For a complete technical treatment of the theory, see Elhanan Helpman and Paul R. Krugman, Market Structure and Foreign Trade: Increasing Returns, Imperfect Competition, and the International Economy (Boston, MA: MIT press, 1985).

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 via 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 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 U.S. 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.¹¹

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

For one of the earlier theoretical pieces that focused on high-technology industries, see James Brander and Barbara Spencer, "Export Subsidies and International Market Share Rivalry," *Journal of International Economics* 18 (February 1985): 83-100. Although the strategic trade theory literature 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 policies often reduce national welfare. See J. David Richardson, "Empirical Research on Trade Liberalization with Imperfect Competition," *OECD Economic Studies* 12, (Spring 1989): 8-44.

¹¹The result 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 D.C. Mowery, "New Developments in US Technology and Trade Policies: Declining Hegemon, Wounded Giant, or Ambivalent Gulliver?" Working Paper 90-1, Consortium on Competitiveness and Cooperation, Center for Research in Management, University of California, Berkeley, April 1990.

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.

II. Trade Barriers, Structural Impediments and Structural Differences as 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 non-border 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 things like 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 in high-technology industries because they are actively used to build national or regional production bases in such industries.

Other trade conflicts in technology-intensive industries, however, do not involve border or non-border "trade barriers." Rather they involve 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

U.S. in its recent bilateral negotiations with Japan.

Broad structural differences can influence the terms of international competition in global high-technology industries in two basic 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 U.S. 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.¹²

III. Trade Barriers, Structural Differences and New Multilateral Rules for Technology Trade: A Long-Term Agenda

Traditionally, the U.S. has followed a rules-based approach in its multilateral and bilateral

¹²As 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, The Competitive Advantage of Nations.

trade negotiations. Even the aggressive unilateralism of the US 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 GATT had huge loopholes in product coverage and in the specification of bidding procedures. Only about one-half of worldwide government purchases were open to competitive bidding after the code was negotiated.¹³ 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 U.S. 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 European Community's 1992 rules.

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 anti-dumping 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 which include credible sanctions for rule violations. The only way to reduce overt non-tariff 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

¹³Robert W. Jerome, ed., Issues in the Uruguay Round: US Trade Law Changes: Risks and Benefits (Washington, D.C.: Economics Strategy Institute, 1990).

partners are giving reciprocity--i.e., are complying with the rules--is to have an effective, enforceable means of adjudicating claims of violation. At this point and for the foreseeable future, GATT has neither all of the rules nor the necessary means of adjudication.¹⁴

Moreover, even precise and enforced rules about overt trade barriers are not sufficient. Rules are also required to reduce structural impediments--structural differences among nations that affect the accessibility of different national markets to trade and investment flows and that affect the terms of competition in the international marketplace.

These structural differences make a rules-based approach to liberalizing trade a much more complex task, involving negotiations about business and government practices which although motivated by domestic economic and political considerations have unintended but nonetheless wide-reaching effects on trade. Thus the MOSS talks between the US and Japan in the mid 1980s involved negotiations about such non-tariff impediments to trade as national testing and certification requirements for telecommunications equipment and Japan's National Health Insurance Reimbursement system, while the SII talks involved such domestic policy issues as land use, infrastructure spending, and retail distribution systems in Japan, and education policy and credit-card use in the U.S. The broader the range of policy areas included in trade negotiations, the larger the community of policy-makers 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 in such a world is how to determine which national policy differences are the appropriate focus of international 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, anti-dumping

¹⁴Robert E. Hudec, "Dispute Settlement," in Jeffrey Schott, ed. Completing the Uruguay Round: A Results Oriented Approach to the GATT Trade Negotiations (Washington, D.C.: Institute for International Economics, 1990).

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, electric power and 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."¹⁵ This broad definition would cover national PTTs as well as multinational entities, like 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*¹⁶

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

¹⁵For a discussion of the European Community proposal, see The Financial Times, August 3, 1990, p. 16.

¹⁶The following discussion of intellectual property protection draws heavily on Jeffrey J. Schott, "The Uruguay Round: What Can Be Achieved," and Keith Maskus, "Intellectual Property," in Schott, ed. Completing the Uruguay Round.

through lax enforcement.

New international rules are needed to supplement existing international treaties, administered primarily under the World Intellectual Property Organization (WIPO). 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).

International rules should set minimum standards and enforcement procedures to bolster protection of patents, copyrights, trade marks, 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 first 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.¹⁷

Anti-Dumping Procedures

The appropriate objective for anti-dumping regulations is the prevention of predatory pricing—a particular type of anti-competitive business behavior which involves short-run price cutting in an effort to exclude rivals in order to 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

¹⁷The problems of Section 337 of US 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.

behavior for that matter--is a set of supranational rules on competition policy to regulate anti-competitive 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 anti-dumping 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 anti-dumping laws for anti-competitive or protectionist purposes and too lenient to prohibit efforts by predatory sellers to circumvent anti-dumping duties. The basic objective of new rules should be the adoption of more precise, uniform, and transparent national anti-dumping 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.¹⁸ 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.¹⁹

At a minimum, tighter international regulations should be imposed on national methods for

¹⁸ 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.

¹⁹ Under current practice, both the US 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.

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 upon the false precision of constructed cost and FMV concepts, the application of anti-dumping 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 profits 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.²⁰

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 anti-dumping complaint. Price undertakings, which are explicitly allowed under current GATT regulations, encourage price floors and cartel-like arrangements. Ironically, as presently 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 anti-dumping 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 anti-dumping procedures. U.S. procedures require extensive judicial review by the ITC 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.²¹ Both the U.S. and

²⁰The 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 discussions. Such a concept while sensible in intent is problematical in implementation. It is difficult to come up with measures of life-cycle costs and prices with even the most sophisticated techniques.

²¹Some of the procedures used in the application of dumping laws in other nations are even less transparent and more subject

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 anti-dumping 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.²²

The new international dumping code also needs provisions relating to the effective enforcement of anti-dumping 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 U.S. and Europe have already experimented with unilateral anti-circumvention efforts, and 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.²³

Finally, if and when supranational rules on competition policy come into effect, there should be some international mechanism for examining the competitive effects of national anti-dumping 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 anti-competitive behavior. Predatory pricing can only succeed when markets do not function properly.

To determine whether such pricing decisions have predatory intent, it is necessary to analyze

to abuse.

²²These objectives are especially important for American export interests. Currently, European and American companies are the most frequent targets of anti-dumping suits. US-based exporters face less transparent systems abroad than foreign producers face in the US.

²³To deter repeated dumping by particular producers in a single or related product lines, anti-circumvention rules may have to be combined with rules for special penalties for demonstrated recurrent "dumpers." This is the approach suggested by the US and Europe in the Uruguay Round discussions.

the market situation and the business practices of the producers in question. This requires an anti-trust 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 anti-dumping 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 those cases which survive the first tier, a multifaceted inquiry would be required, focusing on the relationship between prices and costs, and examining what factors are behind the observed pricing behavior.²⁴

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 for technology-intensive industries should be the restriction of infant-industry support programs by mature industrial economies. As a general principle, mature economies are too old to have infants. The definition of an infant-industry support program is comparable to the definition of industrial targeting suggested by the U.S. 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/or export credits.

New international rules are required to restrict such programs and when they are allowable, to

²⁴OECD, Predatory Pricing (Paris, France: OECD, 1989).

require that they be made available to foreign firms on the same terms as domestic firms. Ideally, any new code must include sub-federal and parastatal subsidies as well as federal ones. In addition, it should be possible to bring action against subsidies that encourage investment at an early stage, when plant location and development are being decided. By the time an investment decision has been made, the injurious effects of the underlying subsidies are much more difficult to offset. Finally, because of the frequent use of mixed-credits as an export subsidy, these credits should be strictly limited or treated as a prohibited export subsidy item altogether.

The research and development area poses a number of vexing problems for new international rules on infant-industry promotion. The presence of externalities has long provided a rationale for government subsidies for basic research. But, in Japan and Europe, and increasingly in the U.S., government subsidies are extended to pre-competitive 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 "pre-competitive" research and provided no other signatory to a subsidy agreement can demonstrate an adverse effect.²⁵

To establish binding disciplines on R&D subsidies, it is first necessary to get international agreement on precise distinctions between basic, pre-competitive and applied research.²⁶ But, according to most scientists and technologists, precise distinctions do not exist, so the control of R&D subsidies will require prior negotiation 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 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

²⁵Note that the Cartland draft for discussion of subsidies in the Uruguay Round argues that subsidies for the purpose of regional development, pre-competitive 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.

²⁶According to what appears to be the current working definition in US policy circles, R&D is pre-competitive when the results of research can be published and used without restriction.

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 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—vying with one another 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;²⁷ 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 anti-dumping clarification to attract semiconductor investment comes immediately to mind.

²⁷For a fascinating discussion of the many factors that influence the attractiveness of a nation for foreign direct investment, see John H. Dunning, Bruce Kogut, and Magnus Bloomstrom, Globalization of Firms and the Competitiveness of Nations (Lund, Sweden: Institute of Economic Research, Lund University, 1990).

Broader multilateral rules are needed to restrict national policies, like regional development subsidies and implicit or explicit local content requirements, that are routinely used to attract foreign direct investment. Without multilateral disciplines, the world is in a classic prisoners' dilemma--each nation is tempted to act on its own, but if everyone does, the danger is that everyone will be worse off. At the very least, if all countries continue to compete for the high-tech production of global companies--an outcome which seems likely--then such competition should be disciplined by a international framework that rules out zero-sum behavior.²⁸

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 oligopolists, 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

²⁸For a more complete discussion of the kinds of international rules that may be needed in the FDI area, see Fred Bergsten and Edward H. Graham, "Global Corporations and National Governments: Are Changes Needed in the International Economics and Political Order in Light of the Globalization of Business?" unpublished Working Paper, Institute of International Economics, 1991.

companies is protected from such attempts.

Of all the structural differences among nations, differences in competition policy may be the most significant in terms of their 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.

Even where national laws appear to be similar in substance--as in merger law in the U.S. and Europe--there are wide variations in interpretation and application.²⁹ A general prohibition against mergers that "substantially lessen competition" leaves ample scope for discretion on the part of the relevant national authorities. Moreover, behind different interpretations of remarkably similar laws lie different weights on such goals as efficiency or equity and different judgments about the optimality of the market. Both the Europeans and the Japanese believe that competition can be excessive and that cooperation may sometimes be required to realize the benefits of the market. The evolving antitrust laws of the European Community are principally designed and used to create a single functioning market, not to limit firm size or to promote competition when it threatens the unified market objective. And the distinctive "contestable markets" approach to the application of anti-trust law in the U.S. in the 1980s appears to have won few foreign converts.

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--via widely differing national antitrust channels and via trade disputes among national governments which are sometimes forced to represent the interests of their national firms, even when those interests do not conform to the interests of the nation.

²⁹For more on these points see Sylvia Ostry, "Beyond the Borders: The New International Policy Arena," Barry E. Hawk, "The American (Anti-trust) Revolution: Lessons for the EEC?" ECLR National Reports 1988; and George A. Hay, "Competition Policy," Oxford Review of Economic Policy, 1, 3.

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, anti-dumping 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.³⁰

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 US decision makers.

IV. 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 collapse of the Uruguay Round over 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 anti-competitive 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.

³⁰ 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 via trade and cross-border investment. The main challenge is to harmonize those differences which impede such competition and therefore impede a healthy competition between different forms of economic organization.

Anti-dumping Laws

During the 1980s, recourse to anti-dumping laws became increasingly popular for American and European companies alike, particularly in their dealings with East Asian competitors.³¹ In addition, dumping increasingly became defined not as selling below an actual home market price but selling below a constructed measure of production costs.³² Often, a dumping determination 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% profit markup.³³

If and when 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 his 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—to deter predatory behavior by foreign firms—is utterly 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.

³¹For evidence, see Patrick Masserlin, "Anti-dumping," in Schott, Completing the Uruguay Round.

³²For example, according to the Department of Commerce, approximately two-thirds of anti-dumping 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.

³³At 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.

Under current procedures, the only restraint on the anti-competitive use of the dumping law is the extensive judicial review required by the ITC and the allowance for disclosure of detailed information by exporters and importers alike. This restraint does not exist in the European procedures, so it is not surprising that they have become a powerful anti-competitive factor.

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 which is injurious or threatens to be injurious but which is not predatory and which is 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 or countervailing subsidy 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 nation's trade law, which is designed to provide import relief, regardless of the underlying case of import damage.

Finally, dumping which 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 which 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. Penalties or damages should be assessed and collected on foreign companies for the injury done to domestic companies by dumping from the time dumping is initiated until it is terminated. Under certain conditions, such as dumping by repeat offenders or evidence of predatory intent, collusive behavior, or foreign government support of dumping practices, the law should allow for both actual and punitive damages. Punitive damages appropriately reflect the notion of the damages inflicted on domestic companies by the "anti-competitive," predatory behavior of foreign companies or governments.

The U.S. should also continue to clarify and strengthen its regulations to deter the establishment of assembly operations or the fictitious introduction of new products by foreign companies to circumvent the nation's dumping laws.

Modifying 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 anti-competitive 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.

Even with the modifications to the nation's dumping laws proposed here, Japanese firms would have been found guilty of dumping in televisions in the 1970s and in semiconductors in the 1980s. In the case of televisions, the policy error was not the finding of dumping but the politically-motivated decision not to collect the assessed dumping penalties for the entire 1972-77 period.³⁴ In the case of semiconductors, the policy error was not the finding of dumping but its timing and the remedy chosen. The remedy in EPROMs worked, because it was applied early enough and in competitive enough market conditions that it deterred dumping and encouraged competition.³⁵ But the remedy in DRAMs

³⁴Originally, these duties were assessed at \$328 million by the US Treasury Department. Under substantial Japanese lobbying and political pressure, this assessment was reduced to \$138.7 million in 1980, and a further settlement between the US and Japanese governments reduced this amount to \$77 million of which only \$16 million was ever collected. For full accounts of the television story, see Pat Choate, Agents of Influence (New York, NY: Knopf, 1990) and Kozo Yamamura, "Caveat Emptor: The Industrial Policy of Japan," in Paul Krugman, ed., Strategic Trade Policy and the New International Economics (Cambridge, MA.: MIT Press, 1986.)

³⁵For a detailed discussion of the effects of the semiconductor trade agreement on EPROM and DRAM prices, see Laura

was too late and had distinctly anti-competitive effects in prevailing market conditions, effects which worked to the advantage of the dumping firms.

Ironically, since it was the government that brought the dumping case in 256K DRAMs, it was the government, not the private firms, that was responsible for this costly policy error. As this case also demonstrates, even when dumping is established, the appropriate remedy may be something quite different from dumping margins or a negotiated agreement which amounts to a price undertaking by foreign firms.

In the DRAM case, the national interest would have been better served by some kind of countervailing subsidy to offset the injury to domestic DRAM producers by Japanese dumping. The cost of such a subsidy could have been partly defrayed by the dumping margins and penalties imposed on the Japanese companies. Moreover, the introduction of such a subsidy might have had a lasting effect on the strategies of the Japanese companies. A credible commitment by the U.S. government that it was prepared to support a domestic DRAM capacity against a predatory attack by the Japanese would undoubtedly have affected their motivations for launching such an attack.

In neither the television nor the semiconductor case were the Japanese firms compelled to pay penalties to the American companies for the damages resulting from their predatory behavior. Unfortunately, in both cases, despite compelling evidence of dumping by the Japanese companies, the application of the nation's dumping laws worked to their advantage and harmed both private and public interests at home.

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.³⁶

Tyson and David Yoffie, "Semiconductors: From Manipulated to Managed Trade." Discussion Paper, Harvard Business School, Seminar on Global Trade and Competition, April 1991; forthcoming as a BRIE Working Paper.

³⁶I.M. Destler, "US Trade Policy Making in the Eighties," forthcoming in Alberto Alessena and Geoffrey Carliner, *The*

The first-best solution to the problem of trade distortions caused by foreign subsidies would be new international agreements to restrict them. The U.S. has sought this first-best solution in international negotiations, by pushing for stricter multilateral regulations on allowable subsidies—both their kinds and amounts. The U.S. approach rests on the presumption that it can come to an agreement with its trading partners about allowable subsidies.³⁷ But this outcome, while laudatory in intent, is difficult to realize in practice.

Subsidies reflect fundamental philosophical differences regarding the 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 U.S. 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 result in the full burden of the duty being borne by the foreign suppliers, does not

Politics and Economics of the Eighties, (Cambridge, MA: NBER, 1991).

³⁷When international agreements identify certain subsidies as "green-light" or allowable subsidies, the importing country cannot impose a CVD. So to the extent that the US realizes its objective of limiting certain kinds of subsidies in the Uruguay Round, it correspondingly limits the application of its own CVD law.

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 strategic trade theory literature 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 which 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 U.S., performing the last manufacturing stage in a third country, or altering the product.

For all of these reasons, a CVD remedy is unlikely to be an effective offset to 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.

An alternative to the CVD approach is the countervailing subsidy (CVS) approach—an approach which 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 for all of the reasons noted earlier—then a CVS approach may be a defensible and sensible second- best solution.

Such an approach has very different budgetary implications from a CVD approach in the short

run—the former uses government funds while the latter provides them. But the ultimate cost to the U.S. economy of cutbacks in an industry resulting from a successful foreign targeting program are likely to be far greater than CVS support to deter such a program or offset its long-term effects. Moreover, if the U.S. made a credible commitment to a CVS strategy in one or two key industries, such as semiconductors and computers, it is quite likely that this would permanently reduce both the incentives of foreign governments to undertake targeting programs in these or other industries and the incentives of foreign companies to expand in response to such programs. For a short-term cost, the U.S. might gain a long-term strategic benefit.

Ironically, the current U.S. position in international subsidy negotiations makes it more difficult for a CVS approach. If the U.S. gets its way, it is likely that Sematech, which can be viewed as a kind of belated CVS strategy in semiconductors—albeit a small one—would be disallowed under stricter multilateral restrictions on subsidies. It is hard to make a convincing case that Sematech is a form of "pre-competitive R&D support." If the U.S. succeeds in its subsidy initiatives at the multilateral level, it may be forced to drop one of the few CVS programs it has.

Section 301 and Super 301

Section 301 and "Super 301" are the major channels within U.S. trade law for addressing unfair trading practices. Section 301, which was introduced in the 1974 Trade Act, deals with disputes in particular goods, while "Super 301," which was introduced in the 1988 Trade Bill, deals with disputes with individual countries on a broad range of unfair trading practices.³⁸ Both parts of the law allow the U.S. government to identify a particular trading practice as violating U.S. law, even when such a practice is not currently proscribed by GATT, and to retaliate on a unilateral basis.

"Super 301" contains an extensive list of possibly unfair and inequitable practices, including industrial targeting and the toleration of systematic anti-competitive business practices. Countries identified as guilty of unfair trading practices under Super 301 have to reach agreement with the USTR within 12 to 18 months after such a designation or face U.S. retaliation. For example, in the first

³⁸For some critical assessments of both Section 301 and Super 301 see Jagdish Bhagwati and Hugh Patrick, eds., Aggressive Unilateralism, (Ann Arbor, MI: University of Michigan Press, 1990).

application of Super 301 in 1989, three countries--Japan, India and Brazil--were named as unfair trading partners, eight countries were put on a priority watch list because of their allegedly inadequate protection of intellectual property, and another seventeen were told that they were being kept in mind for similar treatment. Before these lists were even announced, Taiwan and South Korea made substantial trade concessions to avoid the unfair trading designation which they anticipated.

Section 301 and Super 301 have been criticized on two grounds--their unilateralism and their threat of retaliation. Both allow the U.S. government to determine what is "fair" and what is not, bypassing GATT at will. Both allow for remedies that can violate three basic principles of GATT: reciprocity, because the U.S. can demand a reduction of a foreign trade barrier without offering a reduction of one of its own; nondiscrimination, because the U.S. can block or threaten to block imports from a single country; and transparency, because a trade dispute can be settled by some kind of non-tariff intervention in trade flows. And both call for retaliation if a trade dispute is not satisfactorily resolved. Indeed, Super 301 mandates the unilateral imposition of retaliatory tariffs when negotiations fail--a clear violation of GATT's nondiscrimination principle.

Critics of unilateralism argue that trade concessions granted to the U.S. under the gun of compulsory negotiations can create negative spillover effects on third parties. So far, however, the U.S. has been careful to use 301 and Super 301 to negotiate for nondiscriminatory, MFN 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.³⁹ Indeed, Super 301 has been used by the U.S. as a bargaining chip to press for such reforms.

But the main defense of 301 and Super 301 is that they are essential as interim measures--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 cause substantial damage to national economic

³⁹In fact, as Robert Hudec has argued, it is conceivable that US unilateralism may overcome the negotiating inertia currently blocking reforms of the GATT dispute-settlement mechanism--in his words, the US breach of GATT law may actually result in an improvement of this law in the long run. See Hudec, "Dispute Settlement."

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.

The Super 301 approach takes this option a step further by calling for the U.S. government to adopt "priorities" in its identification of countries and industries in which trade barriers or structural impediments cause the most harm to American interests. By enshrining the priority concept into the nation's law, Congress pushed the Administration to develop a strategy, something it should have been doing all along. Prior to the enactment of Super 301, U.S. trade policy was largely reactive—with the U.S. government responding to the political pressure of American companies. The response was usually too little, too late. Moreover, the strategic message to the nation's trading partners was loud and clear—until their practices had inflicted serious damage on U.S. industry, the U.S. government would look the other way.

Despite their merits, 301 and Super 301 have obvious dangers. The possible threat to multilateral cooperation has already been noted. The process of determining which countries, practices, and industries get on the priority list for negotiation is a political one, as is the process of determining when a country has made sufficient concessions to be dropped from the list. Although Super 301 calls for a strategic approach to trade priorities, the political process could easily undermine such an approach. But the greatest danger to both 301 and Super 301 is that they can be used for protectionist purposes—to close off domestic markets and reduce competition rather than to open foreign markets and increase competition. Indeed, their most vehement detractors see these sections of U.S. trade law as simply protectionism in another guise.

But the available evidence does not support this conclusion. By and large, the 301 approach has been used to open foreign markets. Indeed, the greater use of this approach in the 1980s marked a change in U.S. trade policy from a purely defensive stance concerned about high imports to a more offensive stance concerned about high exports and foreign market access. The MOSS talks, the U.S.-Japan agreements on the access of Motorola, Cray Computer, and Allied Signal to the Japanese

market, and the market access part of the semiconductor trade agreement are not protectionist by intent or design. A similar conclusion applies to the effects of Super 301 in other areas. The overall assessment seems to be consistent with the evidence from these cases--Super 301 has worked not least because it has been used with intelligence and restraint.

IV. Rules and Outcomes: Managed Trade as a Second-Best Alternative⁴⁰

An important ingredient of Super 301's success has been the continued U.S. focus on negotiating rules rather than outcomes. A "rules-based" approach should always be the first approach in trade negotiations. However, the distinction between rules and outcomes is often not clear-cut.

At one end of the negotiating continuum are general rules that are broadly applicable across all industries and trading partners and that are weakly enforceable. At the other end of the continuum are specific quantitative results which apply to specific industries and specific trading partners and which are enforced by the threat of penalty. As trade negotiations move along the continuum from rules to results, the rules become much more precise, covering specific practices in specific industries by specific trading partners. And the enforcement mechanisms become more powerful. The more precise the rules and the more effective the enforcement mechanism, the greater the influence of a trade agreement on market outcomes.

US experience supports two conclusions about the rules-results debate as it pertains to technology-intensive industries. First, to be effective, rules often require a degree of precision only possible at the industrial level and only achievable through bilateral negotiations. MOSS-type talks that have a sectoral focus and that involve a relatively small number of trading partners are more likely to be effective than either SII-type talks that deal with broad policy issues or multilateral talks that attempt to harmonize structural impediments among a large group of countries with different levels of development and different policy objectives and institutions.

Second, under exceptional circumstances, when rules-based negotiations fail to reduce trade barriers or structural impediments that are costly to American economic interests, the second-best

⁴⁰For a more complete discussion of the pros and cons of managed trade in high technology industries, see Laura D'Andrea Tyson, "Managed Trade: Making the Best of Second Best," in Robert W. Lawrence and Charles L. Schultz, eds., *An American Strategy* (Washington, DC: The Brookings Institution, 1990).

alternative may be a managed-trade agreement specifying results. The results-approach should be used sparingly and only to open foreign markets, not to close the domestic one. In other words, managed trade should be limited to agreements requiring import expansions abroad--so-called voluntary import expansions (VIEs)--rather than to agreements requiring import reductions at home--usually in the form of voluntary export restraints (VERs). Although both types of agreements tend to be attacked by economists, the arguments against the latter are more compelling than the arguments against the former.

VERs and other forms of quantitative import restraints are clearly protectionist in nature and design. The extensive empirical evidence on such arrangements confirms their many negative effects, including: higher prices for both domestic and foreign goods, frequently accompanied by higher wages and salaries of protected domestic producers; higher profits for foreign producers that allow them to increase their investment and R&D and that provide incentives for them to move to other locations or to higher value-added products to escape the quantitative limits of the agreement; the erosion of competition at home and abroad through the promotion of cartel-like arrangements among domestic and foreign producers; the weakening of market incentives for industry rationalization and productive international specialization; the creation of vested interest groups and rent-seeking behavior; and spillover effects on suppliers and markets not covered by the agreement.⁴¹

Politically, export restraints are an understandable stop-gap response to the threats to domestic producers caused by imports. They are, however, hard to defend economically. And they are poorly designed to realize their objectives, since the higher profits they generate for foreign suppliers work to their advantage in future rounds of competition. In addition, such restraints are rarely accompanied by programs to rationalize and strengthen the protected domestic industry for such competition. The protected producers are left to decide how to use their higher prices and profits, but protection blunts the incentives to use higher returns wisely.

Economically, temporary tariffs or quota auctions are preferable to exports restraints as a tactic

⁴¹For detailed case studies of many of these effects in the US, see Gary Clyde Hufbauer, Diane T. Berliner, and Kimberly Ann Elliot, Trade Protection in the United States: 31 Case Studies (Washington, DC: Institute for International Economics, 1986).

to safeguard domestic producers.⁴² Quota auctions allow foreign producers to compete with one another for shares of an overall import quota. In theory, the low-cost producers will be able to offer the highest bids. This will limit the anti-competitive effects of the quota and will hold down its price effects. Moreover, both the tariff and the auction approach mean that at least part of the higher revenues resulting from protection will go to the government imposing protectionist measures. These revenues can be used to support a restructuring program or countervailing subsidy for domestic producers.

Although it is hard to defend voluntary export restraints from an economic perspective, the economic case against voluntary import expansion restraints (VIEs) is weaker and less well documented. A VIE sets a target for the minimum share of a given national market to be supplied by foreign producers. To date, there are few managed trade agreements that embody VIEs. The semiconductor trade agreement negotiated between the US and Japan is a notable exception.⁴³ But VIEs are likely to become more important in the future in high-technology industries as part of new attention to issues of "fair market access" and selective reciprocity.

VIE's only make sense when there is compelling evidence that a combination of policies and structural impediments make a particular national market inaccessible to foreign producers. This was certainly the case in the Japanese markets for semiconductors, telecommunications equipment, supercomputers, and a variety of other products at important points in their development.⁴⁴ At least by intent, VIEs are designed to stimulate competition where it is effectively excluded—not to reduce competition where it already exists.

Opposition to VIEs as a form of managed trade rests on three grounds: that they result in the

⁴²For a complete analyses of auction quotas, see C. Fred Bergsten, Kimberly Ann Elliot, Jeffrey J. Schott, and Wendy Taka, Auction Quotas and United States Trade Policy (Washington, DC: Institute for International Economics, 1987).

⁴³If Japan agrees to open a share of its protected rice market to imports, the resulting agreement will be another example of a VIE. Other VIEs include US-Japan agreements on beef, citrus, and other food products, and a Tokyo Round agreement with the EEC on high-quality beef. Other VIE-like activities include Commerce Department jawboning of the Japanese automakers to buy more US parts and those parts of the FSX deal that substituted purchase of US goods for goods that would have been built in Japan.

⁴⁴For evidence on continuing Japanese efforts to nurture high-technology production see Chalmers Johnson, Laura D'Andrea Tyson and John Zysman, eds., Politics and Productivity: How Japan's Development Strategy Works (New York, NY: Ballinger Press, 1989) and Marie Anchordoguy, "Japanese Industrial Targeting: A Challenge to Free Trade?" Working Paper, University of Washington, May 1990.

cartelization of markets for specific products; that by limiting competition, they raise prices for these products; and that by violating the nondiscrimination principle of the GATT, they undermine the world trading system. All three of these arguments are subject to qualification on analytical grounds alone, and none of them seem to be confirmed by the results of the US-Japan Semiconductor Trade Agreement.⁴⁵

First, the establishment of a minimum import or purchase target by a particular country from the companies of one or more of its trading partners is a far cry from an industry cartel. Indeed, if the target applies to a country and an industry in which there is ample evidence of market closure—an essential precondition for the imposition of a VIE—and if the target applies broadly to sales from all foreign suppliers or the most important foreign suppliers rather than sales from a specific supplier, then the VIE may actually increase competition. From a static perspective, the target may look like nothing more than a buyer's cartel or a tax on the importing country. But from a dynamic perspective, the target may set in motion changes in supply and demand behavior that can increase competition in both the importing country and the world market. There is evidence of such dynamic, pro-competitive effects in the Japanese and global semiconductor markets as a result of the semiconductor trade agreement.⁴⁶

Second, because of the potential for greater competition resulting from VIEs, their long-run effects on prices are uncertain. Indeed, if a VIE encourages more competition among suppliers and

⁴⁵For a detailed discussion of the content and consequences of the agreement see Laura Tyson and David Yoffie, "Semiconductors: From Manipulated to Managed Trade."

⁴⁶Developments in the Japanese semiconductor market show evidence of such pro-competitive, dynamic effects as a result of the agreement. On the supply side, several American producers anticipating at least a minimum share of the lucrative Japanese market have increased their investments in sales, distribution, technical support facilities, and production capabilities in Japan. In addition, both Korean and European suppliers have been able to increase their presence in the Japanese market. The credible long-term threat of the Korean suppliers was one of several factors that broke the Japanese pricing cartel in DRAMs in 1990.

On the demand side, Japanese users of semiconductors have increased their purchases from foreign suppliers, and the share of these suppliers in the total Japanese marketplace has increased, especially during the last two years. Even more important to the long-run dynamics of the market, Japanese users are now more willing to entertain bids and design in products from American suppliers. Several American companies have reported instances of winning contracts that they would not even have been able to bid on in the absence of the agreement pressure. These bidding opportunities are especially important for producers of ASICs, products in which US companies still have significant competitive advantages. The agreement has served to break down some of the usual keiretsu impediments that have traditionally advantaged Japanese suppliers over American suppliers of such products.

more choice for demanders, prices may fall rather than increase at least in the long run.⁴⁷

Finally, even though VIEs may be sector-specific and country-specific, they may be liberalizing over time. In the case of the SCTA, the target for market access in Japan covers "all foreign-capital affiliated firms." And the evidence suggests that the agreement has benefited all foreign suppliers--between the end of 1986 and the second quarter of 1990, the share of European, Korean and Taiwanese producers in the Japanese semiconductor market more than doubled.

In high-technology industries, where trade barriers and structural impediments remain strong, and where even temporary exclusion from foreign markets can have long-term dynamic effects, import expansion agreements setting quantitative targets for market access by excluded foreign producers are not dismissable as a second-best alternative. Given the long lags involved in negotiating new multilateral rules and governance institutions, a VIE may sometimes be a wise interim policy response with unexpected benefits for long-term competition.

V. 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 "non-border" 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 US trade policy negotiations at the multilateral level. The goal of US trade policy should remain more and freer trade, safeguarded by new international rules. In pursuing this goal, however, US policymakers must be mindful of the fact that the process of developing such rules will be a slow one.

⁴⁷The price effects of the semiconductor trade agreement were the result of its anti-dumping provisions, not its market access provisions. Nonetheless, the evidence does suggest that the agreement resulted in more competition in the EPROM market and that greater competition prevented a major price hike in the market in response to the anti-dumping provisions.

In the interim period, the US will continue to face the challenge of preventing further erosion in its relative economic position. To meet this challenge, US policy makers 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 large 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.

Table 1

Shares of Selected Countries and Areas In World Trade In Science-Based Sectors

	1970	1973	1976	1979	1982	1985	1987
<i>Ratio of national exports to world exports (percent)</i>							
OECD	96.25	94.63	92.3	88.63	87.33	85.03	83.81
United States	29.25	25.39	24.41	22.46	25.17	23.87	19.86
Canada	4.87	3.63	3.09	2.06	2.39	2.53	2.15
Japan	7.81	9.07	9.61	10.37	11.6	14.75	16.16
EEC (9)	44.61	46.66	46.15	45.69	41.15	37.14	38.15
(a)	31.62	32.49	32.67	31.45	27.83	24.58	23.83
Germany, Fed. Rep.	15.85	17.33	16.19	15.37	13.83	12.04	13.13
(a)	11.08	12.04	11.28	10.01	8.82	7.62	8.21
France	6.81	7.31	8.61	8.67	7.76	6.73	7.01
(a)	4.41	4.65	6.39	6.15	5.79	4.81	4.58
United Kingdom	9.87	9.48	8.74	9.72	8.93	8.09	7.23
(a)	8.61	8.16	7.23	8.15	7.17	6.01	5.28
Italy	4.61	4.07	4.05	3.81	3.69	3.55	3.55
(a)	2.95	2.89	2.97	2.73	2.72	2.58	2.16
Other EEC (9)	7.48	8.47	8.56	8.12	6.94	6.72	7.22
Greece, Portugal, Spain	0.41	0.58	0.63	0.73	0.88	0.92	0.97
EFTA	9.12	8.91	8.17	7.09	5.88	5.58	6.26
Non-OECD Countries	3.29	4.91	7.26	9.52	11.35	13.35	15.43
Middle East	0.21	0.27	0.42	0.44	0.78	0.79	0.68
NICs in Asia	1.04	2.32	3.75	4.76	5.42	7.61	9.29
China	0.04	0.07	0.11	0.11	0.16	0.24	0.47
Other Asian Countries	0.22	0.31	0.72	1.25	1.61	1.72	2.15
North Africa	0.01	0.03	0.02	0.03	0.07	0.06	0.05
NICs in Latin America	0.44	0.59	0.57	0.66	0.82	1.58	1.69
COMECON	0.74	0.76	0.98	1.25	0.64	0.47	0.47

(a) Excluding intra-Community trade.

Source: Paolo Guerrieri, "Technology and International Trade Performance of the Most Advanced Countries."

His calculations are based from the SIE-World Trade data base.

Table 2

Exports of high-tech products, by selected countries: 1970-86

	All* Countries	France	West Germany	Japan	United Kingdom	United States	Other	Europe
Exports	<i>Billions of Dollars</i>							
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
Share of total high-tech exports	<i>Percentage Shares</i>							
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 Organisation for Economic Co-operation and Development definition of high intensity technology products.

Sources: Organisation for Economic Co-operation and Development, *Industrial Outlook Database* (July 1988 and December 1988); *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	Change 1970-87
United States	18.87	13.79	13.85	10.99	10.91	3.62	1.38	-17.49
Canada	-2.35	-3.47	-2.47	-2.48	-2.19	-2.58	-1.89	0.46
Japan	3.28	4.74	6.19	7.02	8.05	10.99	12.61	9.33
EEC (9)	8.27	8.35	10.63	7.02	6.42	3.72	2.06	-6.21
Germany, Fed. Rep.	7.82	8.65	7.22	5.01	4.15	3.11	3.53	-4.29
France	-0.66	-0.67	1.01	1.01	0.81	0.86	0.15	0.81
United Kingdom	4.03	2.66	2.75	1.83	1.17	0.46	-0.21	-4.24
Italy	0.06	-0.68	-0.07	-0.42	-0.32	-0.61	-1.15	-1.21
Greece, Portugal, Spain	-2.89	-3.29	-2.47	-1.54	-1.45	-1.13	-1.81	1.08
EFTA	0.49	0.64	0.43	0.13	-0.17	-0.33	-0.28	-0.77
NICs in Asia	-2.14	-2.32	-1.47	-2.02	-1.51	0.08	0.45	2.59
NICs in Latin America	-3.52	-3.54	-2.96	-2.12	-1.69	-0.48	-0.45	3.07

*Standardized trade balances expressed as percentages of total world trade in science-based sectors.

Sources: Paolo Guerrieri, "Technology and International Trade Performance of the Most Advanced Countries."

His calculations are based on data from the SIT-World Trade data base.

Table 4

Shares of Selected Countries and Areas in World Trade in
High R&D-Intensity Electronic Industries

	1970	1973	1976	1979	1982	1985	1987
<i>Ratio of national exports to world exports (percent)</i>							
United States	35.4	29.3	27.2	29.7	34.5	28.2	22.8
Japan	11.1	15.4	16.1	17.4	19.3	23.8	26.1
Asian NICs	2.1	5.4	8.7	9.3	9.1	12.3	15.8
EEC (9)	31.1	30.4	29.1	26.6	20.9	19.8	19.1

*Source: Paolo Guerrieri, "Technology and International Trade Performance of the Most Advanced Countries."
His calculations are based from the SIE-World Trade data base.*

TECHNOLOGY CHALLENGES TO TRADE POLICY

David B. Yoffie

Prepared for the
National Academy of Engineering Symposium
"Linking Trade and Technology Policies: An International Comparison"
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Panel III

TECHNOLOGY CHALLENGES TO TRADE POLICY

David B. Yoffie

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April 15, 1991

This paper has been prepared for the National Academy of Engineering conference on "Linking Trade and Technology Policies: an International Comparison," June 9-11, 1991.

Panel III: Technology Challenges to Trade Policy

The demands for trade intervention in high technology industries are expanding. Policy makers 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 towards 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 semiconductors and high definition television, with numerous bilateral conflicts in sectors such as aircraft (between the U.S. 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 post-war trading system was developed to solved 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 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, very 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. The GATT dispute settlement mechanism and U.S. trade law 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's high technology industries.

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--i.e., foreign trade barriers which continue to pervade many countries--and insure 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 argue this last point.

I. Why is High Technology Different?

First, from a trade policy perspective, why should anyone

care about high technology? Or to paraphrase Dick Darman's oft quoted comment, 'potato chips or silicon chips, who cares--they are both chips.' How much the national interest depends on silicon vs. 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, like steel, textiles, cars, footwear, etc. 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. While these traditional industries were very diverse, they were typically characterized by long product life cycles (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 (the relatively low level of investment in R&D meant that managers in textiles, footwear, steel, cars, etc. 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 managers and trade policy makers. 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 and its 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 problems 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 upfront 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, like commercial aircraft, the upfront intangible investments are so risky that the firm has to bet the company with each new product introduction.

Moreover, dynamic learning economies and the very high switching costs associated with many high technology products create the possibility of "first mover advantages"; i.e., early

winners in the marketplace may sustain lower costs for long periods of time; and/or early winners may be able to make it very costly for their customers to switch vendors. Consider two well-known examples: dynamic RAMs and operating system software. In dynamic RAMs, costs generally decline about 30% for every doubling of volume. Ever since Japanese manufacturers moved ahead of the U.S. and European manufacturers in 64K RAM production in the early 1980s, it has been very 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 my new modern factory or low labor costs, but my 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 tie 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 PCs with its choice of Microsoft's DOS operating system, independent software companies wrote applications designed for that system. Over the decade of the 1980s, PC users invested more than \$30 billion in software written exclusively for DOS based machines, which made it very costly for the average

PC customer to switch to non-Microsoft based machines.

II. 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 put out of business. While 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 which 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 late comers to drive down prices.¹

¹Of 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.

Yet the very structure of GATT's dispute settlement mechanism and U.S. trade law, especially escape clause (section 201), anti-dumping 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 U.S. can rarely expect its government to respond in less than one year (see Table 1).²

Fast actions against definable trade violations is only part of the trade policy dilemma in high technology industries. An equally significant issue for trade policy in high technology industries 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 U.S. and Europe protected the textile industry to insure 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

²When 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 U.S. and Europe.

se; rather it is to reap the "externalities" associated with high research and development activities. Countries want to maintain the semiconductors, computers, aircraft, telecommunications, etc. 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 in the firm which 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 1000 cubic feet in size. The products are manufactured in high volume assembly plants around the world. AT&T has factories in the U.S., Holland, Spain, Korea, and Taiwan; NEC assembles in Japan, a variety of developing countries, and Texas; Siemens manufactures in Europe, 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 central office switch business, trade policy is a particularly ineffective tool. While tariff 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 uses some form of protectionist barriers. The corporate solution is simple: invest around the barrier with assembly or even fully integrated manufacturing. In the last five years, it has been easy for long-term capital to flow across national boundaries (see figures 1 & 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 which 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 blocks have each strategically intervened in their domestic industries by setting of local standards which don't 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 questions one must pose is: what's 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 U.S., 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 implicit 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 be hesitant 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 under-invest. The risk for a firm like McDonnell Douglas to invest in the next generation aircraft might outweigh the possible returns.

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

III. An Illustration: U.S.-Japan Semiconductor Trade Agreement

The U.S.-Japan semiconductor trade agreement, 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 Semiconductor Trade Agreement (SCTA) is a model for trade policy in high technology industries. It was the

first major U.S. trade agreement in a high-tech strategic sector which was motivated by concerns about the loss of high-tech competitiveness 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 U.S. and Japan but in other global markets.

The purpose of the 1986 semiconductor agreement 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 (301) case 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% market share within five years." The 20% figure meant an effective doubling of the foreign share of the Japanese market.

On the dumping issue, the SCTA suspended EPROM and DRAM investigations 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 eight percent profit margin in the U.S. market. The Japanese agreed to have MITI monitor export prices on a wide range of semiconductor products, including EPROMs, 256K DRAMs, 8-bit and 16-bit microprocessors, to prevent Japanese producers from selling at less than fair market values in the U.S. or in third countries. The Department of Commerce, in turn, was given the responsibility to calculate foreign market values (FMVs) 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 U.S. 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 of trade policy in high technology industries which are listed above. 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 which 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 of 1987, market share did rise (see Figure 3). As of the end of 1990, the foreign share of the Japanese market was approximately 13.35%, substantially below the expected 20%, but up from 8.5% when the agreement was signed, and at its highest level ever.³

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

³Note that given the way SIA 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.

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 precipitous increase lasting through the end of 1988. Spot prices for 256K DRAMs tripled over a four month period⁴, 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--with spot prices rising three to six times higher than long-term contract prices, with the result that the effective price paid by any consumer 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 have disappeared. But Ken Flamm estimates that higher prices meant about \$4 billion of annual profits on global DRAM sales on the order of \$50 billion 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

⁴For detailed price information, see Kenneth Flamm, "Measurement of DRAM Prices: Technology and Market Share," Working Paper, Brookings Institution, November 1990.

⁵ The two remaining American DRAM producers, TI and Micron Technology, also profited substantially from the surge in demand for DRAMs. According to one Wall Street semiconductor analyst,

While 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 users.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 U.S. Future efforts to use trade policy to affect the balance in the United States between Japanese-owned chips versus American-owned chips will verge on the impossible.

IV. 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

between 30% and 40% of TI's semiconductor operating profit in 1987, and as much as 60% in 1988, was attributable to DRAM sales. Micron, which specified in DRAM production, enjoyed a 6-fold 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, Ph.D., semiconductor analyst at Prudential-Bache.

⁶For a full evaluation of the SCTA, see Laura Tyson and David Yoffie, "Semiconductors: From Manipulated to Managed Trade," unpublished manuscript, Harvard University and BRIE, 1991.

helped induce Japanese policy makers and private actors to eliminate many of the vestiges of the past which have kept the market implicitly as well as explicitly closed to foreigners. Where trade and other barriers to high technology trade continue to persist in markets around the world, trade policy remains an appropriate tool.

But to facilitate a high technology industry's vitality, to manage production or pricing in such sectors, to stimulate entry, etc., trade policy is probably obsolete. The dynamism of high technology products and process, 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, anti-trust exemptions and other forms of industrial policies--remains the best option.

TABLE 1

Summary of Most Commonly Used U.S. Trade Laws

	<u>Escape Clause</u>	<u>National Security Clause</u>	<u>Retaliation</u>	<u>Countervailing Duties</u>	<u>Anti Dumping</u>
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 threatened 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, OMA or trade adjustment assistance, or other action	At president's discretion	Determined by USTR, 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:	ITC	Commerce (ITA)	USTR	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	Commerce (ITA)	
Decision due:	60 days	No deadline	Included in recommendation, 30 day implementation limit	Upon recommendation	
Congressional override:	Yes, within 90 days if president rejects	No	No	No	No

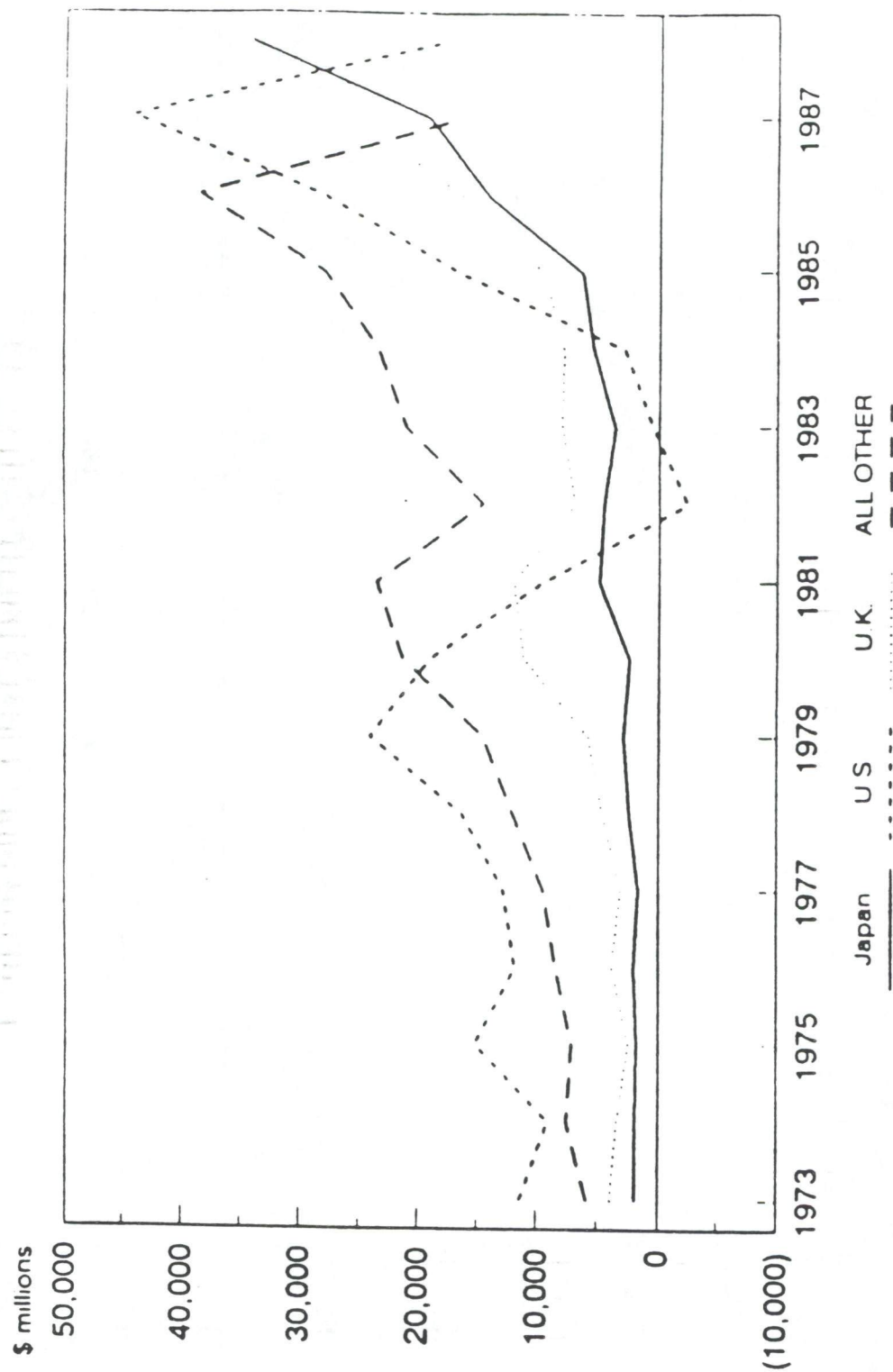
^aIn 1983, penalty was determined by the President, who was the decision-maker in 301 cases. The USTR's recommendation was due between 9 and 14 months, depending on the nature of the unfair practice. The decision was due 21 days after the USTR's report to the President. The OTA of 1988 gave this authority to the USTR.

^bIn 1983, recommendation was due in 12 months.

Source: David B. Yoffie, Alvin G. Wint, Richard Phelps, and David Dobrowolski, "United States Trade Law," HBS Case 9-387-137, Boston, MA: Harvard Business School, 1987, p. 18.

FIGURE 1

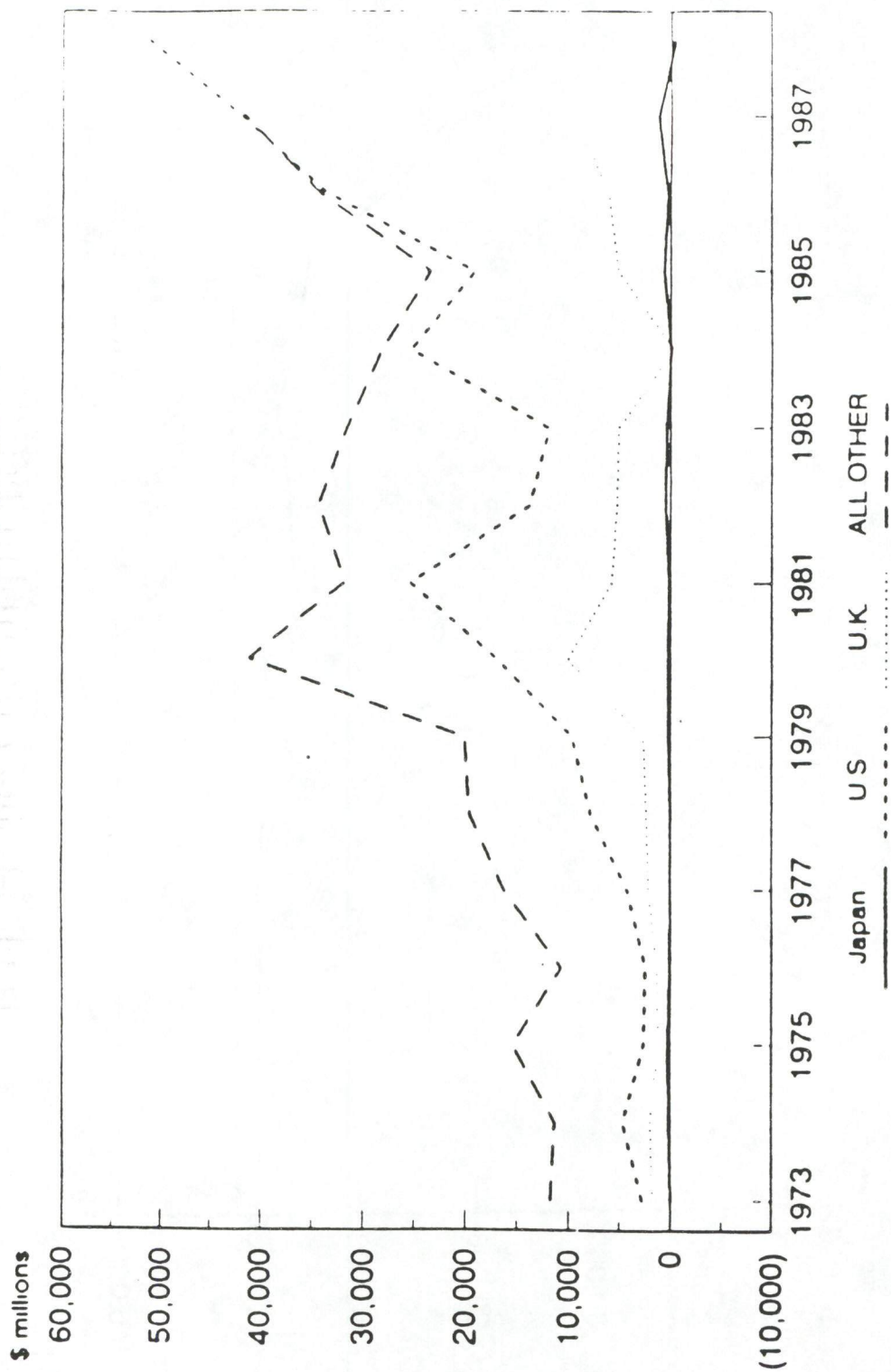
FOREIGN DIRECT INVESTMENT OUTFLOWS



SOURCE: IMF, Survey of Current Business,
Bank of England, Bank of Japan

FIGURE 2

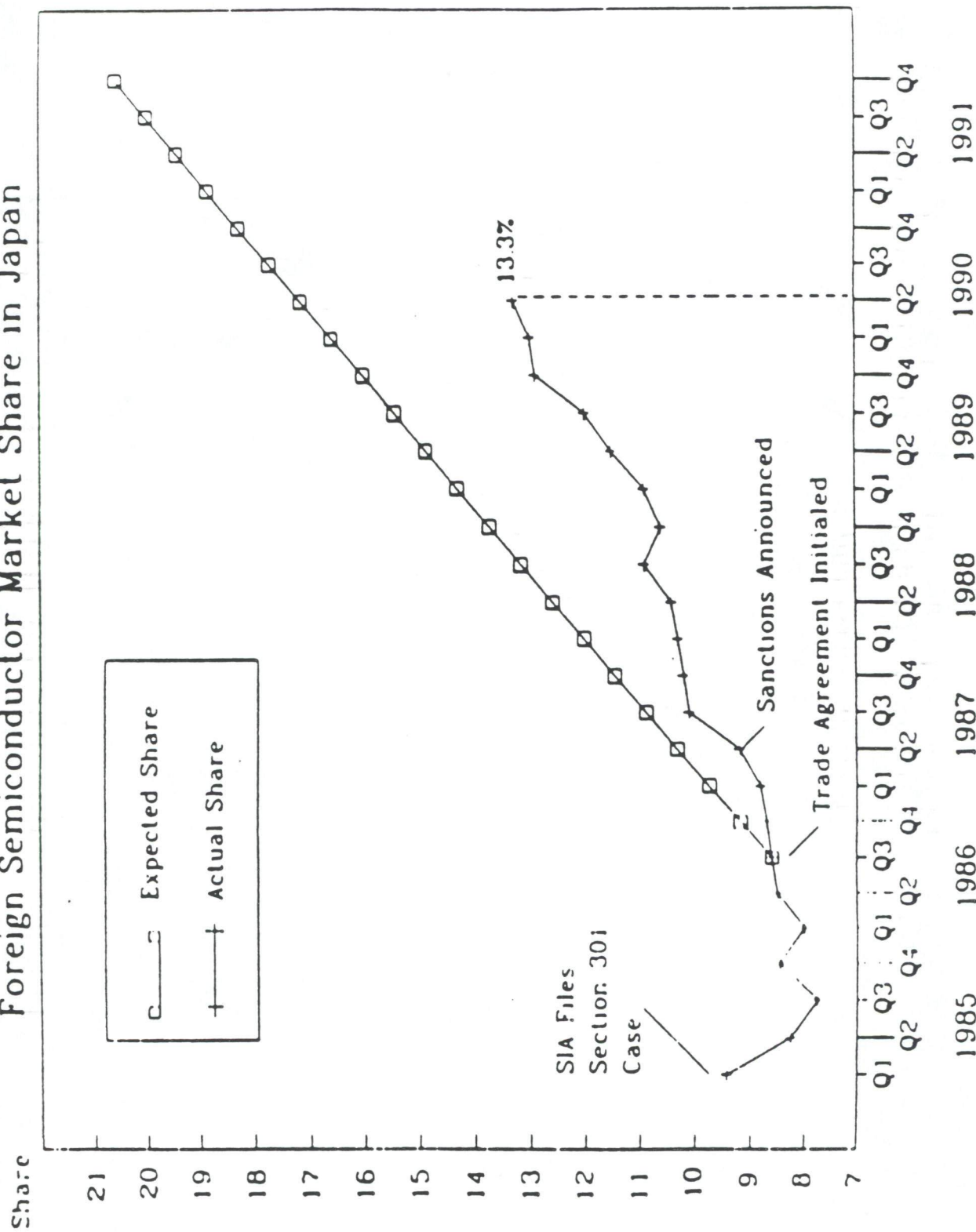
FOREIGN DIRECT INVESTMENT INFLOWS



SOURCE: IMF, Survey of Current Business,
Bank of England, Bank of Japan

FIGURE 3

Foreign Semiconductor Market Share in Japan



SOURCE: SIA

**THE CHALLENGES OF INTERNATIONAL TRADE TO U.S.
TECHNICAL POLICY**

David C. Mowery

Prepared for the
National Academy of Engineering Symposium
"Linking Trade and Technology Policies: An International Comparison"
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The Challenges of International Trade to U.S.
Technology Policy

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April 1991

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1. Introduction

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 U.S. 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

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.

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 U.S. than in either the 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 (e.g., 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.

2. The structure of U.S. technology "policy"

U.S. technology "policy" is the outcome of a series of very 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 the fact 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 recommendations of Vannevar Bush's famous report, Science: The Endless Frontier. The

National Science Foundation 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 within either the Executive or the Congressional branch of the federal government review 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 within the U.S. economy, more than 50% 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,² 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 important 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 Ergas³ 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

² See the report by the National Research Council's Office of Japan Affairs, The Working Environment for Research in U.S. and Japanese Universities (National Academy Press, 1989)

³ See H. Ergas, "Does Technology Policy Matter?", in H. Brooks and B. Guile, Technology in the Global Economy (Washington, D.C.: National Academy Press, 1987).

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.

3. 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.⁴ This shift in the economic relationship between military and civil technologies contributed to the decision of the Defense Advanced Research Projects Agency 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

⁴ 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 report of the Panel on the Impact of National Security Controls on International Technology Transfer pointed out in its 1987 report, Balancing the National Interest (National Academy Press, 1987).

designed primarily to aid the competitive capabilities of U.S. firms in civilian technologies.⁵ Nevertheless, U.S. firms benefitted 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 quickly apply these results 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 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

⁵ Indeed, the impressive economic performance of the U.S. during 1900-1940, 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 R.R. Nelson, "U.S. International Competitiveness: Where Did It Come From and Where Did It Go?", Research Policy, 1990).

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 policymaking 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, antitrust 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. GNP 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.⁶ The speed

⁶ Data in E. Graham and P. Krugman, Foreign Direct Investment in the United States (Institute for International Economics, 1989) show that measured as a share of national manufacturing employment, direct foreign investment in the U.S. grew from 3% to 7% during 1977-86, compared with declines during this period from 2% to 1% in Japan, 14% to 13% in Germany, and 14% to 15% in Great Britain; the share grew from 18% to 21% 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; much of the

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 U.S. 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 U.S. 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

rise between then and now can be viewed as a shift to a more typical position. This was a specifically US 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." (p. 25).

organization of research, finance, or industry, and these structural differences loom much larger.⁷

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

⁷ See S. Ostry, Governments and Corporations in an Interdependent World (Council on Foreign Relations, 1990) for additional discussion.

their R&D operations.⁸ 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.⁹ Similar alliances have grown between firms within the EC, in many instances with financial support and encouragement from Commission 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 that are in turn intensifying economic and technological interdependence between U.S. and foreign firms.

4. Responses and complications

⁸ 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.

⁹ See D.C. Mowery, ed., International Collaborative Ventures in U.S. Manufacturing (Ballinger, 1988) for a collection of studies.

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.¹⁰ The contrast between its 1981

¹⁰ 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 C.E. Barfield, Science Policy from Ford to Reagan (Washington, D.C.: American Enterprise Institute, 1982), p. 41.

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. If the examples from the 1980s are representative, they 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 European Communities 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 U.K.) 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.¹¹ 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

¹¹ R.R. Nelson, High-Technology Policies: A Five Nation Comparison (American Enterprise Institute, 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.

important exceptions (IBM Europe has been allowed to participate in parts of ESPRIT and EUREKA), these programs have not welcomed foreign firms.¹²

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 fourteen laws (including the establishment of the Court of Appeals for the Federal Circuit in 1982) increasing protection for intellectual property owners.

¹² 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." Remarks of Jean-Jacques Duby, in Europe 1992: The Implications of Market Integration for R&D-Intensive Firms (National Academy Press, 1991), p. 30.

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% of their equity owned by foreigners).¹³

Just as U.S. trade policy frequently has been called on to redress the problems created by unbalanced macroeconomic policy,¹⁴ 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

¹³ 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.

¹⁴ Destler, American Trade Politics: System Under Stress (Institute for International Economics, 1986), 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.'" (p. 177).

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 treatment by U.S. policymakers of 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).¹⁵ 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 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.

¹⁵ Another example is the opposition of Commerce Secretary Baldridge 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.

government must be seriously addressed."¹⁶

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.¹⁷

5. 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

¹⁶ "MIT Exploring Linked Supercomputer Center," News Office, Massachusetts Institute of Technology, 11/5/87, p. 2; see also G. Putka, "MIT Cancels Supercomputer Plan, Citing US Pressure to Reject Japanese Bids," Wall Street Journal, 11/6/87; and D.E. Sanger, "M.I.T., Pressed by U.S., Won't Buy Computer," New York Times, 11/6/87.

¹⁷ See "A Gun that Needs to Get Knotted," Economist, 9/9/89 pp. 82-85.

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.¹⁸ 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.

¹⁸ 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." T.C. Hayes, "Developing a Computer Chip for the 90's," New York Times, 12/23/88, p. C6. 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 (A. Pollack, "Sony to Share Data at U.S. Plant," New York Times, 2/21/90, p. C1). Sematech participants Motorola and IBM also have technology-sharing alliances with foreign semiconductor producers (respectively, Toshiba and Siemens).

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.¹⁹

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

¹⁹ 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 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. See R.L. Hudson, "In Europe, Electronics Industry Sends Protectionist Message to ICL," Wall Street Journal, 3/27/91, B2.

maintain military aerospace industries by supporting the participation of their national aircraft firms in a major commercial project. This justification is very 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.²⁰

Further relaxation of U.S. antitrust policy, for example, could allow domestic consortia to acquire market power in the

²⁰ For an excellent discussion of this issue, see P.A. David, "Technology Diffusion, Public Policy, and Industrial Competitiveness," in R. Landau and N. Rosenberg, eds., The Positive Sum Strategy (Washington, D.C.: National Academy Press, 1986).

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.²¹ Similarly, intellectual property protection often represents a compromise between the interests of innovators and those of potential adopters.

A similar tension is present within the EC debate over strategies 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 the effect of raising the price and lowering the quality of the information technology and microelectronics products available to Western European firms and consumers, slowing

²¹ 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 U.S. of a "technology policy" or strategy will complement, but will not replace, the use of trade policy for domestic technological objectives.

adoption.²² 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 premises of these Japanese policies: encouragement for domestic technology diffusion.

6. Conclusion: issues for the future

Within the U.S. government, science and technology policy oversight and coordination within and between the Congressional and Executive branches is 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

²² Commenting on the recent EC Commission paper on future strategies for information technology, the Financial Times 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 US--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." "Europe and electronics," Financial Times, 3/27/91, p. 16.

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 very difficult to achieve, in large part because of the lack of a consensus position among U.S. policymakers and private firms on the appropriate limits for R&D subsidies. U.S. government suggestions during the planning of the Uruguay Round that a "high-technology" negotiating group be organized also led to naught because the U.S. government could not work out a consensus position 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 U.S., 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 extension, 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 U.S. 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 may be 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 very

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. startups 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 startup firms are not 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 by foreign enterprises of U.S. firms, these critical human assets do not leave the United States following the acquisition--instead, they frequently leave the firm, transferring their skills and knowhow to other U.S. firms. As such, the putative "drain" of U.S. technology through foreign acquisitions of high-technology firms

may be exaggerated.²³ 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 U.S., however, are difficult to square with the stated position of the U.S. 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 U.S. and global scientific enterprise than do universities in some other industrial economies.²⁴ 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, e.g., 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

²³ 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.

²⁴ 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: The Working Environment for Research in U.S. and Japanese Universities (National Academy Press, 1989); and Learning the R&D System (National Academy Press, 1989).

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 multi-tiered 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 mandated 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 within the United States will be powerfully influenced by evidence that foreign research establishments are being made accessible to U.S. firms and individuals, 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.

NINE PRINCIPLES OF COMPETITIVENESS STRATEGY

National Academy of Engineering Symposium
"Linking Trade and Technology Policies:
An International Comparison"

National Academy of Sciences
2101 Constitution Avenue, N.W.
Washington, D.C. 20418

June 11, 1991

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[1] MARKET SIZE

Since the beginning of the year, quite a few reports have been issued voicing concern about the competitiveness of the U.S. high technology sector. I would suggest that these reports ignore an important issue - namely, the economic value of the market which is expected to be generated by new technologies. To fill that gap, I have compared the industrial structure of the U.S. and Japan for our reference.

Table one reveals a key factor in the competitive problems facing the U.S. Look, for example, at the aerospace industry. The U.S. unquestionably dominates the world aerospace sector, but the size of the aeronautical market is only one third that of the automobile market. Likewise, the U.S. computer industry is very competitive globally, but the size of that market is smaller than that of home appliances - VCR's, audio players, TV's, video games, etc. So a major problem confronting the U.S. economy is the loss of technical dominance in large-scale-industries - such as cars, iron and steel, and home appliances.

The lesson here is to be sure to take account of market size in planning competitiveness strategy for the high technology sector.

[2] INDUSTRY APPEAL TO POTENTIAL WORKERS

When I attended a conference held in Finland in 1988, a vice president of McDonnell Douglas Aircraft Co. made a fascinating presentation about the next generation passenger plane. It will use just one third the fuel of the traditional aircraft; through such innovations as replacing the fan jet with a non-ducted fan engine; smoothing the vortex on the wing with new technologies, and so on.

As I listened to his talk, it suddenly became clear to me that the U.S. auto industry would experience a decline. The reason? If I were a graduate of the faculty of engineering, I would join with the industry that provided the most opportunity to develop new technologies - in the U.S., not automobile but aerospace.

Any industry which cannot tempt talented engineers will collapse sooner or later. That applies to the car industry too, even if it currently leads the manufacturing sector in sales.

Another difficulty the U.S. industry faces, then, is the decline of its appeal to young people. To recover industrial power, the U.S. should endeavor to make strategic industries as attractive as possible to young workers.

[3] WHAT IS "TECHNOLOGY"?

The term "Technology" is interpreted differently by different people. In my presentation, I would like to define the term as the whole process of producing marketable goods.

To develop new technology, we should go through three steps:

1. to create a concept
2. to develop the know-how for making things
3. to improve the manufacturing process and to sell the products.

To win the competitive war in the technology market, these three steps should be revisited continuously. Otherwise, the technology will not succeed in the market. I would like to give some examples:

Ferrite, a magnetic material, was invented by Dr. T. Takei of Tokyo Institute of Technology, and is used in almost all electronic equipment today. He held the basic patent, but during World War II, Phillips, the giant electronics company of Holland, developed the manufacturing process and application. Then, other firms, including Japanese firms, had to contract and pay royalty fees to Phillips for producing Ferrite.

The idea of the Rotary Engine was proposed by Dr. Wankel of Germany and was accepted as an innovative engine - simple, light weight, high power, etc. Every car manufacturer made an effort to commercialize it as the next generation engine to replace the traditional piston engine. However, quite a few difficulties arose in practical use, especially inadequate lubrication of the rotor head causing it to stick on the liner. One after another, companies abandoned the new engine. Only one company, Mazda of Hiroshima, managed to commercialize it using it in the best selling sports car, the RX-7.

Therefore, I would like to point out that any idea, however innovative is not technology but merely knowledge if we fail to produce marketable goods. To bring competitive technology to the market, the third principle - improving the manufacturing process - should always be adhered to in order to adapt technology to the future. Otherwise, even so called innovative technology will be rejected by the market.

[4] MASS PRODUCTION FOR A MASS MARKET

In free economies, no market can be created without effort by private firms. Only profitable sales can sustain any technology. In the case of Gallium Arsenide (GaAs) semiconductor chips, Japanese firms enjoy the highest world market share. The reason is quite simple - namely CD players, the laser diode of which is GaAs, and which use hundreds of thousands of chips produced in Japan monthly.

Japanese semiconductor firms have been able to install the most up-to-date machines in their factories using the money earned from sales of CD players. They can therefore supply every kind of GaAs chips, with the low noise, high speed, high power transistor. It became a so called dual use technology itself.

Today, high-tech products can be manufactured only by machines developed for that specified purpose. Therefore, a product cannot be made until the machine is perfected. For profits from the product to recover the cost of the manufacturing machine requires large scale sales.

The excellent characteristics of GaAs was well known by the experts. However, the technology cannot be perfected through low-quantity production. Mass production is really the driving force to cultivate and to improve technology.

To make mass production possible, there must be a market for the product, developed in parallel with new technology, as the CD player develops in parallel with GaAs.

The creation of the mass market always depends upon the efforts of the private sector, not by the government.

[5] QUALITY CONTROL FOR QUALITY PRODUCTS

I made a presentation at the VHSIC committee of DOD in 1986 concerning the importance of production engineering for the purpose of explaining some problems in maintaining product quality.

At the beginning of my presentation, I showed accelerated life test data on the same type of IC (Integrated Circuit) produced by several semiconductor manufacturers, 100 sample chips manufactured by each firm were tested, and the chips were broken down in different ways.

The chips from firm A recorded no failure after 5000 hours of testing. All samples pass the test even after withstanding 10,000 hours under the extreme conditions.

The chips made by firm B did not fare as well. Two (2) were discovered to be defective before testing even began, twelve (12) broke down after 1000 hours, eight (8) more after 2000 hours, and all were rendered inoperative after being tested for 4000 hours. Another batch of 100 chips had no trouble up to 3000 hours but afterward, in a random pattern, all of them broke down.

The manufacturing equipment used to produce these chips was all about the same. The number of companies manufacturing the silicon wafers used in the semiconductor manufacturing process is fixed, and the pattern designs almost all the same. Since we should not expect any major differences in the capabilities of the engineers, on their workplaces, what is the reason for the differences noted in the accelerated life test?

The answer is quality management. I cannot emphasize this point enough.

[6] CROSS BORDER COLLABORATION AMONG COMPANIES

Factory shop floors are inherently international because any manufacturer which installs a machinery inferior to the competitor's will see its products defeated and driven from the market. Manufacturing equipment is analogous to weapon systems on the battlefield: cannons never hit the target outside their shooting range.

Therefore, wise engineers strive to equip their factory with the most up-to-date machinery and instruments possible, disregarding the nationality of the suppliers. Otherwise, they are sure to be defeated in the unforgiving battlefield of the marketplace.

Collaboration among private firms is a popular means of adapting various demands of customers. In the semiconductor field, Motorola has joined with Toshiba to exchange specified products. In the personal computer field, Texas Instruments has collaborated with Hitachi, IBM with Matsushita and so on. Before engaging in such collaboration, each firm should be sure it has a specific technology the other firms needs, as leverage to ensure it receives what it wants form the transaction.

[7] GOVERNMENT AS A FACILITATOR

When MITI announced to start the 5th Generation Computer project in 1982, by organizing a new consortium, ICOT (Institute of New Generation Computer Technology), it was misunderstood that a box named 5th Generation Computer was to be produced in the year 1992.

The most fruitful impact expected from the project expected is not only to produce a new machine but also to cultivate scientists and engineers who have joined the consortium from their firms and who will transfer knowledge and skills back to their home firms. Already, several firms have commercialized the inference machine and have started to market it.

The role that ICOT plays is somewhat like an experienced guide through an unfamiliar and perilous jungle.

MITI's projects are not always successful. The VLSI (Very Large Scale Integrated Circuit) project yielded fruitful results and was praised highly as an ideal example of R & D consortia. On the other hand, quite a few projects have ended in miserable failure. I dare say the success rate of MITI's success rate is about 40% or less.

Government investment can sometimes help in providing strategic direction to industry, but it is never a guarantee of industry's success.

[8] MAINTAIN THE COMPANY'S TECHNOLOGICAL BASE

Portfolio management, the tool of financial experts, has many times proven hazardous to technology development. The easy way to cut down production costs, especially for labor-intensive production, is to move a factory offshore and /or procure finished goods from outside suppliers under the OEM name (Original Equipment Manufacturers). By doing so, however, one fails to keep the technology for manufacturing the product in one's own hands. One loses the opportunity to gain the know-how for one's self, and that is the key for manufacturing.

The Sendai factory of Matsushita, a CD players factory, was struck by high valued yen since 1985 and suffered heavy deficit due to lost market share to cheaper products of South East Asia. The wage rate of those countries was one fifth that of Japan. Then, Matsushita installed about 850 assembling robots, a 40 million dollar investment. Today, the cost of the products of the Sendai factory is lower than that of South East Asia. Moreover, the factory makes higher profits because it has shifted to more sophisticated, high-value-added products than in the past.

The bold decision by the director of the factory to choose robotic technology over offshore suppliers reversed the factory's fortune. Once the new technology operated satisfactorily, Matsushita began to construct a complimentary new factory offshore.

[9] ENTREPRENEURSHIP IS THE KEY TO THE FUTURE

The blunt but honest conclusion of my presentation is also quite simple. That is, we have no other way to promote high-value industries than to encourage entrepreneurship in the private sector. As Professor Robert Samuelson said, "Excuse Industry" will fail without exception.

NINE PRINCIPLES OF COMPETITIVENESS STRATEGY

TABLE ONE

INDUSTRIAL STRUCTURE OF U.S. & JAPAN (SHIPMENT) (MIL. DOL.) (1987)

INDUSTRY	U.S.	JAPAN
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX
Food and Kindred Products	280,529	192,361
Tobacco Products	20,761	13,880
Textile Mill Products	63,508	60,721
Apparel and Other Textile Products	65,765	20,138
Lumber and Wood Products	69,607	31,251
Furniture and Fixture	37,137	15,273
Paper and Allied Products	108,249	49,281
Printing and Publishing	134,901	71,527
Chemicals and Allied Products	230,089	134,722
Petroleum and Coal Products	130,683	47,912
Rubber and Misc. Plastics Products	86,272	78,472
Leather and Leather Products	8,908	4,285
Stone, Clay, and Glass Products	60,918	60,423
Primary Metal Industries	120,169	122,916
Fabricated Metal Products	148,263	101,138
Industrial Machinery and Equipment	220,097	197,791
Electronic and Other Electric Equip.	172,136	261,180
Transportation Equipment	332,470	241,666
Instrument and Related Products	108,269	24,305
Miscellaneous Manufacturing Industries	31,909	26,388

HIGH TECH AND KEY INDUSTRIES (1987)

INDUSTRY	U.S.	JAPAN
XXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX	XXXXXXXXXXXXXXXXXXXX
Iron and Steel	63,194	95,138
Motor Vehicles and Parts	204,678	220,138
Electrical Machinery	113,162	172,135
Aircraft and Parts	78,150	3,472
Guided Missiles and Space Vehicles	26,245	-0-
Computer and Office Equipment	62,432	59,722
Communications Equipment	23,820	13,888
Semiconductors and Apparatus	18,055	13,194

Source: "Industrial Statistics Outlook 1990" United Nations
 "Statistical Abstract of the U.S. 1990" Department of Commerce

THE WHITE HOUSE

WASHINGTON

July 22, 1991

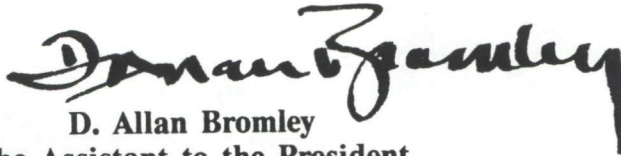
Dear Dr. Reid:

Thank you for sending copies of six of the papers presented June 10-11 at the NAE symposium "Linking Technology and Trade Policy: An International Comparison."

If the six papers you sent me are representative, I will look forward to reading the full symposium proceedings to be published later this year. Reasons for the growth of high technology Japanese industries over the past 2-3 decades and the relative decline of a number of U.S. industries are well documented in the papers. As might have been expected, there was a good deal less unanimity on appropriate remedial measures.

All in all, an important contribution to this crucial debate.

Sincerely,

A handwritten signature in dark ink, appearing to read "D. Allan Bromley". The signature is fluid and cursive, with the first name "D." being small and the last name "Bromley" being larger and more prominent.

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