Consumer Electronics,

HDTV

and the

Competitiveness of the U.S. Economy

Submitted by:

The Electronic Industries Association's
Advanced Television Committee

to

Congressman Edward Markey (D-MA) Chairman,
House Telecommunications and Finance Subcommittee

February 1, 1989

PREFACE

This report is submitted by the Electronic Industries Association's Advanced Television Committee (EIA/ATV Committee) in response to a September 7, 1988 request by House Telecommunications and Finance Subcommittee Chairman Edward Markey to EIA/ATV Committee Chairman Sidney Topol. This report addresses many of the questions raised that day by Chairman Markey and his colleagues on the Subcommittee as well as questions raised in Congressman Markey's December 7, 1988 letter to Mr. Topol.

The EIA and its ATV Committee believes it is uniquely suited to address these questions. EIA and EIA's ATV Committee include developers, manufacturers, sellers and installers of studio, broadcast, transmission and consumer equipment. EIA is the only association representing all facets of electronics hardware manufacturing and its members sales account for over 85 percent of the dollar volume of electronics manufactured in the United States.

Recognizing the importance of advanced television ("ATV"), EIA has formed a committee which has, for over a year, considered all public policy and technical issues associated with ATV. The EIA/ATV Committee includes representatives from the broad spectrum of the electronics industry.* Participating in the EIA/ATV

* The EIA/ATV Committee is chaired by Sidney Topol, Chairman of the Board of Scientific-Atlanta, Inc. Companies participating in the Committee include: ADC Telecommunications; ANIXTER; AVX Corp.; AMP, Inc.; AT&T; AT&T Federal Systems; AT&T Bell Laboratories; Alcatel, NA; Belden Wire & Cable; Bellcore; Cincinnati Electronics Corp.; Cooper Industries; Corning Asahi Video Products Co.; Corning Glass Works; GE Americom Communications, Inc.; Harris Corp.; Hitachi Sales Corp. of America; Hughes Network Systems; Hughes Communications, Inc.; IBM; Imaging & Sensing Technology Corp.; Magnavox-CATV Systems Co.; Matsushita Electric Corp.; Mitsubishi Electric Sales America, Inc.; Motorola, Inc.; NEC Home Electronics (USA), Inc.; North American Philips Corp.; OI-NEG IV Products, Inc.; Panasonic Technologies, Inc.; Philips Consumer Electronics; Quasar Com-

Committee are EIA members, including members of the EIA's affiliate—the Telecommunications Industry Association (TIA)**, as well as non-EIA members.

The EIA/ATV Committee approached this task with urgency and seriousness. The Committee believed, and continues to believe, that Chairman Markey's request reflects a growing national concern that HDTV provides our country with both a fundamental challenge and a tremendous opportunity.

Unanimously, the EIA/ATV Committee agreed that it should address the issue of HDTV and competitiveness directly, thoughtfully, and comprehensively. This was no easy task. The EIA has previously addressed the issues of competitiveness and HDTV, but not in tandem. While the EIA for several years has spoken, testified and lobbied on several issues affecting U.S. competitiveness, it has only recently addressed issues involving HDTV. Its focus on HDTV has been primarily oriented to developing consensus on technical issues so that a marketable product would be developed in a timely manner.

To meet the challenge presented by Chairman Markey, the EIA/ATV Committee has taken three key steps, each involving significant expenditures of resources.

First, Committee Chairman Topol appointed a working subcommittee composed of diverse industry sectors and

pany; Scientific-Atlanta, Inc.; Siecor Corp.; Sony Corp. of America; TRW, Inc.; Thomas Electronics, Inc.; Thomson Consumer Electronics; Toshiba America, Inc.; Varian Associates, Inc.; U.S. Precision Lens, Inc.; and Zenith Electronics Corp.

Although a member of the EIA/ATV Committee, Zenith Electronics Corp. is filing its own response to Congressman Markey's request and does not necessarily share in any or all of the viewpoints contained herein.

** The Telecommunications Industry Association (TIA), is a full service national trade organization with nearly 600 members that provides materials, products, systems, distribution services and professional services to the telecommunications industry in the United States and countries around the world. The TIA represents the telecommunications industry in association with the EIA.

interests to forge an industry-wide consensus on all critical issues. The subcommittee included different product manufacturers with different perspectives but, fortified by real world expertise in the development, manufacturing and selling of electronics hardware, the subcommittee reached a remarkable degree of consensus on almost every major issue.

Second, upon receipt of Congressman Markey's request, the EIA redirected the process, focus and timetable of an ongoing study of U.S. television manufacturing by the economic consulting firm of Robert R. Nathan and Associates. Chapter four of the Robert R. Nathan report, which is referred to in this document, was released prior to public release of chapters one through three to provide reliable and usable data for use by policymakers.

Finally, but of critical importance to the success of this project, the EIA/ATV Committee reached out to several eminent scholars from the Berkeley Roundtable on the International Economy (BRIE). These professionals uniquely combine expertise, academic objectivity, and the highest reputation with which to address the issues of electronics and competitiveness. Although this report reflects EIA's views, much of the research, prose, ideas and comprehensive analytical approach are attributable to these scholars: Professors Michael Borrus, Steven Cohen, Jeffrey Hart, Laura Tyson and John Zysman. We are grateful for their contribution.

SIDNEY TOPOL, Chairman
EIA/ATV Committee

PETER MCCLOSKEY, President
Electronic Industries Association

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February 1, 1989

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EXECUTIVE SUMMARY

In recent months the question of whether the U.S. will occupy a competitive position in the emerging HDTV market and related technologies has become symbolic of the broader question of how the U.S. can regain its competitive strength in world markets. As HDTV has become perceived as a symbol of the nation's competitive challenges, Congressional enthusiasm for national policies to promote U.S. participation in HDTV has mounted, not simply because of the anticipated production, employment and trade effects of such participation, but because of the anticipated spillover effects on U.S. competitiveness more broadly defined.

The premise of this Report is that competitiveness is primarily an economy-wide issue, most effectively addressed by broad-based or aggregate policy measures that are designed to promote investment in physical plant, knowledge, and human capital throughout the economy. Without such aggregate policies, industry-specific policies aimed at HDTV or at any other individual industrial activity deemed to be of strategic significance will fail to improve the nation's competitiveness. In combination with the appropriate aggregate policies, judicious industry-specific policies aimed at industries with important linkages and technological spillovers for a wide variety of industries may have a beneficial effect on national competitiveness.

Segments of the electronics industry, particularly the semiconductor industry—and in the future, the HDTV industry—provide positive technological spinoffs and beneficial linkage effects for other industries and related technologies. Thus there may be a public rationale for policy measures to promote these activities. This public rationale must be distinguished from the rationale of anticipated private profits, production, and employment that motivates private actors as they decide whether and how

to exploit perceived market opportunities in semiconductors, HDTV or any other electronics activity.

Section I provides an introduction to the Report. Sections II and III focus on national competitiveness, broadly defined as the ability of the nation to realize balanced trade over time while simultaneously increasing the real incomes of its citizens. Several indicators, including the trade and current account imbalances, sluggish productivity and real income growth, the pace of technological innovation and diffusion, and the low investment rate indicate that American competitiveness has declined.

To restore national competitiveness, seven aggregate policy initiatives are recommended in Section IV:

1. The adoption of a gradual deficit reduction plan to decrease the nation's depedence on foreign capital and to increase the national savings rate. The goal of such a plan should be approximate budget balance by 1993 in accordance with Gramm-Rudman guidelines.

2. A shift in the composition of federal spending toward education and worker training, infrastructure, and commercial science and technology.

3. A change in the nation's tax laws to encourage investment. In particular, the re-introduction of an investment tax credit and a graduated capital gains tax, adjusted for the period of time over which gains are realized, should be adopted. The relationship between private saving and taxation should also be studied to determine whether existing disincentives to saving should be eliminated or new incentives to saving added.

4. The introduction of a permanent research and development (R&D) tax credit. Existing studies suggest that such a credit has a significant effect

on the amount of R&D done by the private sector and that the social returns from such R&D far exceed the private returns of the firms financing it.

5. The use of government funds to encourage the formation of public-private consortia for middle-ground or generic technology projects. Sematech is an example of such a project, but there may be other more useful models for consortia. Public funds should only supplement and not substitute for private funds for such projects. The initiative for such projects should come from the private sector and the private sector should be responsible for their management and operation.

6. The further relaxation of existing antitrust restrictions on cooperative research and development activities among private firms. In particular, the National Cooperative Research Act should be amended to encompass joint production as well as joint research activities under certain circumstances.

7. International negotiation and the nation's trade laws should be used to press for greater openness in international markets and to insure fair competition in both international and U.S. markets.

Sections V and VI of the Report examine the influence of the electronics sector, especially the semiconductor and consumer electronics industries, on national competitiveness. Due to significant technological spillovers and linkages between these industries and the rest of the economy, and their effects on national output, employment and trade trends, these industries have special significance for preserving the nation's long-term competitiveness.

Section VII of the Report examines the potential importance of HDTV to the consumer electronics industry.

A variety of studies indicate that HDTV products, despite their initial high price, are likely to prove attractive to consumers and to provide growing market opportunities for consumer electronics producers in the future. Beyond these market opportunities, there are reasons to believe that HDTV could be a factor in the development of future technologies in computers, telecommunications, and defense electronics. Thus, the United States should participate as much as possible in the development and commercialization of HDTV products.

Section VIII of the Report considers sector-specific policies to promote U.S. participation in the emerging HDTV market. Such policies should be designed to maximize the positive spillover benefits from HDTV for the rest of manufacturing, particularly related electronics industries such as the semiconductor industry. Three general recommendations to guide the development of policies for HDTV are made:

1. Policies should promote, not impede, the expeditious adoption of standards. Electronics generally and TV manufacturing in particular are global industries. If the U.S. delays, the rest of the world will proceed to advance technologically to the relative disadvantage of technology for the U.S. market.

2. To the extent that public funds are made available for the promotion of HDTV, they should be focused on generic technological problems the resolution of which will benefit a large number of industries. For this reason, R&D consortia for integrated circuitry, large displays and electronic manufacturing technology would seem to be good candidates for public funding.

3. Foreign-owned U.S. producers already play a leading role in the television industry. Due to their investment in manufacturing and R&D facilities in the United States they are active in many of the technologies related to successful HDTV participation. Any policy efforts that attempt to exclude these producers will delay the development and introduction of HDTV technology in the U.S. and discourage foreign producers from expanding their production and R&D operations here. In the case of HDTV technological consortia, it is quite likely that foreign-owned firms will want to participate and that it is in the interests of the United States to encourage their participation.

4. Finally, competitiveness is a national concept; concerned with the economic performance of nations, not companies. **According to this perspective, domestic firms can adopt production, investment, location and sourcing strategies that weaken national competitiveness, while foreign-owned firms operating in the U.S. can adopt comparable strategies that actually strengthen the competitiveness of the United States.**

I. INTRODUCTION

There is widespread interest in HDTV for three reasons.

First, the HDTV market is projected to be large, and the potential effects of HDTV on national production, employment, and trade performance are estimated to be substantial.

Second, HDTV is viewed by some as a way for the U.S. to re-enter television and VCR markets—which U.S.-owned firms, with few exceptions, have virtually abandoned. According to some observers, the costs of this abandonment of a major part of the consumer electronics market have been lost production, sales, employment, and a dramatic deterioration in the U.S. trade balance in electronics. As we shall see later in this report, these costs have been greatly exaggerated.

Third, there is growing policy concern about U.S. participation in HDTV due to the technological spillovers that HDTV production may generate in a variety of related activities, including the development of new semiconductor componentry and new video display technology. These spillovers could affect the American competitive position in a variety of important industries, including computers and advanced telecommunications equipment. Spillovers with applications to defense are also considered likely.

It is claimed that there have been additional costs in linked industries such as semiconductors. The dramatic drop in the U.S. share of world semiconductor sales is, in part, the result of the increasing content of semiconductors in consumer electronics (televisions, radios, disk players, electronic games, etc.), a business which companies based in Japan dominate. At least 35 percent of Japanese consumer-electronics production has been sold to the U.S., and roughly as many semiconductors have entered the U.S. in consumer-electronics prod-

ucts as have been sold to the U.S. directly. But recapturing semiconductor market shares through a revived U.S. consumer electronics industry will not be easy because that industry will continue to be competitive and thus will behave more or less as it has in the past—companies will source their electronic components from those firms which provide the optimal combination of price, performance, and quality.

To many the question of whether the U.S. will be able to occupy a competitive position in the emerging HDTV market and related technologies has become symbolic of the broader question of whether the U.S. will be able to regain its national competitive strength. Increasingly, the competitiveness of the nation has become associated with its ability to emerge a winner in the HDTV market. This symbolism is seriously misleading.

A fundamental premise of this Report is that competitiveness is primarily an economy-wide issue and is logically distinct from the competitive position of the nation's producers in a particular industry or activity. A corollary is that the most effective policies to improve national competitiveness must address broad-based problems, such as the low rates of national saving and investment, the high cost of capital, an inadequately educated and skilled workforce, and insufficient public support for generic or middle-ground R&D, all of which adversely affect private sectors across the industrial spectrum.

An aggregate perspective, however, overlooks the reality that certain industries or activities may contribute more than others to national competitiveness over the long run. And there is evidence to suggest that the electronics sector, broadly defined to include the semiconductor industry, the telecommunications industry, the computer industry, and at least segments of the consumer electronics industry, falls into this category. For the reasons identified in this Report, many policymakers

and industry participants believe that the long-term competitive health of many parts of the U.S. electronics sector will be adversely affected by a U.S. competitive failure in HDTV. One objective of this Report is to evaluate this position.

Even if U.S. policymakers and industry representatives are persuaded that the U.S. competitive position in the emerging HDTV area is important to the nation's long-run competitiveness, many unresolved policy issues remain. Two such issues are of paramount importance. The first arises because of the particular ownership configuration of television producers in the U.S. Currently, most producers are foreign-owned, and some of the foreign-owned facilities operating here have broad-based activities, ranging from R&D to distribution. Many conduct extensive R&D activity in the United States, an activity which should be encouraged by government policy.

This raises a fundamental question that must be addressed before policy decisions are made, to wit: if the objective of policy is to foster U.S. participation in HDTV, will participation by foreign-owned firms operating from U.S. locations support this objective? In other words, does U.S. participation mean participation by domestically-owned firms regardless of where they locate their production, employment and research facilities, or does it mean participation by foreign-owned firms operating in the U.S.—or perhaps does it mean a combination of both? The HDTV issue reveals the increasingly global nature of many high-technology industries and the difficulties of making public policies to foster national participation. To limit such policies to domestically-owned companies is likely to delay the development and introduction of HDTV technology in the U.S. market and to discourage foreign-owned producers

from expanding their production and R&D operations in the U.S.

A second basic policy question is whether policies specifically targeted to HDTV are required to foster U.S. participation, however defined. Perhaps a combination of broad-based pro-competitiveness policies, such as a change in the monetary and fiscal mix with lower interest rates, an R&D tax credit, further relaxation of antitrust limitations on joint R&D activity, and continued efforts to insure fair competition in U.S. and international markets is all that is needed. Certainly, as this Report argues, without a change in at least some of these broader policy areas, it is unlikely that all the beneficial effects of U.S. participation in HDTV on U.S. competitiveness will be realized.

Finally, even if special policies to foster U.S. participation are required, what form should they take? What are the appropriate roles of standards-setting, R&D consortia, Defense Department spending, and other policies?

II. THE MEANING OF NATIONAL COMPETITIVENESS

During the last several years, the dramatic and sustained deterioration in the U.S. trade deficit has created growing concern over American competitiveness. Indeed, competitiveness, a concept that did not even exist in national policy discussions five years ago, has become a buzzword. Business, labor, education, and government leaders speak of the competitiveness challenge confronting the United States and offer a potpourri of sometimes conflicting policy solutions. Initiatives in such diverse areas as trade legislation, educational reform, and taxes are defended or criticized on the basis of their effects on U.S. competitiveness.

Like most buzzwords, competitiveness has symbolic significance. It draws national attention to the undeniable fact that the position of the United States in the world

economy is weakening. America can no longer rest comfortably in the belief that it will continue to be the leading economic power in the world. Although still the largest and one of the richest economies, the United States has lost ground compared to many countries with which it competes in world trade. To some extent, of course, this was inevitable. As the other developed countries rebuilt from war destruction and as many developing countries introduced ambitious development programs —helped by American funds and American technology— some catching-up was inevitable. But the pace and extent of the catch-up—or to put it differently, the pace and extent of the relative decline in the U.S. position—were not inevitable. And significantly for the future, there is no inevitability of a continued decline in the U.S. position.

If competitiveness is to have more than symbolic significance, if it is to become a reliable guide for policy, it must be properly defined. For the purposes of this Report, competitiveness is defined, as it was in the Report of the President's Commission on Industrial Competitiveness and more recently by the Council on Competitivess, as "the degree to which a nation, under free and fair market conditions, produces goods and services that meet the test of international markets while simultaneously maintaining and expanding the real incomes of its citizens."[1] There are four important points about this definition that should be emphasized.

First, competitiveness implies an ability to compete in international markets, with balanced trade over the long run, without an associated decline in real wages, and without a continued decline in the value of the dollar that would cause falling real wages over time. Com-

[1] President's Commission on Industrial Competitiveness, *Global Competition: The New Reality* (Washington, D.C.: USGPO, December 1984); Council on Competitiveness, *America's Competitive Crisis: Confronting the New Reality* (Washington, D.C.: March 1987).

petitiveness is not simply the ability to sell abroad or to maintain a sustainable trade position at some exchange rate. The very poorest nations often boost exports just by devaluing their currencies. The consequences, however, are sharp declines in relative wages and relative standards of living, declines that are at odds with national competitiveness as defined here.

Second, competitiveness implies an ability to compete in free and open markets. In this sense, neither a worsening of U.S. trade performance occasioned by unfair trade measures abroad nor an improvement occasioned by protectionist trade measures at home is a sign of a real change in U.S. competitiveness.

Third, competitiveness is a concept related to economy-wide performance. Policy discussions sometimes focus on the competitive position of particular U.S. industries in world trade. Often, the competitive performance of certain industries, such as the U.S. semiconductor or consumer electronics industry, is taken as indicative of U.S. competitiveness broadly understood. While certain industries or activities may be especially important to national competitiveness—for reasons discussed later in this Report—competitiveness is best understood as an economy-wide concept rather than as a sectoral or industrial one. And the most effective policies for improving national competitiveness are broad-based policies aimed at strengthening national productivity and technological performance—the two basic determinants of national competitiveness.

Finally, competitiveness is a national concept. It is concerned with the relative economic performance of nations, not companies. The focus on national economic performance means that indicators of national competitiveness, rather than indicators of the competitiveness of individual firms whose headquarters are in one nation but whose production and distribution facilities are internationally located, are the relevant subject for policy con-

cern. According to this perspective, **domestic firms can adopt production, investment, location and sourcing strategies that weaken national competitiveness, while foreign-owned firms operating in the U.S. can adopt comparable strategies that actually strengthen the competitiveness of the United States.**

Just as the choices of American multinationals have contributed to the growing competitivenes of the East Asian newly industrializing countries, so the choices of foreign multinationals operating in the United States may contribute to the restoration of American competitiveness. In short, there is no simple or necessary relationship between the ownership of firms operating in a nation and its competitiveness as defined here.

III. EVIDENCE OF WEAKENING U.S. COMPETITIVENESS

The long-term weakening of U.S. competitiveness does not show up in any single economic indicator but rather is suggested by several different ones. Among the most meaningful indicators of national competitiveness are: the trade and current account balances; the productivity growth rate; the rate of growth of wages and real incomes; the pace of technological innovation and diffusion; and the rate of investment.[2] The evidence on these indicators presented in Tables 1 through 7 and Figures 1 through 3 reveals an erosion in the U.S. competitive posi-

[2] The Council on Competitiveness has developed a set of four competitiveness indicators comparing U.S. performance with that of the other advanced industrial countries. The four indicators include: the growth of the standard of living (measured as the gross domestic product plus the current account per employed worker); the growth of labor productivity in manufacturing; the share of world export markets; and the investment rate. Although these indicators differ somewhat from those discussed in this Report, there is substantial overlap between the two. For a discussion of the Council's indicators, see the Council on Competitiveness, *Competitiveness Index* (Washington, D.C.: July 1988).

tion in recent years. The following discussion presents a brief analysis of each of these indicators.

Perhaps the most often cited indicator of the nation's competitive challenge is the dramatic deterioration in the merchandise trade deficit from $25.5 billion in 1980 to $160.3 billion in 1987. During the same period, the U.S. current account declined from a surplus of $1.9 billion to a deficit of about $154 billion.[3] Given present policies and exchange rates, no respectable economic analysis shows the current account deficit falling much below $100 billion over the next several years. At this rate, U.S. external debt will hit $1 trillion—perhaps as much as 20-25 percent of GNP—sometime in the early 1990s.

The sharp fall in the value of the dollar since late 1985 has had a beneficial effect on external performance. In real terms, U.S. exports grew much more rapidly than exports from the other developed counries in 1986 and 1987 (see Table 1). U.S. import growth continued to be surprisingly strong in these years despite the dollar's decline (see Table 2). Since January 1988, however, imports have begun to level off in real terms. Together, export growth and import stagnation in real terms should contribute to a significant decline in the trade deficit in 1988—perhaps by as much as $30-$40 billion from the record high of 1987.

The drop in the dollar has meant a real boost in the price competitiveness of U.S. exports (see Table 3). As a result, the declining share of the U.S. in world export between 1980 and 1986 was reversed in 1987. But U.S. producers and policymakers cannot and should not rely on further adjustments in the dollar's value to restore

[3] In 1987, the current account deficit hit 3.4 percent of GNP, the highest rate since the U.S. was last a net debtor nation at the end of the nineteenth century.

the nation's productivity and real income growth and to bolster its technological performance.

Another obvious indicator of the nation's eroding competitiveness is its sluggish productivity growth rate. Despite the pickup in productivity growth in recent years, the U.S. continues to be a laggard in the productivity growth race (see Tables 4 and 5). In some critical sectors, like automobiles, semiconductors, and consumer electronics, we are no longer the productivity leader.

A poor productivity record has translated into a poor record on wage and income growth. Depending on the accounting methodology and dates used, real per worker earnings have either barely risen, stagnated or fallen during the last eight years. By 1987, average real weekly earnings had dropped to the level which prevailed in the early 1960s.[4] Because of relatively weak productivity growth, U.S. wages have had to rise more slowly than wages in many other developed countries. In 1970, U.S. wages were four and one-half times as high as Japanese wages. By now Japanese workers have almost caught up with American workers.

In addition to productivity growth, technological improvements are a major determinant of national competitiveness. Improvements in product quality or serviceability and product innovations are often the source of competitive success in international markets. For products that compete on such features, technological improvements in process or product design are significant influences on competitive outcomes.[5]

[4] Economic Policy Institute, *The State of Working America* (October 1988).

[5] Improvements in product quality or serviceability and product innovations are especially important to competitive outcomes in high technology products, which account for about two-fifths of U.S. trade in manufactures.

Research and development drive the creation of new technology. In aggregate terms, the U.S. spends more on R&D than any other nation, but Japan and West Germany spend about the same fraction of their GNP on R&D and a much higher fraction on non-defense or commercial R&D (see Table 6). Approximately half of U.S. R&D spending is funded by the federal government, which spends the bulk of its money on defense and space programs.[6] Between 1980 and 1987, total federal R&D support increased 100 percent, but 90 percent of the increase went to the military. Real federal R&D spending for non-defense purposes in 1988 was 14 percent below its 1980 level.[7]

The problem of insufficient federal support for nondefense R&D is compounded by comparatively low U.S. corporate R&D spending. While R&D spending by U.S. firms has improved from the low levels of the late 1970s, the growth in spending by Japanese and German firms has been even faster (see Table 6).[8]

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[6] Military R&D programs can generate technological and knowledge spillovers for commercial uses, as the history of several American industries indicates. But times have changed. Several foreign governments are now sponsoring commercially oriented R&D programs in areas in which the U.S. government is focusing on narrow military applications. A recent study suggests that as defense needs in the U.S. have become more esoteric and highly specialized, the spinoffs of military R&D programs for the civilian economy have decreased. See Jay Stowsky, *Beating Our Plowshares with Double-Edged Swords*, Working Paper No. 17, Berkeley Roundtable on the International Economy, April 1986.

[7] About half of real federal R&D spending for nondefense purposes is concentrated in support for basic research in health sciences. Most of this spending goes to fund university research. See Martin Neil Baily and Alok Chakrabarti, *Innovation and the Productivity Crisis* (Washington, D.C.: The Brookings Institution, 1988).

[8] The leading firms in Japan's major industries now spend as much as or more than do their U.S. counterparts on R&D as a percentage of sales.

Some recent studies suggest that the problem in U.S. technological performance has not been as much the slowdown in the creation of new knowledge as the failure of industries to take advantage of available new technology.[9]

There are several possible explanations for the failure of U.S. firms to exploit technological opportunities as rapidly as their competitors. On the public policy side, there has been too little support, either in the form of public funding or tax policy, for "middle-ground" or generic R&D projects.[10] Such projects consist of applied research with commercial applications, but where the results are too general to make them attractive to private companies operating on their own. On the private side, R&D consortia among private actors to support such projects have been discouraged by antitrust considerations. The Justice Department under President Reagan significantly eased its antitrust restrictions on joint-venture R&D arrangements. The new regulations, however, still allow competitors excluded from a joint R&D venture to file damage suits and still limit the kinds of joint research activities exempted from usual antitrust conditions. Perhaps as a result, the U.S. has remarkably few private joint R&D ventures compared with the other advanced industrial countries at a time when the risk and capital requirements of new technologies preclude a go-it-alone R&D strategy by even the largest companies.[11]

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[9] See Baily and Chakrabarti, *op. cit.*, and Henry Ergas, "Does Technology Policy Matter?" in Bruce R. Guile and Harvey Brooks, eds., *Technology and Global Industry* (Washington, D.C.: National Academy Press, 1987).

[10] For a broader discussion of the lack of support for generic and middle-ground research, see Baily and Chakrabarti, *op. cit.*

[11] See Tom Jorde and David Teece, "Innovation, Strategic Alliances and Antitrust," paper prepared for Brookings Institution panel on microeconomics and growth, November 1988.

A major reason behind the failure of American firms to exploit technological opportunities is their relatively low investment rate in plant and equipment. New plant and equipment expenditures in manufacturing declined as a percentage of GNP in the 1980s (see Figure 1). As a result, the age of the nation's capital stock in manufacturing equipment has increased to relatively high levels by historical standards.

Capital investment also increases labor productivity. There is a strikingly close relationship between the rate of growth of the quantity of physical capital per worker and the rate of growth of labor productivity among the advanced industrial countries (see Figure 2).[12] During the 1970-86 period, the U.S. consistently had the lowest investment rate in plant and equipment, the lowest growth in physical capital per worker, and the lowest growth in labor productivity (see Table 7). Furthermore, the already low U.S. investment rate has been on a downward trend—the net national investment rate in the 1980s was lower than during the 1950s, 1960s and 1970s (see Figure 3).

As the preceding discussion indicates, public or private actions that reduce the trade imbalance; increase productivity growth; generate high-wage, high-productivity jobs; stimulate more R&D spending; hasten the diffusion of technological knowledge; and increase the rate of capital formation, can improve the nation's competitiveness. The next section considers policy actions required to realize these objectives.

Before considering these actions, it is important to emphasize that foreign-owned firms operating in the U.S. can contribute to national competitiveness in all of the ways identified here. Foreign-owned firms can in-

[12] George Hatsopoulos, Paul Krugman, and Lawrence Summers, "Beyond the Trade Deficit," unpublished paper, April 1988.

vest in physical and human capital and R&D; create high-wage, high-productivity jobs; introduce new production technologies and organization skills; and increase U.S. exports and reduce U.S. imports, thereby improving the trade balance. The basic challenge for government is to formulate policies that will encourage both domestic and foreign firms to take the private actions required to strengthen national competitiveness.

IV. GENERAL POLICIES TO IMPROVE U.S. COMPETITIVENESS

This section suggests policy initiatives to strengthen national competitiveness over the long run. The policy recommendations include: a gradual deficit reduction plan; changes in government spending priorities and tax policy to increase national saving and national investment in physical plant, human and knowledge capital; the further relaxation of antitrust laws and the use of government funds to stimulate R&D consortia for generic or middle-ground technologies; and the use of international negotiations and national trade laws, including the new Omnibus Trade Bill of 1988, to maintain open and fair conditions in global trade. The following discussion describes the rationales for each of these recommendations.

The first step in addressing the nation's competitiveness is increasing its investment commitment. This is where the nation's macroeconomic challenge and its competitiveness challenge come together. During the next several years, the gap between national saving and national investment must be reduced in ways that encourage more investment. This will require an increase in national saving.

The U.S. saved less than two percent of its income in 1986 and 1987. This is less than one-third of the savings rate realized in the 1970s, less than one-fifth of the aver-

age saving rate of the major industrialized countries, and only one-eighth of the saving rate in Japan.[13]

Low national saving discourages national investment by raising the cost of capital. Recent studies suggest that the cost of capital is significantly higher in the United States than in Japan. For example, one study indicates that in 1985, American firms had a real cost of funds of six percent while Japanese firms had a real cost of funds of only 1.5 percent.[14]

Although there is disagreement about the exact size of the cost of capital disadvantage to American firms, there is general agreement that such a disadvantage exists and that the real cost of capital in the U.S. remains high by historical standards. The high cost of capital is an important factor behind the myopia that is thought to affect American companies.[15] The cost of funds plays a critical role in determining how much a firm values future as opposed to current earnings.[16] It influences how

[13] Rudiger Dornbusch, James Potreba, and Lawrence Summers, "Business, Economics and the Oval Office: Advice to the New President and Other CEOs," *Harvard Business Review* (November 1988).

[14] George N. Hatsopoulos and S.H. Brooks, "The Cost of Capital in the United States and Japan," paper presented at the International Conference on the Cost of Capital, Kennedy School of Government, Harvard University, 1987.

[15] See Dornbusch, Potreba, and Summers; Martin Feldstein, "Business, Economics and Oval Office: Advice to the New President and Other CEOs," *Harvard Business Review* (November 1988).

[16] For example, an investment decision that lowers a firm's earnings by one dollar today while increasing earnings by two dollars ten years from now is a profitable decision if the firm's cost of funds is five percent, but it is an unprofitable decision if the firm's cost of funds is ten percent. It follows that a firm's investments will be rationally lower, the higher the cost of funds it faces. See Hatsopoulos, Krugman and Summers, *op. cit.*

much patience is actually rational. Because American companies have operated in an environment of high capital costs, they have rationally developed a short-term focus.[17]

The low national saving rate also makes the nation dependent on foreign capital inflows to finance its productive investment. Perhaps as much as two-thirds of gross private investment in plant and equipment is currently financed by foreign funds. There can be no significant reduction in the nation's current account imbalance without a reduction in its reliance on foreign capital.

Although *private* saving has also fallen in the 1980s below its post-war average, record federal budget deficits in the 1980s have been the major cause of low *national* saving. The deficit has absorbed more than two-thirds of the nation's private savings during the past five years, drawing funds away from private investment and making the nation increasingly dependent on foreign investment to make up the difference. As a result, the deficit has been a major burden on the nation's competitiveness.

There is widespread concern that the deficit will not go away as a result of continued economic growth. Indeed, recent estimates by the Congressional Budget Office show the deficit beginning to rise even though the

[17] The myopia of American business has also been encouraged by the cyclical variability and relatively low growth rate of the American economy relative to that of Japan. Japan has had only one serious recessionary downturn during the postwar period. Japan's producers have come to expect rapidly growing national markets with little perceived risk of a slowdown which could reduce returns on investment. In contrast, American producers operate in a national market which has grown slowly and which has suffered from recurrent and sometimes prolonged recessionary slowdowns. This has increased the riskiness of investment for American companies and has encouraged a short-term focus.

economy is rapidly approaching full employment.[18] Therefore, the first and most significant step toward improving the nation's competitiveness is a credible program to reduce the deficit. Meaningful deficit reduction will require real policy changes on both the revenue and spending sides of the ledger.

Since this is not a report on deficit reduction, we will not make any detailed recommendations for the necessary changes. But we do endorse the need for a sustained deficit reduction package to increase national saving and investment. The goal of deficit reduction should be to bring the budget into approximate balance by fiscal year 1993 in accordance with the Gramm-Rudman guidelines. But the spending and revenue measures used to realize this goal must be guided by the additional goal of restoring national competitiveness. And this implies that the deficit reduction package finally adopted have certain features.

On the spending side, federal priorities must be changed. In particular, the composition of federal spending must be shifted toward spending in certain critical public investment areas including education, worker training, infrastructure, and commercial science and technology. We must address the glaring weaknesses in the nation's primary and secondary education; shortages in the number of qualified engineers and scientists; the erosion in the laboratory and research facilities of the nation's universities;[19] the deterioration of the national infrastructure and its negative consequences for the productivity performance of the private sector;[20] and the relative decline in the nation's commitment to commercial R&D spending compared to many other industrial countries.

[18] The Congressional Budget Office predicts that the deficit will rise to $220 billion by fiscal year 1993. Only if the Social Security Trust Fund surplus is included does the deficit appear to be on a downward trend.

[19] Federal funding for university plant and facilities for research has declined over 92 percent in real terms over the past twenty years. Corporate and university leaders agree that many of these facilities are far behind the technological frontier, impeding the pace of university basic research and the training of engineers and scientists for the corporate sector.

There is a consensus among business, educational and civic leaders that the most important spending priority for national competitiveness in the coming years is education. As a result of new production technologies, the skill requirements of new jobs are projected to rise rapidly over the next decade.[21] At the same time, the labor force is projected to grow much more slowly than in the 1980s, and more than one-half of new workforce entrants will come from groups which have historically experienced high dropout and illiteracy rates and low educational achievement rates relative to the rest of the population. The nation faces a developing shortage in the skilled workforce it needs to be a competitive location for production by domestic and foreign firms alike. The nation also suffers from a shortage in engineering and scientific manpower—thousands of engineering faculty jobs around the country are currently unfilled, jeopardizing both engineering training and research.

[20] A recent study by the Federal Reserve Bank of Chicago shows a strong correlation between productivity performance in the private sector and investment in public infrastructure, including roads, transportation facilities, and waste management. See David Alan Aschauer, "Net Private Investment and Public Expenditure in the United States, 1953-84," Occasional Paper, Federal Reserve Bank of Chicago, 1987.

[21] These projections are reached by William Johnston and Arnold Packer in their study for the Hudson Institute, *Workforce 2000: Work and Workers for the 21st Century* (1987).

Although education is largely a state issue, federal programs are necessary to address certain important needs. Along with (rather than at the expense of) deficit reduction, federal government spending should be gradually increased on several fronts including: educational programs serving the disadvantaged,[22] and loan and grant programs to ensure access to post-secondary education; programs to strengthen math and science education—areas in which the U.S. lags behind its major competitors,[23] and which are needed if the nation is to increase its supply of qualified engineers; and training programs for dislocated workers. Most of the necessary programs to serve these objectives currently exist, but, due to budgetary priorities none of them are fully funded to serve the eligible populations.

On the revenue side of the ledger, the deficit reduction package must be sensitive to the effects of tax policy on private saving, and on investment and R&D by private companies.

The federal government does not bear sole responsibility for the low national saving rate. The private saving rate, which was already low throughout the 1960s and 1970s compared to the private rates of other industrial countries, fell to even lower levels in the 1980s.

The causes of the traditionally low private saving rate and its more recent decline are not well understood. Nonetheless, many believe that the federal tax code—

[22] The federal government already has in place several successful programs to help the economically disadvantaged at primary and secondary school levels, including the Women, Infants and Children Program, the Head Start Program, and Chapter I of the Education Consolidation and Improvement Act. All of these programs have been severely underfunded and have served only a small fraction of eligible populations.

[23] The National Science Foundation is committed to strengthening engineering and scientific training at the post-secondary level out of its larger budget, which is currently slated to double by 1993.

which treats saving unfavorably—has been a factor, and that changes in the tax code to encourage higher levels of private saving are warranted. Some possible measures in this direction include a broad-based consumption tax, limiting home-equity loan deductions, phasing out deductibility of mortgage interest on vacation homes, and expanding the eligibility for IRAs. Further analysis of the relationship between private saving and taxation is needed before specific moves are made in any of these directions.

As far as investment spending is concerned, the 1986 Tax Reform Act, while introducing several improvements in the nation's tax system, reduced the incentive for investment in new equipment. The corporate tax rate, which applies primarily to profits earned on past investment, was reduced, resulting in a windfall on the returns to the existing capital stock. In contrast, the investment tax credit, which applies only to new investment, was eliminated, reducing the anticipated returns from new investment. Together, these two tax changes raised manufacturing production costs and tended to reduce demand for manufacturing output, particularly in high-technology industries.[24]

A pro-competitiveness deficit reduction effort should consider possible changes in the tax code to increase the incentives for private investment. Restoring the investment tax credit, a proven measure for stimulating investment in plant and equipment, is likely to be at odds with deficit reduction as long as no new taxes are introduced. But, as a group of distinguished economists has recently recommended, it may be possible to regain much of the credit's incentive effect at a fraction of its former cost by adopting an incremental approach.[25] An incre-

[24] See Dornbusch, Potreba, and Summers, *op. cit.*

[25] Dornbusch, Potreba, and Summers, *op. cit.*

mental tax credit would apply only to the change in a company's net capital stock during two successive years. Thus, it would subsidize expansion of the net stock of plant and equipment, but provide no subsidy on the existing capital stock.

In addition to the re-introduction of some form of investment tax credit, the tax treatment of capital gains should be reconsidered. In particular, to encourage long-term investment, the taxation of capital gains could be steeply graduated, declining from the current high rate on short-term gains to a zero rate on gains earned over a five to ten year period.

Finally, as a stimulus to private investment in knowledge capital, a permanent tax credit for corporate R&D should be considered. A conservative estimate indicates that the 1981-85 R&D tax credit increased corporate R&D by 1.2 percent or $500-$600 million per year.[26] And a recent study suggests that the actual effect may have been much larger—increasing corporate R&D spending by as much as $2.9 billion per year between 1982 and 1985.[27] Whatever the actual size of the effect, the overall case for an R&D tax credit is compelling. Study after study indicates that the social return from corporate R&D is two to four times the private return. The nation should use tax policy to encourage private R&D spending which generates significant returns throughout the economy.

In addition to tax policy, government policy should be used to encourage private coalitions or consortia for middle-ground or generic R&D. It is the nature of such R&D that the results are likely to benefit a large number

[26] For a summary of the conservative estimates of the effects of the R&D tax credit on R&D spending see *Research and Experimentation Tax Credit*, Hearings before the Subcommittee on Oversight of the House Committee on Ways and Means, 98th Congress, 2nd Session, August 2-3, 1984.

[27] Baily and Chakrabarti, *op. cit.*, p. 129.

of producers, no one of which is likely to be willing to finance the R&D commitment to generate these benefits for others. Under these circumstances, there is a real possibility that a partnership among private actors or between them and the public sector can work to the advantage of the nation.

Public-private consortia can be an effective means for stimulating and organizing generic research projects. Private actors, responding to market conditions and evolving technological and scientific knowledge, identify promising directions for generic R&D, and the government provides an infusion of public funds to encourage the commitment of private resources. Sematech, a recently formed consortium for research in semiconductor manufacturing processes, is an example of such a public-private consortium. The new federal initiative on superconductivity calls for the establishment of similar cooperative research groups for basic research in superconductivity.

Public-private R&D consortia for competitiveness should have seven distinguishing characteristics.[28]

- First, they should involve risky but promising applied R&D activities at a pre-competitive or generic stage.
- Second, the identification of potential activities should come from the private sector, not from the government. The government should follow the lead of the private sector and not engage in picking "winning" technologies itself.
- Third, the consortia should be financed partly by private firms expecting to benefit from the results

[28] The characteristics of public-private R&D consortia discussed in this Report are based on suggestions in Baily And Chakrabarti, *op. cit.*, and Laura D'Andrea Tyson, "Business, Economics and the Oval Office: Advice to the New President and Other CEOs," *Harvard Business* (November 1988).

of the R&D effort and partly by the government. Because of the difficulty companies will have in earning an adequate rate of return on generic R&D which generates knowledge for other companies, it is appropriate to provide part of the cost with public funds. But because of the danger of wasteful government projects, it is appropriate to insist that most of the funding be private.

- Fourth, consortia should be organized cooperatively to encourage collaboration and communication among private producers. Company scientists should perform the R&D and cooperatively decide how to proceed.

- Fifth, these consortia should have a commercial orientation, not a military one. In current technological and competitive circumstances, the U.S. should no longer rely on uncertain and costly spillovers from military R&D to substitute for applied, commercially focused R&D. While devoting significant R&D support to the semiconductor industry for defense purposes, the U.S. found itself increasingly dependent on commercially developed semiconductor technology from Japan for its defense needs. If anything, the recent evidence from the semiconductor industry suggests that the beneficial spillovers from commercial R&D to defense uses may be at least as great as the beneficial spillovers from defense R&D to commercial uses.

- Sixth, participation should be based on contributions to the United States' economy such as; R&D in the United States, the participants' added value in the United States, and potential for exploitation of the results of the R&D in the United States.

- Seventh, and finally, the government should further relax antitrust laws to encourage the formation of joint R&D ventures among private firms.

As a result of the National Cooperative Research Act of 1984, antitrust restrictions on joint-venture R&D arrangements have been eased. The 1984 regulations, however, still allow competitors excluded from a joint venture to file damage suits, although only single rather than treble damages are permitted. While the elimination of treble damages is an important step forward, cooperating firms are still not protected from antitrust litigation.[29] In addition, the antitrust relaxation in the 1984 law is limited to joint research activities and does not apply to joint development and production arrangements often required for the successful commercialization of new technology. For example, the Act's limitation to joint marketing of intellectual property unwisely precludes joint manufacturing and production of innovative products and processes which in turn may provide the cooperating firms with significant feedback information to aid in further innovation and product development.

As a result of these limitations in the 1984 antitrust legislation, there is still a great deal of antitrust uncertainty facing firms considering formation of research consortia. In addition, the realization of commercial returns from such cooperative efforts may be impeded by the remaining restrictions on related joint production activities. Perhaps as a result, the U.S. has remarkably few private joint research ventures compared to the other advanced countries at a time when the risk and capital requirements of new technologies increasingly preclude a go-it-alone strategy by even the largest companies.

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[29] The cost of defending an antitrust suit can be extremely high, which is not alleviated by the Act's exceedingly narrow award of attorney's fees to prevailing defendants.

During this session of Congress, a revision to the National Cooperative Research Act will be introduced which attempts to address some of the substantive and procedural shortcomings of the existing law.[30] There are two basic principles behind this amendment: first, the National Cooperative Research Act should be extended to encompass joint production as well as joint research acticities under certain circumstances; and second, procedures should be adopted that remove the threat of damages for cooperating firms that secure approval for their cooperative arrangements from the Department of Justice and other relevant government agencies.

Finally, in addition to the other policy measures discussed here, the government must make active use of international negotiation and domestic trade policy to maintain and expand an open global trading system. The U.S. needs a world of expanding markets to eliminate its current account deficit. The drop in the dollar's value gives producers operating in the U.S. an opportunity to capture a growing share of such markets. Achieving such an outcome will require a tough American negotiating stance in the Uruguay Round talks and enforcement of the nation's new trade law to open foreign markets and to insure fair competition in both U.S. and international markets.

V. RECAP OF PRO-COMPETITIVENESS POLICY RECOMMENDATIONS

The nation has an opportunity to use the enhanced competitiveness afforded by a lower dollar to build the foundation for improved competitiveness over the long run. To realize this objective, six main policy initiatives are recommended: first, the introduction of a gradual deficit reduction package to bring the budget to approxi-

[30] A copy of one such draft that will be introduced shortly by Reps. Rick Boucher (D-VA) and Tom Campbell (R-CA) is attached as an appendix to this Report (Appendix A).

mate balance by 1993; second, a change in the composition of federal spending toward education, worker retraining, science and technology, and infrastructure; third, changes in tax policy to encourage greater private saving and more private investment and R&D spending; fourth, the use of government research funds to support private-public consortia for middle-ground or generic R&D in areas judged to be of significant market and technological value by the private sector; fifth, the further relaxation of antitrust restrictions on private cooperative R&D consortia; and sixth, the active use of national and international trade laws and negotiations to insure fair competition in both U.S. and international markets.

VI. THE ROLE OF ELECTRONICS IN U.S. COMPETITIVENESS

So far this Report has taken a broad, economy-wide perspective. Trends in national competitiveness, broadly defined, have been examined, and recommendations for economy-wide or macroeconomic policies to improve long-run competitiveness have been made. The discussion has been based on the notion that competitiveness is an economy-wide concept that is logically distinct from the competitive position of private producers in particular industries.

Such a perspective overlooks the possibility that certain industries or activities may contribute more than others to national competitiveness over the long run. Yet it is just such a possibility that has motivated growing national concern about the health of the U.S. semiconductor industry and that is a factor behind growing concern about U.S. participation in HDTV. To evaluate these concerns and the policy recommendations that accompany them, this section of the Report examines some of the reasons why the electronics sector—broadly defined to include the semiconductor industry, the computer industry, the display industry, the telecommunications in-

dustry, and various segments of the consumer electronics industry—is judged by many to be of particular importance to national competitiveness.

From a national competitiveness perspective, the critical node of the electronics sector is the microelectronics or semiconductor industry. Semiconductors are at the heart of electronics products ranging from computers, telecommunications systems, and industrial robots to VCRs, video games and state-of-the-art television receivers. More fundamentally, semiconductors are a major source of innovation in products and processes throughout the economy.

The spillover effects of the microelectronics revolution on the rest of the economy are best understood by distinguishing between two categories of effects: linkage impacts and technological spillovers.[31] Linkage impacts are those that generate increasing positive benefits for economic activities tied to chip production. Technological spillovers are pervasive, benefit-creating impacts on scientific and technological activities more loosely associated with chip development and production—for example R&D in physics or superconductivity.

The sustained economic benefits from linkage impacts arise because chip production generates a cycle in which increased investment in R&D and capacity leads to increasing chip performance at decreasing cost. The improved price-performance characteristics in turn deliver improved price-performance in products like computers, and also generate new markets such as antiskid braking systems. The applications generate broad societal returns. As these markets expand, substantially

[31] The following discussion is from Michael Borrus, *Competing for Control: America's Stake in Microelectronics* (Cambridge, MA: Ballinger, 1988).

increased demand for chips is generated. Increased user demand occasions expanding investment in chip development and production, which leads to another round of improved price-performance. The cycle is repeated. Such has been the history of the microelectronics industry for over three decades.

Although somewhat imprecise by contrast to linkage impacts, technological spillovers generally result from the interdependence that characterizes precursor and complementary technological activities. This is most obvious in the relationship between chips and the systems that incorporate them. Increasingly, the chips embody the systems functions and performance characteristics of the products that incorporate them: advanced chips are systems and innovation in systems occurs at the level of the chip. This is the most precise type of technological spillover but there are other, broader, spillovers as well.

Advances in chip technology depend upon and contribute to continued technological innovation in physics, chemistry and materials sciences. For example, it is no coincidence that recent advances in superconducting materials originated partly at IBM Research, AT&T Bell Laboratories, and Bellcore where the search for superfast microelectronic switching devices for computer and telecommunications applications motivated experimentation with superconductivity. The gains from superconductivity will not be confined to chips but will pervasively influence activities ranging from electricity generation to high-speed transportation.

As a result of both linkage effects and technological spillovers, microelectronics has driven both product and process innovation throughout the economy. Microelectronics-based technologies are already automating both primary commodity and goods production and transforming the activities that make up the service industry. Global competition in a variety of both tradi-

tional industries, such as textiles and steel, and high-technology industries, such as aircraft, is increasingly based on microelectronic-driven innovations.

In addition to their effects on innovation and competitiveness in a wide variety of industries, the microelectronics industry and the electronics sector, more broadly defined, are important to national competitiveness in more direct ways. Between 1965 and 1985, the global output of the electronics complex grew by over 13 percent per annum in real terms, and by 1985 it equalled the global output of the automobile industry and surpassed the global output of the steel industry. In 1987, U.S. sales of electronics products exceeded one-quarter of total durable industries' shipments and have been growing at over five percent annually. Electronics, in total, employs more than one and one-half million Americans, many of them highly skilled. The wage of the average worker in the electronics industries is higher than the average wage of workers of similar skill, education, experience, and personal characteristics, such as age, sex, and race, in many other manufacturing activities and in most service activities.[82]

The electronics sector is tightly linked to many other portions of the U.S. economy. Not only do the nation's defense industries depend on electronic technologies but both manufacturing and service industries—ranging from the production of numerically controlled machine tools to banking and insurance—use electronic products both directly and indirectly. These products—which range from CB radios to satellite-based communications systems, carbon resistors to vastly powerful computers—are probably distributed more widely through the rest

[82] This conclusion is based on calculations in Williams Dickens and Kevin Lang, "Why It Matters What We Trade," in Laura D'Andrea Tyson, William Dickens, and John Zysman, eds., *The Dynamics of Trade and Employment* (Cambridge, MA: Ballinger, 1988).

of the U.S. economy than the output of any other industry.[83] Because many electronics products serve as inputs in other sectors of the economy and because they are produced under conditions of increasing returns or declining costs due to the significant learning curve economies realized in their production, the electronics sector gives rise to what economists call "linkage externalities"—increasing private returns in the electronics industry are accompanied by increasing societal returns in downstream user industries.

Finally, as the global electronics industry has grown, it has become an increasingly important determinant of national trade flows and national trade balances. The U.S. trade position in electronics deteriorated between 1980 and 1987, although measures of the extent of the decline vary depending on how broadly electronics is defined (see Table 8 and Figure 4).[84] All of the estimates indicate that the decline was broad-based, ranging from consumer electronics and components to office computing equipment and sophisticated telecommunications equipment. Notably, the electronics trade balance continued to drop despite the dollar's decline. Even with further declines in the dollar's value, the U.S. will continue to run a significant deficit in many electronic products. This is true for many consumer electronics items. To illustrate, about 13.3 million VCRs were sold in the U.S. in 1987. Only 230,000 were made in the U.S. (assembled from imported parts), resulting in a total import bill of over $3 billion. Although by 1989, nearly 900,000 VCRs are expected to be made in the

[83] Office of Technology Assessment, *International Competitiveness in Electronics* (Washington, D.C.: USGPO, November 1983).

[84] It is important to emphasize that the electronics trade balance is heavily influenced by the decisions of U.S. multinationals. Some estimates indicate that as much as a third of the electronics imports from individual East Asian countries come from U.S.-owned operations.

U.S., they will represent approximately seven percent of estimated sales, and will likely rely heavily on imported components, implying a continued large deficit in this item for the foreseeable future.[35]

World production shares in electronics also indicate a drop in U.S. competitiveness relative to other regions. According to an analysis of data collected by the Electronic Industries Association of Japan (EIAJ), the U.S. production share of electronics dropped from 50.4 percent in 1984 to 39.7 percent in 1987. During the same period, Japan's share rose from 21.3 to 27.1 percent. The same trend was observed in a different study, with sligthly different numbers, done by the European Electronics Industry Council.[36]

World production shares in semiconductors also indicate a drop in U.S. competitiveness in the last decade, particularly relative to Japan. Figures from Dataquest indicate that Japan produced slightly more than 50 percent of world production in 1988 while the U.S. produced around 37 percent. In 1978, the U.S. accounted for 55 percent and Japan less than 30 percent of world production.[37]

The next section attempts to demonstrate that an enhanced U.S. participation in consumer electronics with HDTV products in the future can make a limited contribution to maintaining U.S. competitiveness in electronics. The increasing sophistication of consumer electronics technology embodied in HDTV products will mean that

[35] Allen Lenz, "Slimming the U.S. Trade and Current Account Deficits," *The AMEX Review, Special Papers*, No. 16 (October 1988).

[36] Lawrence M. Fisher, "U.S. Share Declines in Electronics," *New Times*, (January 5, 1989), p. C1.

[37] "Preliminary 1988 Worldwide Semiconductor Market Shares: Japanese Gain Share: Memories and Micros Dominate Market," *Dataquest Newsletter*, January 1989, pp. 1 and 3.

there may be more spinoffs to the rest of the electronics industry from consumer products research and production. Even more important could be the relationship between the diffusion of HDTV and the building of the national telecommunications network.

VII. THE ROLE OF CONSUMER ELECTRONICS WITHIN THE ELECTRONICS COMPLEX

There are three important forms of linkage between the consumer electronics industry and the rest of the electronics complex. They are:

- upstream effects
- downstream effects
- manufacturing effects

Upstream effects derive mainly from the role of consumer electronics production as a source of demand for inputs, and, in particular, for semiconductor components. The consumer electronics industry in the United States first contracted and then shifted from domestic to predominantly foreign ownership. The ability and interest of U.S.-based semiconductor firms to service markets for consumer-related semiconductors virtually disappeared.[38] By the mid-1980s, only six percent of semiconductor production in the U.S. went to consumer applications, whereas in Japan, 40 percent did. In dollar terms, this meant that Japan was producing 7.2 billion consumer chips in 1987 while the U.S. produced only 0.9 billion. The corresponding figure for Europe was around four billion.[39]

[38] It should be noted that the decision of U.S. semiconductor firms to stop building chips for consumer electronics at the beginning of the massive growth in imports of consumer products occurred much earlier than the acquisition of major U.S. consumer firms by foreign firms.

[39] Statement by Jeffrey A. Hart submitted to the Subcommittee on Telecommunications of the House Committee on Energy and Commerce, September 7, 1988, p. 8.

There is an honest dispute about how this occurred. Some U.S. firms claim that foreign-owned consumer electronics firms had preferential supply arrangements that excluded them from the market. The more vertically-integrated foreign electronics firms often sourced their semiconductors from their internal semiconductor divisions. In all the major industrialized regions, there is a preference for working with regional suppliers of components whenever possible. The Japanese consumer industry, as represented by the EIAJ, claims that U.S. firms were unable to produce the necessary products, or to deliver them on time, or to match the quality/reliability of other (particularly Japanese) producers. The U.S. semiconductor firms accuse the Japanese of preferentially sourcing from Japanese semiconductor producers. Both of these claims may be true. Of key importance for many U.S. firms was the fact that the consumer chip business was less profitable, because it involved standard devices in which markets were highly competitive, than business for industrial or defense applications.

Another key factor was the increased product design activity that built up in Japan. Product design in a foreign country makes it extremely difficult for U.S. semiconductor firms to compete. It is estimated that around 12% of the semiconductors produced in Japan are used in VCRs. The end result of these two factors was major abandonment of consumer chip production in the U.S. This is particularly true in such specialty devices as charge-coupled devices (CCD) and liquid crystal displays (LCD).

Downstream effects refer to the impact of consumer electronics on industries downstream from the semiconductor industry. The VCR volume base led to video cameras. The camera base contributed to commercially priced CCD chips. The VCR, camera and CCD base led

to camcorders, still video photography, video printers and new video printer film.

In a similar manner, Japanese strengths in LCDs for watches and calculators helped to give them an edge in the emerging markets for laptop computers and personal TVs.

Manufacturing effects involve the loss of strength in generic manufacturing skills and technologies associated with the reduced role of U.S.-owned firms in the consumer electronics industry. While a number of U.S. firms were able to match their international competitors in the adoption of advanced manufacturing techniques, such as automated insertion and surface-mount technologies, the majority failed to do this rapidly enough to meet the competition. These technologies are important not just for consumer electronics but for many other kinds of high-volume production. The decline of the U.S. consumer electronics industry, therefore, meant a narrowing of the manufacturing skill base of the U.S. economy.

There are reasons to believe that upstream, downstream, and manufacturing effects will be even greater in the next two decades than they were in the past.[40] HDTV circuitry will be much more complex than NTSC circuitry. HDTV circuitry needs could contribute to advancing technology in some important areas, such as digital signal and image processing, and parallel proc-

[40] Competitive issues are also raised by the efficient use of the broadcast spectrum. To the extent the Federal Communications Commission allocates spectrum efficiently, new opportunities for growth in the U.S.-based land mobile and cellular telephone industry will be created. An important issue in the development of HDTV is the bandwidth proposed for each channel and the channel spacing. The EIA believes that the FCC should consider spectrum efficiency and HDTV terrestrial signal quality required to be competitive with other delivery media when it adopts the Terrestrial HDTV transmission standard.

essing. HDTV receivers will require larger and better video frame storage devices than NTSC receivers. In addition, competition in the HDTV business will create sizeable incentives for the development of large displays, and particularly for the development of flat-panel displays—e.g., liquid crystal displays (LCD), and semiconductor-based projection systems.

The downstream spillover effects of HDTV technology could be significant in the computer, defense electronics, and telecommunications industries. The problems of image and digital signal processing that have to be solved for HDTV receivers also have to be solved for fast displays of color images on advanced computer workstations. The production of large, high-resolution displays for HDTV equipment will allow some firms to produce cheaper and more competitive displays for computers and workstations.

There is an important mutually reinforcing relationship between advances in HDTV and network (telecommunications) technology. The networking of advanced computer workstations creates network architecture design problems similar to those posed by the use of HDTV receivers as interactive terminals. Interactive video and interactive 3-D color CAD/CAM are both more demanding than existing interactive character and graphics networking.[41] If you can solve one problem, then you have more or less contributed to the solution of the other. The unanswered question in this equation is how much demand there will be for "interactive" (two-way) as opposed to "passive" (one-way) television.

More important than the technological linkages between HDTV and telecommunications are the likely linkages between the two that arise with the building of a new national telecommunications infrastructure based on

[41] Workstation firms are now introducing NTSC video image processing in the high-end of their product lines.

optical fibers. HDTV signals will be delivered to the home before the fiber optic network is universally operational. Nevertheless, the sooner HDTV broadcasts and other home deliveries begin, the sooner there will be demand for transmitting HDTV signals via optical fiber (because of the greater fiber optic bandwidth and the opportunity for reducing transmission noise with broadband digital signals). By the same token, the faster high quality fiber optic delivery to the home is in place, the easier it will be to convince consumers to make the switch from NTSC, or interim products, to HDTV.[42]

The greater U.S. participation in HDTV consumer markets is, therefore, the greater the upstream, downstream and maunfacturing benefits for the rest of the U.S. economy will be. Thus, policy measures should be aimed at maximizing U.S. participation. Because U.S. based foreign-owned firms already possess such an important stake in this country's R&D and manufacturing of consumer electronics, they should be included in efforts to promote the HDTV industry.[43]

VIII. THE POTENTIAL IMPORTANCE OF HDTV TO CONSUMER ELECTRONICS

Factory sales of consumer electronics products were around 30 billion dollars in 1987. Of this total, 42 percent was derived from sales of TVs, VCRs, and camcorders (see Table 9 below). Over twenty million color TV sets, 11.6 million VCRs, and 1.6 million camcorders were sold in the United States in 1987.

[42] For further information on this point, see Appendix C prepared by the Fiber Optics Division of the Telecommunications Industry Association.

[43] Joseph Donahue, of Thomson Consumer Electronics in Indianapolis, estimates that the annual R&D expenditures of Thomson, Zenith, and Philips in the United States are around 150 million dollars per year.

TABLE 9

Factory Sales of Consumer Electronics Products
in the United States, 1977-1988,
in millions of dollars, including imports

Year	Mono TVs	Color TVs	Proj. TVs	VCRs	Video Disc	Audio Systems	Audio Comp.
1977	530	3289		180		606	1275
1978	549	3674		326		748	1143
1979	561	3685		389		748	1178
1980	588	4210		621		809	1424
1981	505	4349	287	1127	55	720	1363
1982	507	4253	236	1303	54	573	1181
1983	465	5002	268	2162	81	630	1268
1984	419	5538	385	3585	45	976	913
1985	309	5562	488	4738	23	1372	1132
1986	328	6024	529	5258	26	1370	1358
1987	287	6271	527	5093	30	1048	1715
1988e	200	6530	525	5055	40	1140	1800

Source: EIA, *1987 Electronic Market Data Book*, p. 6; EIA, *Consumer Electronics U.S. Sales*, January 1989.
e = estimate

Several of the largest U.S.-owned firms in consumer electronics were purchased by foreign firms. RCA was purchased first by General Electric in 1985, and then sold to Thomson of France in 1987. Philips of the Netherlands purchased Magnavox in 1975, and Philco and Sylvania in 1981. Zenith remains the only major U.S.-owned producer of TVs. In 1987, Thomson, Zenith, and Philips were the "big three" firms and accounted for about half of all color TVs sold in the United States. The rest of the market was divided among mostly Japanese and Korean producers. Both U.S.-owned and foreign-owned firms contribute to U.S. competitiveness in a variety of ways. There is significant variance in the degree to which each firm locates its research and development, manufacturing, and component production/sourcing in the United States (see Tables 10-11).

Despite the increased participation of foreign-owned firms in the United States, the color TV part of the consumer electronics market still retains a significant proportion of local content. The domestic manufacturing content of the average color TV made in the United States in 1987 is estimated to be around 70 percent,[44] and there has been a reversal in the last year or so of the downward trend in domestic content thanks to increased use of picture tubes manufactured in the United States. A number of foreign-owned tube manufacturing facilities came on line, a development which owes much to the decline in the value of the dollar relative to Asian and European currencies (see Table 10 and Figure 5). The foreign content of TV sets is primarily in the electronic circuitry, but there is also some foreign content in the form of license and royalty payments for tube and chassis technology.

[44] This estimate is based on figures for U.S. content of color TV receivers manufactured by Thomson. In Thomson's case, the U.S. content was 74 percent for 20 inch direct view receivers, 77 percent for 26 inch direct view receivers, and will be 82 percent for 31 inch direct view receivers. U.S. content increases in sets with the larger pictures because the tubes are mostly manufactured in the United States and they become a larger proportion of the total manufacturing cost of the larger sets. The domestic content of receivers produced by other firms may be somewhat lower than Thomson, but 70 percent is a reasonable estimate given the practices of other firms.

U.S. Set and Tube Production, 1988

TABLE 10

Company	Location	No. of U.S. Employees	Plant Type	Annual Production	Export/Where?
BANG & OLUFSEN (Joint Venture w/Hitachi)	Compton, CA (opening 1989)	(See Hitachi Below)	Assembly	Not available	yes/Canada
GOLDSTAR	Huntsville, AL	400	Total Production	1 million	yes/Taiwan
HARVEY INDUSTRIES	Athens, TX	900	Cabinet Assembly/TV Assembly	600,000 capacity	yes/Mexico, Far East
HITACHI	Anaheim, CA	900	Total Production for 24", 27" 31"	over 360,000	no
JVC	Elmwood Park, NJ	100	Total	480,000	yes/Canada
MATSUSHITA	Franklin Park, IL	800	Assembly	1 million capacity	yes/Japan
AMERICAN KOTOBUKI (Subsidiary of Matsushita)	Vancouver, WA	200	VCR/TV Assembly	Not available	Not available
MATSUSHITA (Joint Venture w/Philips)	Troy, OH (opening spring 1989)	100-200 upon opening; eventually 400	Tubes	1 million	Not available
MITSUBISHI	Santa Ana, CA	550	Final Assembly	400,000	no
MITSUBISHI	Braselton, GA	300	Total/Full	285,000	no
NEC	McDonnough, GA	400	Final Assembly	240,000	no
O-I/NEG TV PRODUCTS (Joint venture of Owens-Illinois & Nippon Electric Glass)	Columbus, OH	800	Tubes (capabilities up to 45")	Not available	no
O-I/NEG TV PRODUCTS	Pittston, PA	750	Tubes (capabilities up to 45")	Not available	no
O-I/NEG TV PRODUCTS	Perrysburg, OH	75	Component glass for TV (solder glass)	Not available	no
ORION	Princeton, IN	250	Assembly	Not available	yes
PHILIPS	Arden, NC	400-500	Parts (Plastic Cabinets and Accessories)	Not applicable	yes/Mexico, Canada
PHILIPS	Greenville, TN	3,200	Assembly/Full Manufacturing	over 2 million	yes/Canada, Taiwan & Mexico
PHILIPS	Jefferson City, TN	1,000	Parts (Wood Cabinets)	6-700,000	no

TABLE 10—Continued

Company	Location	No. of U.S. Employees	Plant Type	Annual Production	Export/Where?
PHILIPS	Ottawa, OH & Emporium, PA	2,300	Tubes	3 million	no
SAMSUNG	Saddlebrook, NJ	250	Production for 13"-26" TVs	1 million capacity	yes/Canada
SANYO	Forrest City, AR	400	Assembly	1 million capacity	no
SHARP	Memphis, TN	770	Assembly	1.1 million	no
SONY	San Diego, CA	1,500	Full Manufacturing of Color TVs & Tubes	1 million	yes/Canada, South America, Central America, Taiwan & Japan
TATUNG	Long Beach, CA	130	Assembly	17,500	yes/Canada, Mexico & Taiwan
THOMSON	Bloomington, IN	1766	Full Manufacturing/ Assembly	over 3 million	yes/Latin & South America
THOMSON	Indianapolis, IN	1604	Components Manufacturing (Printed Boards & Cabinet Production)	Not applicable	no
THOMSON	Mocksville, NC	626	Cabinet Production	Not applicable	no
THOMSON	Marion, IN	1982	Tubes	Not available	yes/Europe
THOMSON	Circleville, OH	700	Glass for Picture Tubes	Not available	no
THOMSON	Scranton, PA	1242	Tubes	Not available	yes/Europe
TOSHIBA	Lebanon, TN	600 (300 add'l. planned for 1989)	Assembly	900,000 (1.3 million planned for 1989)	yes/Canada, South America, Japan & Taiwan
TOSHIBA	Horseheads, NY	1,000 (500 add'l. planned for 1989)	Tubes	1 million (1.5-2 million planned for 1989)	no/(probably will export in 1989)
TOSHIBA	Springfield, MO	2,000-2,500	Full Manufacturing/ Final Assembly	Not available	yes/Canada
ZENITH	Melrose Park, IL	2,500-3,000	Tubes	Not available	yes/Far East

Source: Electronic Industries Association, HDTV Information Center.

TABLE 11

U.S. Consumer Electronics Research Facilities, 1988

Name of Firm	Name of Facility	Location	Comments
Thomson	David Sarnoff Laboratories	Princeton, NJ	currently run by SRI with revenues from GE and RCA patents
Philips	Philips Laboratories	Briarcliff Manor, NY	
Zenith	n.a.	Glenview, IL	

Source: company annual reports.

A study done by Robert R. Nathan Associates (henceforth RRNA) for the EIA forecasts that 13 million HDTV receivers will be purchased in the United States in 2003 and that 92 percent of them will be made in the United States. The domestic content of these sets will be around 78 percent. The RRNA study projects that HDTV products will capture over 30 percent of the market for TVs by 2003. The production and sale of these receivers will contribute 23 billion dollars to the gross national product and will require the skills and efforts of 232,000 workers. The RRNA study argues that the production of HDTV receivers will increase the contribution of TV manufacturing to total GNP by six billion dollars more than would be the case if HDTV were not commercialized.[45]

[45] Robert R. Nathan Associates, Inc., *Television Manufacturing in the United States: Economic Contributions—Past, Present and Future*, prepared for the Electronic Industries Association, Washington, D.C., November 22, 1988, Chapter IV, pp. 1, 4 and 20.

The RRNA study is echoed by a study done for the National Telecommunications and Information Administration. Using different assumptions and methodology, the author of that study concludes by saying that HDTV markets will support about 240,000 jobs in the United States and add around 7 billion dollars to total GNP by the year 2003.[46]

The assumptions and methods used by both these reports, and several others, are predictions, but the underlying fact is that all seem to confirm that HDTV products will be attractive to U.S. consumers, even though higher-priced than existing NTSC products, because consumers will want to see wider and larger pictures with higher resolution. The general confidence of all analysts in the demand side of the HDTV equation, therefore, makes it possible to focus attention seriously on the need to minimize, through measured public policies, the potential roadblocks to the commercialization of HDTV technology in the United States.

The RRNA study assumes, for example, that an HDTV standard will be adopted in 1991. It also assumes that the displays in HDTV receivers will be based on existing CRT technology. The assumptions are actually quite optimistic. Lengthy debates over the characteristics of the various proposals could very well delay the adoption of a standard for HDTV. A dramatic breakthrough in display technology outside the U.S. could rob the U.S. of a large proportion of the added-value that will come with the growth of HDTV markets. The results of the RRNA study, therefore, lend urgency to our recommendations in the next section for R&D consortia and for resolving the HDTV standards issues as soon as possible.

[46] Larry F. Darby, Darby Associates, *Economic Potential of Advanced Television*, Washington, D.C., April 7, 1988, p. 43.

IX. SPECIAL POLICIES TO PROMOTE U.S. PARTICIPATION IN HDTV MARKETS

The main objective of U.S. policies toward HDTV should be to use the promotion of HDTV to strengthen overall U.S. competitiveness in world markets. We have argued already that the importance of HDTV derives from its centrality to the future of consumer electronics and from the place of consumer electronics in the electronics complex. HDTV, by itself, cannot make or break the electronics complex or turn the tide in U.S. electronics competitiveness, but it can make a contribution to what has to be a larger national effort.

To maximize the positive impact of HDTV promotional policies on the rest of manufacturing, and particularly on the electronics complex, policies must be chosen with an eye to maximizing the technological spinoffs from HDTV to other areas. Policies which favor HDTV at the expense of undermining the competitiveness of other key industries should be avoided.

A. HDTV Standards Policies

Adoption of uniform, national standards for HDTV program production and transmission will speed the development of a U.S.-based industry. Transmission standards should be developed through the FCC processes and through the development of industry consensus in other forums (see Appendix B). Japanese MUSE and European HD-MAC transmission standards for HDTV were developed for broadcasting and telecommunications environments that are different from that in the United States. These foreign standards were developed for DBS delivery. U.S. production and transmission standards will have to take into account our greater dependence on terrestrial transmission and cable systems. The FCC has already ruled that the existing stock of NTSC receivers, estimated to be around 140 million, must also receive signals sent out from HDTV terrestrial transmission.

The probable coexistence of at least three distinct and incompatible HDTV transmission standards for the United States, Japan, and Europe will not prevent Japanese and European firms from building HDTV equipment for the North American market. These firms already have established a significant manufacturing presence in the United States. The large size of the U.S. market and the lower value of the dollar relative to Japanese and European currencies since 1985 makes it possible for them to produce at globally competitive costs in the United States.

U.S.-owned firms have to be willing to reenter the market knowing that the consumer electronics market is an international market and will remain highly competitive. For this reason, any effort to delay the adoption of HDTV standards until some specific group of U.S.-owned systems firms can catch up to the international state of the art in HDTV technology will only result in the building of a "hot house" industry that is unlikely to be internationally competitve. If U.S. components producers are limited to supplying "hot house" U.S. systems firms, then they are unlikely to be competitive suppliers to foreign HDTV producers.

Similarly, the proposal to not adopt a standard for HDTV until the development of digital TV is unlikely to increase U.S. competitiveness in consumer electronics. It will be very difficult, if not impossible, to develop a digtal TV industry without the technological and manufacturing base that will be developed for HDTV. In addition, many of the other electronics industries will be hurt if a technological and manufacturing base for HDTV is not allowed to develop.

At the receiver end, one major proposal has been to develop an Open Architecture Receiver (OAR). Some proposals for an OAR are for a set that would be capable of processing an HDTV signal from various trans-

mission media to the HDTV display and would allow owners of receivers to add on a variety of devices, such as cameras, keyboards, printers, and so forth, on the model of contemporary personal computers. Current manufacturers of TV receivers are skeptical of this proposal because of increased cost and creation of confusion among consumers.

In essence, the specific OAR proposal discussed above begs the question of transmission standards. It will be possible to reach compromises among the producers concerning the types of signal inputs that all receivers will be able to handle. Receiver manufacturers must be permitted to design television sets to deal with the possibility of signals from different transmission media. This type of receiver design will be easier if the standards for production and transmission allow for reasonable levels of "interoperability"—i.e., uniformity and simplicity in interfaces and conversion methods. The EIA supports a friendly multiport receiver, with separate inputs for RF and baseband signals, which is a form of open architecture. Such a system permits the necessary flexibility to accommodate all media without the costs and complexities of rigid open architecture burdening the receiver manufacturers.

The principal goals of the U.S. standard-setting process should be the development of an HDTV system which produces HDTV pictures (roughly twice the horizontal and vertical resolution of current NTSC pictures), permits a smooth transition from NTSC to HDTV broadcasting, and minimizes the use of scarce broadcast spectrum. These goals, taken together, constitute a major technological challenge. If this challenge can be met, then the United States will emerge with a very strong consumer electronics industry with major spinoffs for the electronics complex and the rest of American industry.

B. Meeting the Technological Challenge

The main technological roadblocks to the development and commercialization of HDTV equipment in the United States will be in four areas: 1) HDTV-related integrated circuits, 2) large displays, 3) new manufacturing technologies, and 4) broadband switching technologies. Much of the current interest in HDTV derives from the belief that there could be major technological spinoffs from HDTV for the rest of the electronics complex—and especially for semiconductors, computers, and telecommunications equipment. Proposed policies for the promotion of HDTV should be assessed in terms of their ability to generate such spinoffs.

In a current NTSC color TV set that costs around 270 dollars to manufacture, only about 20 to 30 dollars (7-11 percent) goes into the semiconductor components. In an HDTV set that costs around 2,000 dollars initially to manufacture, there will probably be no more than 400 dollars worth of semiconductor components, especially if there are no semiconductor-based alternatives to CRT displays by that time. These HDTV sets will not sell as rapidly as later models because of their high prices, but there will be major learning curves associated with HDTV set production and the average costs of production for HDTV semiconductors, displays, and cabinets will eventually come down toward current NTSC prices.

The RRNA study predicts that HDTV receivers will constitute 30 percent of the national market for TV receivers by 2003, or about 13 million sets. By that time, HDTV circuitry will cost only about 25 to 50 percent more than NTSC circuitry, or around 50-80 dollars per set. Thus, by 2003, the demand for semiconductors attributable to HDTV receivers will be no more than one billion dollars. This needs to be compared with Dataquest projections for total U.S. semiconductor sales of 44 billion dollars in that year.

Between the introduction of HDTV receivers (which RRNA says will occur around 1993) and 2003, it is possible that HDTV sets will provide a larger boost to total semiconductor demand. The key point, however, is that TV sets, even HDTV sets, will never be major items driving total semiconductor demand. It is much more likely that HDTV will become an important factor in the development of integrated circuit technology because of the new types of circuitry it requires.

There is an opportunity to use HDTV-related integrated circuits to promote the U.S. semiconductor industry because of the greater sophistication of circuitry in HDTV as compared with NTSC receivers. HDTV receivers will require more video memory, faster digital signal and video image processors, and more complex analog/digital hybrid circuits than NTSC receivers. Some of these circuit techniques will have uses outside consumer electronics. Video memories and video image processors will be important components in computers and computer workstations. Faster digital signal processors and analog/digital converters will be used in telecommunications equipment. To the extent that HDTV circuit technology has applications outside consumer electronics, there will be major spinoffs from its development.

The semiconductor industry in the United States is looking for a way of intensifying its efforts to reestablish its preeminent position in the world. It recently participated in the formation of an R&D consortium called Sematech, which addresses the need to improve semiconductor manufacturing process technology. The U.S. semiconductor industry, by and large, has gotten out of the business of supplying the consumer electronics markets. Only six percent of U.S. semiconductor output goes to consumer electronics, while in Japan the corresponding figure is over 40 percent. In order to regain lost ground in consumer-related semiconductors, U.S. firms need to get an early start in the development of HDTV-related

chips. Thus, one fruitful approach might be to form an R&D consortium for the development of video-processing circuitry.

To the extent that public funds are made available for the promotion of HDTV, they should be focused on generic technological problems the resolution of which will benefit a large number of industries. For this reason, R&D consortia for HDTV-related integrated circuitry, large displays and electronic manufacturing technology seem particularly good candidates for public funding.

There does not necessarily have to be any public funding of R&D consortia. The main roles for the government in R&D consortia are to serve as a broker for the negotiations that produce them (usually this is done by the Department of Commerce) and to monitor them to prevent antitrust violations (this is done by the Department of Justice). In Sematech, the government provided part of the funding through the Department of Defense because it felt that semiconductor manufacturing technology had important implications for national security. The Defense Advanced Research Projects Agency (DARPA) has already indicated interest in cofunding an R&D consortium for HDTV displays for the same reason. But other R&D consortia, such as the Semiconductor Research Corporation (SRC), do not involve government funds.

Public funding of R&D consortia inevitably raises the issue of the participation of foreign-owned firms. In the case of HDTV technologies, it is quite likely that foreign-owned firms will want to participate and that domestic firms will want them to because of their strong technological base, their ability to contribute, and their high usage of components. It would be counterproductive to exclude foreign-owned firms from R&D consortia for

HDTV technologies, for reasons stated above. The key is not ownership but the level of commitment to R&D and manufacturing in the United States.

X. SUMMARY

One basic premise of this report is that competitiveness is primarily an economy-wide issue. There is a danger connected with equating the competitiveness of a nation with that of a single industry. While a single industry may be symbolic of general, national problems of competitiveness, certain policies designed to promote the revival of such symbolic industries may be prejudicial to the solution of the wider problem of competitiveness. For this reason, we recommend a judicious combination of economy-wide measures and industry-specific efforts. We recommend that economy-wide policies should focus on increasing investment levels in physical plant, human, and knowledge capital. In the case of measures specific to consumer electronics and HDTV, we recommend that only those which are likely to result in positive spin-offs for other industries should be the focus of public policies.

The development and commercialization of HDTV in the United States is an opportunity for the strengthening of U.S. competitiveness in the electronics complex and manufacturing more generally. HDTV is not the answer to all of America's problems in competitiveness, but it can contribute to their solution. Given the major presence of foreign-owned firms in the United States, there is an opportunity to build U.S. competitiveness with the help of those firms. Two main types of public policies are required to promote the HDTV industry in the United States: timely adoption of HDTV standards, and assistance in the formation of R&D consortia to develop indigenous HDTV technologies.

	981	1982	1983	1984	1985	198(
United States	0.9	—7.8	—3.8	6.8	—1.2	3.0
Japan	5.6	3.6	4.2	17.5	5.6	—5.2
Germany	3.2	3.2	—0.5	9.0	6.8	0.0
France	3.7	—1.7	3.7	7.0	1.7	—0.7
United Kingdom	0.8	0.8	2.4	6.6	5.9	3.8
Italy	7.5	—1.1	2.3	7.6	3.8	3.4
Canada	4.4	—2.2	6.4	17.7	6.0	4.1
Total of above countries	1.9	—1.8	0.6	9.7	3.4	0.8
Austria	3.8	1.9	3.3	6.6	6.9	—3.2
Belgium	3.1	2.2	3.2	5.7	1.2	5.7
Denmark	3.2	2.5	4.9	3.5	4.3	0.7
Finland	1.9	—1.1	2.5	5.4	1.2	1.3
Greece	5.9	—7.2	8.0	16.9	1.3	14.0
Iceland	1.4	—9.7	10.3	3.0	11.0	6.2
Ireland	2.0	5.5	10.5	16.4	6.7	2.9
Luxembourg	3.6	0.8	5.1	18.0	9.2	4.2
Netherlands	1.5	0.0	3.5	7.4	5.3	1.6
Norway	1.4	—0.1	7.6	8.2	6.9	1.9
Portugal	3.0	6.0	16.7	14.2	11.0	7.0
Spain	3.4	4.8	10.1	11.7	2.8	1.3
Sweden	4.1	4.4	10.7	6.7	2.2	3.3
Switzerland	1.6	—3.0	1.0	6.4	8.3	0.4
Turkey	7.0	26.5	6.1	20.4	11.3	—0.6
Total smaller European countries	2.7	1.7	5.3	8.1	4.7	2.2
Australia	5.2	6.4	—2.7	16.1	9.9	4.8
New Zealand	3.4	—1.4	7.4	5.1	9.3	0.0
Total smaller countries	3.2	2.0	4.9	8.5	5.1	2.4
Total OECD	1.5	—0.9	1.7	9.4	3.8	1.2
Four major European countries	.8	0.9	1.5	7.7	5.0	1.3
OECD Europe	.4	1.2	3.0	7.9	4.9	1.7
EEC	.3	1.1	2.6	7.9	4.7	1.8
Total OECD *less* the United States	.7	1.4	3.3	10.1	5.2	0.8

[a] Aggregates were compu

Source: OECD Economic

TABLE 1

Growth of real exports of goods and services in the OECD area [a]

Percentage changes from previous period

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	19
United States	8.4	6.0	8.1	0.5	8.9	24.1	11.1	—3.5	5.7	2.6	11.0	14.1	9.1	0.9	—7.8	—3.8	(
Japan	23.2	21.6	17.9	16.4	5.5	7.1	23.2	0.7	15.1	10.7	—0.7	6.2	17.7	15.6	3.6	4.2	17
Germany	12.7	9.7	6.5	6.5	6.5	10.1	12.1	—6.7	9.9	3.3	4.2	4.5	5.3	8.2	3.2	—0.5	9
France	11.2	16.1	16.3	9.2	12.0	10.8	8.8	—1.7	8.2	7.4	5.9	7.5	2.7	3.7	—1.7	3.7	7
United Kingdom	12.6	9.8	5.2	6.9	1.0	12.0	7.3	—2.8	9.1	6.8	1.8	3.7	0.1	—0.8	0.8	2.4	6
Italy	15.6	12.3	6.0	7.2	11.5	3.8	9.9	3.7	13.2	6.7	10.1	9.1	—4.3	7.5	—1.1	2.3	7
Canada	12.6	8.0	8.7	5.2	7.8	10.6	—2.0	—6.8	10.6	8.9	13.6	5.0	2.7	4.4	—2.2	6.4	17
Total of above countries	12.1	10.2	8.9	5.9	7.4	13.8	10.7	—3.1	9.1	5.5	6.4	3.4	6.2	4.9	—1.8	0.6	9
Austria	8.1	17.0	17.2	6.4	10.1	5.4	10.7	—2.4	11.1	4.6	6.0	10.8	5.8	3.8	1.9	3.3	6
Belgium	13.4	14.7	4.7	6.3	10.0	14.4	6.8	—8.9	11.7	12.7	3.4	7.1	3.3	3.1	2.2	3.2	5
Denmark	9.3	6.2	5.6	5.6	5.6	7.8	3.5	—1.8	4.1	4.1	1.2	8.4	5.2	8.2	2.5	4.9	3
Finland	10.0	16.7	8.7	—1.3	14.5	7.3	—0.6	—14.0	12.8	15.7	8.9	8.8	8.4	4.9	—1.1	2.5	5
Greece	—1.0	14.6	12.4	11.9	22.9	23.4	0.1	10.6	16.4	1.8	16.4	6.7	6.9	—5.9	—7.2	8.0	16
Iceland	—6.1	14.2	17.2	—3.9	10.7	8.5	—0.8	2.6	11.6	10.3	15.2	6.3	2.7	1.4	—9.7	10.3	3
Ireland	8.8	4.6	4.4	4.1	3.6	10.9	0.7	7.2	8.1	14.0	12.3	6.5	6.4	2.0	5.5	10.5	16
Luxembourg	10.7	13.8	9.0	5.3	5.3	14.2	10.6	—15.6	1.3	3.8	3.5	9.5	—1.2	—3.6	0.8	5.1	18
Netherlands	12.8	14.9	11.9	11.0	11.0	11.4	2.7	—3.1	9.9	—1.8	3.3	7.4	1.5	1.5	0.0	3.5	7
Norway	7.7	5.3	0.1	1.1	14.1	8.3	0.7	3.1	11.3	3.6	8.4	2.6	2.1	1.4	—0.1	7.6	8
Portugal	—3.4	2.9	—1.6	9.9	18.5	4.2	—15.7	—15.6	0.0	5.9	13.1	27.1	4.5	—3.0	6.0	16.7	14
Spain	18.4	15.5	17.4	13.0	12.2	9.0	0.8	—1.5	10.1	8.5	10.7	6.4	0.6	8.4	4.8	10.1	11
Sweden	7.6	11.5	8.6	4.8	5.9	13.7	5.3	—9.3	4.3	1.5	7.8	6.1	—0.5	1.1	4.4	10.7	6
Switzerland	10.0	13.3	6.8	3.9	6.4	7.9	1.0	—6.6	9.3	9.7	3.7	2.5	5.1	4.6	—3.0	1.0	6
Turkey	—	—	—	—	—	32.3	—20.9	—8.8	8.7	—18.4	3.5	4.4	—5.5	47.0	26.5	6.1	20
Total smaller European countries	10.5	12.6	8.6	6.8	10.0	11.1	2.4	—4.8	9.4	4.7	5.7	6.8	2.8	3.7	1.7	5.3	8
Australia	4.2	14.2	12.3	8.4	5.8	—2.0	—3.3	8.7	8.2	0.6	4.2	13.1	—1.5	—4.2	6.4	—2.7	16
New Zealand	17.2	3.6	10.2	4.9	—5.1	9.1	—2.3	3.8	14.8	0.8	0.7	6.3	3.1	3.4	—1.4	7.4	5
Total smaller countries	10.1	12.5	8.9	6.9	9.4	10.2	1.9	—3.8	9.4	4.4	5.5	7.2	2.5	3.2	2.0	4.9	8
Total OECD	11.6	10.8	8.9	6.2	7.9	12.8	8.3	—3.3	9.2	5.2	6.3	8.1	5.3	4.5	—0.9	1.7	9
Four major European countries	12.8	11.3	7.9	7.3	6.8	9.8	9.8	—3.2	9.8	5.6	4.8	5.7	1.8	4.8	0.9	1.5	7
OECD Europe	11.8	11.8	8.2	7.1	8.1	10.4	6.7	—3.8	9.6	5.2	5.2	6.1	2.2	4.4	1.2	3.0	7
EEC	12.5	11.8	8.2	7.8	7.9	10.4	7.8	—3.5	9.7	5.4	4.9	6.2	2.0	4.3	1.1	2.6	7
Total OECD *less* the United States	12.6	12.3	9.2	7.8	8.6	9.7	7.4	—3.2	10.3	6.0	4.9	6.2	4.0	5.7	1.4	3.3	10

[a] Aggregates were computed on the basis of 1982 exchange rates.

Source: OECD Economic Outlook, December 1988.

TABLE 1

Growth of real exports of goods and services in the OECD area [a]

Percentage changes from previous period

1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
8.4	6.0	8.1	0.5	8.9	24.1	11.1	—3.5	5.7	2.6	11.0	14.1	9.1	0.9	—7.8	—3.8	6.8	—1.2	3.0	13.1
23.2	21.6	17.9	16.4	5.5	7.1	23.2	0.7	15.1	10.7	—0.7	6.2	17.7	15.6	3.6	4.2	17.5	5.6	—5.2	3.7
12.7	9.7	6.5	6.5	6.5	10.1	12.1	—6.7	9.9	3.3	4.2	4.5	5.3	8.2	3.2	—0.5	9.0	6.8	0.0	0.8
11.2	16.1	16.3	9.2	12.0	10.8	8.8	—1.7	8.2	7.4	5.9	7.5	2.7	3.7	—1.7	3.7	7.0	1.7	—0.7	1.7
12.6	9.8	5.2	6.9	1.0	12.0	7.3	—2.8	9.1	6.8	1.8	3.7	0.1	—0.8	0.8	2.4	6.6	5.9	3.8	5.5
15.6	12.3	6.0	7.2	11.5	3.8	9.9	3.7	13.2	6.7	10.1	9.1	—4.3	7.5	—1.1	2.3	7.6	3.8	3.4	3.6
12.6	8.0	8.7	5.2	7.8	10.6	—2.0	—6.8	10.6	8.9	13.6	5.0	2.7	4.4	—2.2	6.4	17.7	6.0	4.1	5.9
12.1	10.2	8.9	5.9	7.4	13.8	10.7	—3.1	9.1	5.5	6.4	3.4	6.2	4.9	—1.8	0.6	9.7	3.4	0.8	6.0
8.1	17.0	17.2	6.4	10.1	5.4	10.7	—2.4	11.1	4.6	6.0	10.8	5.8	3.8	1.9	3.3	6.6	6.9	—3.2	1.6
13.4	14.7	4.7	6.3	10.0	14.4	6.8	—8.9	11.7	12.7	3.4	7.1	3.3	3.1	2.2	3.2	5.7	1.2	5.7	6.3
9.3	6.2	5.6	5.6	5.6	7.8	3.5	—1.8	4.1	4.1	1.2	8.4	5.2	8.2	2.5	4.9	3.5	4.3	0.7	4.9
10.0	16.7	8.7	—1.3	14.5	7.3	—0.6	—14.0	12.8	15.7	8.9	8.8	8.4	4.9	—1.1	2.5	5.4	1.2	1.3	1.7
—1.0	14.6	12.4	11.9	22.9	23.4	0.1	10.6	16.4	1.8	16.4	6.7	6.9	—5.9	—7.2	8.0	16.9	1.3	14.0	7.9
—6.1	14.2	17.2	—3.9	10.7	8.5	—0.8	2.6	11.6	10.3	15.2	6.3	2.7	1.4	—9.7	10.3	3.0	11.0	6.2	4.0
8.8	4.6	4.4	4.1	3.6	10.9	0.7	7.2	8.1	14.0	12.3	6.5	6.4	2.0	5.5	10.5	16.4	6.7	2.9	13.3
10.7	13.8	9.0	5.3	5.3	14.2	10.6	—15.6	1.3	3.8	3.5	9.5	—1.2	—3.6	0.8	5.1	18.0	9.2	4.2	2.0
12.8	14.9	11.9	11.0	11.0	11.4	2.7	—3.1	9.9	—1.8	3.3	7.4	1.5	1.5	0.0	3.5	7.4	5.3	1.6	4.2
7.7	5.3	0.1	1.1	14.1	8.3	0.7	3.1	11.3	3.6	8.4	2.6	2.1	1.4	—0.1	7.6	8.2	6.9	1.9	2.0
—3.4	2.9	—1.6	9.9	18.5	4.2	—15.7	—15.6	0.0	5.9	13.1	27.1	4.5	—3.0	6.0	16.7	14.2	11.0	7.0	10.2
18.4	15.5	17.4	13.0	12.2	9.0	0.8	—1.5	10.1	8.5	10.7	6.4	0.6	8.4	4.8	10.1	11.7	2.8	1.3	5.9
7.6	11.5	8.6	4.8	5.9	13.7	5.3	—9.3	4.3	1.5	7.8	6.1	—0.5	1.1	4.4	10.7	6.7	2.2	3.3	2.5
10.0	13.3	6.8	3.9	6.4	7.9	1.0	—6.6	9.3	9.7	3.7	2.5	5.1	4.6	—3.0	1.0	6.4	8.3	0.4	1.7
—	—	—	—	—	32.3	—20.9	—8.8	8.7	—18.4	3.5	4.4	—5.5	47.0	26.5	6.1	20.4	11.3	—0.6	24.7
10.5	12.6	8.6	6.8	10.0	11.1	2.4	—4.8	9.4	4.7	5.7	6.8	2.8	3.7	1.7	5.3	8.1	4.7	2.2	5.0
4.2	14.2	12.3	8.4	5.8	—2.0	—3.3	8.7	8.2	0.6	4.2	13.1	—1.5	—4.2	6.4	—2.7	16.1	9.9	4.8	9.5
17.2	3.6	10.2	4.9	—5.1	9.1	—2.3	3.8	14.8	0.8	0.7	6.3	3.1	3.4	—1.4	7.4	5.1	9.3	0.0	1.8
10.1	12.5	8.9	6.9	9.4	10.2	1.9	—3.8	9.4	4.4	5.5	7.2	2.5	3.2	2.0	4.9	8.5	5.1	2.4	5.3
11.6	10.8	8.9	6.2	7.9	12.8	8.3	—3.3	9.2	5.2	6.3	8.1	5.3	4.5	—0.9	1.7	9.4	3.8	1.2	5.8
12.8	11.3	7.9	7.3	6.8	9.8	9.8	—3.2	9.8	5.6	4.8	5.7	1.8	4.8	0.9	1.5	7.7	5.0	1.3	2.6
11.8	11.8	8.2	7.1	8.1	10.4	6.7	—3.8	9.6	5.2	5.2	6.1	2.2	4.4	1.2	3.0	7.9	4.9	1.7	3.6
12.5	11.8	8.2	7.8	7.9	10.4	7.8	—3.5	9.7	5.4	4.9	6.2	2.0	4.3	1.1	2.6	7.9	4.7	1.8	3.5
12.6	12.3	9.2	7.8	8.6	9.7	7.4	—3.2	10.3	6.0	4.9	6.2	4.0	5.7	1.4	3.3	10.1	5.2	0.8	3.9

puted on the basis of 1982 exchange rates.

nic Outlook, December 1988.

TABLE 2

Growth of real imports of goods and services in the OECD area [a]

Percentage changes from previous period

	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
United States	15.5	7.8	4.3	5.1	11.7	11.9	—2.0	—10.3	18.5	11.1	7.0	4.1	—6.0	3.4	—2.2	9.6	23.9
Japan	12.5	14.1	22.3	5.6	9.9	24.2	6.2	—9.8	5.2	3.2	5.1	13.4	—6.2	5.1	1.7	—5.1	11.1
Germany	12.1	16.4	15.7	10.0	5.7	4.3	2.2	—0.6	10.5	3.6	5.5	10.5	3.7	—1.2	—0.1	0.6	5.3
France	13.3	22.4	7.4	6.3	13.2	14.2	1.9	—9.7	17.4	0.1	3.0	10.1	2.5	—2.1	2.6	—2.7	2.7
United Kingdom	8.0	2.9	5.0	5.2	10.1	12.3	0.9	—7.0	4.7	1.5	3.8	9.7	—3.2	—2.7	4.9	6.2	9.7
Italy	5.6	19.4	15.9	2.4	11.4	10.5	2.2	—9.6	15.4	—0.2	8.1	13.8	8.3	—3.8	—0.7	—1.6	11.0
Canada	9.8	13.1	—1.7	7.2	13.8	14.7	11.1	—3.3	8.6	1.7	7.4	11.4	4.9	8.5	—15.2	9.0	17.1
Total of above countries	12.2	12.0	9.5	6.1	10.4	12.7	1.8	—7.7	12.4	4.8	5.8	9.0	—1.2	1.2	—0.8	3.0	13.5
Austria	7.1	9.5	15.9	6.3	12.1	9.6	6.9	—4.6	17.4	8.0	—1.3	11.8	6.4	—1.5	—3.3	5.7	9.9
Belgium	13.9	14.6	12.5	5.3	8.4	19.4	7.5	—9.8	11.0	15.4	3.7	9.1	0.3	—2.3	1.1	—0.8	6.0
Denmark	4.9	13.1	9.3	—0.7	1.5	12.8	—3.8	—4.8	15.6	0.0	0.1	5.0	—6.8	—1.7	3.8	1.8	5.5
Finland	—3.9	22.3	20.3	—0.6	4.2	13.0	6.7	0.6	—2.0	—1.5	—3.7	18.4	8.3	—4.7	2.5	3.0	1.0
Greece	10.3	15.5	6.2	7.6	15.4	32.2	—16.3	6.3	6.1	8.0	7.2	7.2	—8.0	3.6	7.0	6.6	0.2
Iceland	—9.0	—12.1	27.8	23.0	0.2	18.6	12.8	—12.3	—3.5	20.2	3.6	2.5	3.0	7.2	—1.1	—5.7	9.3
Ireland	15.6	13.4	2.3	4.7	5.1	19.0	—2.3	—10.2	14.7	13.3	15.7	13.9	—4.5	1.7	—3.1	4.7	9.9
Luxembourg	9.1	11.2	19.0	6.5	2.8	10.6	5.8	—8.7	0.8	1.6	5.9	7.1	3.1	—2.8	—0.1	1.9	15.4
Netherlands	13.0	14.1	14.7	5.7	9.1	8.9	—6.8	—3.9	10.4	2.4	6.2	6.5	—1.0	—5.9	1.1	3.8	5.1
Norway	2.2	1.8	13.6	6.4	—1.0	14.4	4.7	7.0	12.3	3.4	—13.5	—0.7	3.3	1.5	3.7	0.0	9.5
Portugal	33.0	7.6	0.9	14.5	12.0	12.7	4.8	—25.2	3.4	12.0	—1.6	8.7	10.5	3.7	5.4	—8.7	—2.7
Spain	8.1	15.8	7.0	0.7	24.7	16.4	7.7	—1.1	10.1	—4.7	—0.7	11.5	3.8	—4.2	3.9	—0.6	—1.0
Sweden	8.3	12.9	10.4	—3.3	4.0	6.9	9.9	—3.5	9.0	—3.8	—5.5	11.6	0.4	—7.1	4.3	0.4	4.5
Switzerland	8.3	12.9	13.9	6.2	7.3	6.5	—1.0	—15.4	13.1	9.3	10.9	6.9	7.2	—1.3	—2.6	4.4	7.1
Turkey	—	—	—	—	—	10.4	1.7	11.8	24.1	—3.9	—31.4	—7.9	—4.6	16.5	13.4	12.7	15.5
Total smaller European countries	9.5	12.9	12.1	3.8	8.3	12.4	1.6	—4.8	11.0	3.9	0.3	—8.0	1.2	—2.5	1.8	2.1	5.4
Australia	12.6	2.5	5.6	—0.8	—8.2	22.3	25.5	—15.9	12.0	0.3	4.1	2.3	4.9	9.4	5.1	—10.8	20.7
New Zealand	—5.5	7.5	17.1	1.9	6.3	18.3	22.9	—22.0	—2.0	2.4	—5.2	16.5	—3.9	4.6	6.8	—6.0	17.5
Total smaller countries	9.4	11.9	11.7	3.5	7.2	13.1	3.4	—6.0	10.8	3.7	0.5	7.8	1.4	—1.6	2.1	1.0	6.7
Total OECD	11.4	12.0	10.1	5.3	9.6	12.8	2.3	—7.2	11.9	4.5	4.3	8.7	—0.6	0.5	0.0	2.4	11.7
Four major European countries	10.1	14.3	11.0	6.7	9.4	9.6	1.8	—5.9	11.5	1.6	4.9	0.8	2.6	—2.2	1.5	0.6	6.7
OECD Europe	9.8	13.7	11.4	5.5	9.0	10.8	1.7	—5.4	11.3	2.6	3.0	9.6	2.1	—2.3	1.6	1.2	6.2
EEC	10.7	14.2	11.0	6.0	9.7	11.0	1.1	—5.9	11.2	2.7	4.6	0.0	1.7	—2.5	1.7	0.8	5.9
Total OECD *less* the United States	10.1	13.3	11.9	5.4	10.2	13.0	3.5	—6.4	10.2	2.6	3.5	10.1	1.1	—0.4	0.6	0.4	7.9

[a] Aggregates were computed on the basis of 1982 exchange rates.

Source: OECD Economic Outlook, December 1988.

TABLE 3
Competitive positions
Indices, 1982 = 100

	Manufacturing unit labor costs in local currency					Export prices of manufacturers in local currency				
	1986	1987	1988	1989	1990	1986	1987	1988	1989	1990
United States	95	94	94	95	98	93	91	91	93	96
Japan	96	93	89	89	89	79	74	72	72	72
Germany	105	108	108	110	112	103	101	100	102	104
France	123	123	119	120	121	126	128	132	135	137
United Kingdom	108	109	111	114	119	129	134	137	140	143
Italy	128	131	134	137	140	127	128	133	136	141
Canada	100	102	102	105	109	111	112	110	112	115
Austria	104	106	106	107	108	104	101	102	103	105
Belgium-Luxembourg	104	105	107	109	110	118	113	115	118	120
Denmark	122	131	133	138	142	127	127	132	136	141
Finland	115	117	123	126	131	117	120	124	129	134
Netherlands	97	99	98	98	99	99	93	94	95	97
Norway	126	137	145	149	154	123	131	138	142	146
Spain	127	134	140	145	151	150	154	161	168	174
Sweden	123	128	136	144	151	130	133	139	145	151
Switzerland	115	118	121	124	127	113	113	115	119	122
Australia	123	128	135	143	149	137	156	170	172	178
New Zealand	125	134	140	144	147	140	147	152	157	163

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1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
7.0	4.1	—6.0	3.4	—2.2	9.6	23.9	3.4	9.4	7.9
5.1	13.4	—6.2	5.1	1.7	—5.1	11.1	—0.1	2.8	9.2
5.5	10.5	3.7	—1.2	—0.1	0.6	5.3	3.7	3.6	4.9
3.0	10.1	2.5	—2.1	2.6	—2.7	2.7	4.3	7.3	6.4
3.8	9.7	—3.2	—2.7	4.9	6.2	9.7	2.6	6.5	7.3
8.1	13.8	8.3	—3.8	—0.7	—1.6	11.0	4.7	4.7	10.0
7.4	11.4	4.9	8.5	—15.2	9.0	17.1	8.4	7.3	8.6
5.8	9.0	—1.2	1.2	—0.8	3.0	13.5	3.4	6.6	7.6
1.3	11.8	6.4	—1.5	—3.3	5.7	9.9	6.9	0.2	4.4
3.7	9.1	0.3	—2.3	1.1	—0.8	6.0	0.8	7.6	8.4
0.1	5.0	—6.8	—1.7	3.8	1.8	5.5	8.7	6.4	—1.3
3.7	18.4	8.3	—4.7	2.5	3.0	1.0	6.8	3.1	9.0
7.2	7.2	—8.0	3.6	7.0	6.6	0.2	12.8	3.8	8.1
3.6	2.5	3.0	7.2	—1.1	—5.7	9.3	9.7	0.3	22.9
5.7	13.9	—4.5	1.7	—3.1	4.7	9.9	3.3	5.5	4.9
5.9	7.1	3.1	—2.8	—0.1	1.9	15.4	6.2	0.5	3.5
6.2	6.5	—1.0	—5.9	1.1	3.8	5.1	6.6	3.9	5.6
3.5	—0.7	3.3	1.5	3.7	0.0	9.5	5.9	10.4	—6.8
1.6	8.7	10.5	3.7	5.4	—8.7	—2.7	3.9	17.2	24.1
0.7	11.5	3.8	—4.2	3.9	—0.6	—1.0	6.2	16.5	20.4
5.5	11.6	0.4	—7.1	4.3	0.4	4.5	8.0	5.5	6.3
0.9	6.9	7.2	—1.3	—2.6	4.4	7.1	5.1	7.1	5.4
1.4	—7.9	—4.6	16.5	13.4	12.7	15.5	7.7	13.1	18.8
0.3	—8.0	1.2	—2.5	1.8	2.1	5.4	5.8	7.0	7.5
1.1	2.3	4.9	9.4	5.1	—10.8	20.7	5.6	—2.9	3.2
5.2	16.5	—3.9	4.6	6.8	—6.0	17.5	—3.1	2.2	11.2
0.5	7.8	1.4	—1.6	2.1	1.0	6.7	5.6	6.1	7.3
1.3	8.7	—0.6	0.5	0.0	2.4	11.7	4.0	6.5	7.5
1.9	0.8	2.6	—2.2	1.5	0.6	6.7	3.8	5.3	6.7
3.0	9.6	2.1	—2.3	1.6	1.2	6.2	4.6	6.0	7.1
1.6	0.0	1.7	—2.5	1.7	0.8	5.9	4.2	6.0	7.4
3.5	10.1	1.1	—0.4	0.6	0.4	7.9	4.2	5.4	7.4

TABLE 3—Continued

	1986	1987	1988	1989	1990	1986	1987	1988	1989	1990
	Relative unit labor costs in manufacturing, in a common currency					Relative export prices of manufacturers, in a common currency				
United States	87	74	69	68	69	86	76	70	70	71
Japan	144	148	151	152	148	118	118	123	124	121
Germany	108	114	113	112	112	104	107	103	103	102
France	106	103	97	95	94	107	108	108	107	106
United Kingdom	82	79	84	86	87	95	96	103	104	104
Italy	105	105	103	103	103	103	102	101	101	102
Canada	88	91	96	97	98	101	103	107	107	107
Austria	101	103	102	101	100	102	102	103	101	101
Belgium-Luxembourg	97	99	99	99	98	108	107	108	107	107
Denmark	114	123	120	120	121	118	120	121	120	121
Finland	98	97	102	102	103	99	101	104	106	107
Netherlands	97	101	99	96	95	96	98	96	95	95
Norway	99	101	104	103	104	95	97	100	99	99
Spain	90	92	98	101	103	105	106	113	116	118
Sweden	98	97	101	105	108	102	102	105	108	109
Switzerland	116	121	122	122	123	113	118	119	118	118
Australia	74	72	80	88	90	85	92	106	111	112
New Zealand	82	90	97	93	93	95	101	108	104	105

Source: OECD Economic Outlook, December 1988.

TABLE 4

Productivity trends in selected OECD countries

Business sector, compound annual growth rates [a]

	OECD average [b]	United States	Japan	Germany	France	United Kingdom	Italy	Canada	Austria	Belg
Total factor productivity										
Pre-1973 [c]	2.8	1.5	6.3	2.6	3.9	1.9	4.8	2.3	2.8	3.7
1974-1979	0.7	—0.1	1.8	1.8	1.8	0.2	1.6	1.1	1.8	1.4
1980-1986	0.6	0.1	1.7	0.8	1.2	1.0	0.7	—0.3	0.7	1.3
1987-1990	1.2	0.8	2.2	1.3	1.8	1.8	1.6	—0.2	1.2	0.8
Labor productivity										
Pre-1973 [c]	4.2	2.2	8.8	4.7	5.6	3.3	6.6	3.0	5.3	4.8
1974-1979	1.6	0.3	3.2	3.4	3.2	1.3	2.4	2.0	3.9	2.8
1980-1986	1.4	0.7	2.8	2.0	2.4	1.9	1.3	1.1	2.0	2.4
1987-1990	1.9	1.3	3.5	2.3	2.7	2.2	2.4	0.8	2.3	1.8
Capital productivity										
Pre-1973 [c]	—0.4	0.3	—2.0	—1.2	0.3	—0.9	0.6	1.3	—2.5	1.0
1974-1979	—1.4	—0.8	—2.9	—1.0	—1.4	—2.0	—0.3	—0.3	—2.5	—1.8
1980-1986	—1.4	—1.0	—2.0	—1.3	—1.3	—0.8	—0.6	—2.6	—2.0	—1.2
1987-1990	—0.6	—0.1	—2.2	—0.5	—0.1	0.9	—0.4	—1.8	—0.9	—1.4

TABLE 4—Continued

	Denmark	Finland	Greece	Ireland	Netherlands	Norway	Spain	Sweden	Switzerland	Australia
Total factor productivity										
Pre-1973 [c]	1.7	3.3	6.6	4.6	2.7	2.7	2.6	1.7	1.6	1.8
1974-1979	0.1	1.6	1.9	3.3	2.1	2.2	0.9	0.9	—0.8	0.6
1980-1986	0.8	1.6	—0.5	2.6	0.8	1.2	0.8	0.2	0.7	0.4
1987-1990	—0.8	2.4	0.5	2.3	1.1	0.4	0.8	0.5	0.3	—0.2
Labor productivity										
Pre-1973 [c]	3.5	4.8	8.5	5.2	4.4	4.2	5.8	3.4	3.4	2.9
1974-1979	1.6	3.1	3.1	3.8	3.5	3.9	3.9	2.2	0.7	1.9
1980-1986	1.6	2.3	0.2	3.7	1.7	2.0	2.6	1.2	1.5	1.0
1987-1990	0.2	3.5	1.1	2.8	1.8	1.4	1.5	1.6	1.3	0.3
Capital productivity										
Pre-1973 [c]	—1.8	—0.1	—0.9	2.4	0	0.6	—4.5	—1.4	—1.9	—0.3
1974-1979	—3.0	—1.7	—3.0	1.0	0	—0.2	—5.7	—1.7	—4.0	—1.8
1980-1986	—0.6	0.1	—2.9	—1.6	—0.7	0.2	—3.1	—1.9	—1.0	—0.8
1987-1990	—2.8	—0.3	—2.0	0.4	—0.1	—0.9	—0.8	—1.6	—1.7	—1.1

[a] Data for 1987 to 1990 are OECD estimates and projections.

[b] Weighed average of countries based on the 1985 business sector output at 1985 prices and exchange rates.

[c] United States 1960-73, Japan 1966-1973, Germany 1960-1973, France 1964-1973, United Kingdom 1960-1973, Italy 1960-1973. Canada 1961-1973, Austria 1960-1973, Belgium 1960-1973, Denmark 1960-1973, Finland 1961-1973, Greece 1961-1973, Ireland 1960-1973, Netherlands 1961-1973, Norway 1963-1973, Spain 1964-1973, Sweden 1963-1973, Switzerland 1962-1973, Australia 1960-1973.

Note: Total factor productivity = real gross value added (at factor cost)/total factor inputs (1985 weights).
Labor productivity = real gross value added/private sector employment, including self-employed.
Capital productivity = real gross value added/gross capital stock (constant prices).

Source: OECD, Economic Outlook, December 1988.

TABLE 5

International Costs

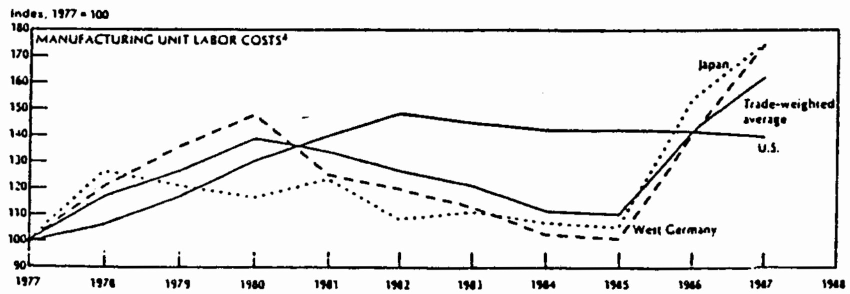
Manufacturing Output Per Hour, Hourly Compensation, and Unit Labor Costs

Average annual rates of change

	Productivity			Labor compensation [a]		
	1973-87	1986	1987	1973-87	1986	1987
United States	2.5	3.7	2.8	7.3	3.3	1.3
Canada	2.1	—0.2	1.7	7.2	2.1	9.5
Japan	5.3	1.7	4.1	12.9	48.6	18.1
France	3.9	2.2	3.7	10.5	35.7	19.1
West Germany	3.3	1.7	1.3	10.2	41.6	25.6
United Kingdom	3.2	2.8	6.9	10.8	21.8	20.9
Weighted average, 11 foreign countries	3.8	1.4	3.4	10.4	30.3	18.3

	Unit labor costs [b]			Unit labor costs [a]		
	1973-87	1986	1987	1973-87	1986	1987
United States	4.7	—0.4	—1.5	4.7	—0.4	—1.5
Canada	7.1	4.1	2.7	5.0	2.4	7.7
Japan	2.6	3.2	—2.5	7.3	46.1	13.5
France	8.7	2.5	—0.2	6.4	32.9	14.9
West Germany	3.8	2.7	2.7	6.7	39.2	23.9
United Kingdom	10.5	4.8	1.1	7.4	18.5	13.0
Weighted average, 11 foreign countries	5.0	3.4	0.8	6.4	28.5	14.4

International Manufacturing Costs



[a] U.S. dollar basis.

[b] National currency basis.

NOTE: The 11 foreign countries are Belgium, Canada, Denmark, France, Italy, Japan, the Netherlands, Norway, Sweden, the United Kingdom, and West Germany.

SOURCE: U.S. Department of Labor, Bureau of Labor Statistics.

TABLE 6

(a) Total Defense and Nondefense R&D Shares of GDP
(Percent)

	Total			Defense			Nondefense		
	1981	1983	1985	1981	1983	1985	1981	1983	1985
U.S.	2.45	2.62	2.83	.61	.75	.85	1.84	1.87	1.96
Japan	2.32	2.56	2.81	.01	.01	.02	2.31	2.55	2.79
Germany	2.45	2.54	2.66	.10	.11	.14	2.35	2.43	2.52
France	2.01	2.15	2.31	.50	.46	.46	1.51	1.69	1.85
U.K.	2.42	2.27	2.33	.69	.66	.68	1.73	1.61	1.65
Canada	1.32	1.35	1.38	.03	.04	.04	1.29	1.31	1.34

(b) Business-Funded R&D as Shares of GDP

	1972	1981	1983	1985	(est.) 1986
U.S.	0.99	1.22	1.32	1.39	1.42
Japan	1.15	1.73	1.99	2.09	2.14
Germany	1.08	1.46	1.56	1.64	1.69

Sources: OECD Science and Technology Indicators data base; and Office of Technology Assessment, *International Competition in Services: Banking, Building, Software, and Know-how* (Washington, July 1987).

TABLE 7

Profits and investment in the business sector

	1971-80	1981-85	1986-90	1987	1988	1989	1990
				Per cent			
Capital/output ratio (1982=100)							
Major seven countries	90.3	98.4	98.9	98.6	98	99	100¼
United States	89.6	96.5	93.9	93.9	93	93½	94½
Japan	88.7	101.0	109.8	107.9	108¾	111¼	114½
Germany	90.5	99.2	100.6	100.6	101	101	101¼
Investment share[a], constant prices[b]							
Major seven countries	16.4	16.2	17.3	16.5	17½	18	18½
United States	13.9	14.6	14.6	14.0	14¾	15	15¼
Japan	22.9	22.2	26.0	24.3	26½	27¾	28
Germany	15.4	15.0	16.3	15.7	16¼	17	17¼
Investment share, current prices[a]							
Major seven countries	16.2	15.6	15.2	14.6	15¼	15½	15¾
United States	13.4	13.8	12.3	12.1	12¼	12½	12½
Japan	23.1	20.9	22.1	20.9	22¼	23¼	23¼
Germany	15.2	14.9	15.4	14.9	15¼	16	16¼
Profit share[c]							
Major seven countries	42.8	42.6	43.5	43.6	43½	43½	43½
United States	39.8	40.2	39.9	40.3	39¾	39¾	39½
Japan	48.0	44.5	44.5	44.6	44½	44½	44½
Germany	41.8	42.9	46.1	45.4	46¼	46¾	47

TABLE 7—Continued

	1971-80	1981-85	1986-90	1987	1988	1989	1990
	Percent						
Net profit rate [d]							
Major seven countries	10.1	4.9	6.7	6.7	6¾	6½	6¾
United States	12.5	6.6	8.9	8.8	8¾	8¾	9¼
Japan	6.2	0.2	2.9	3.1	3¼	2¼	2¾
Germany	6.6	4.6	7.3	7.2	7½	7½	7½

[a] Ratio between fixed investment and output.

[b] The base year for the constant prices series differs across countries; therefore the levels of the ratios are not comparable between countries.

[c] Ratio between non-wage value added and output, at current prices.

[d] Difference between net rate and real long-term interest rate. The net rate of return is defined as the ratio between non-wage value added and capital stock.

Source: OECD Economic Outlook, December 1988.

TABLE 8

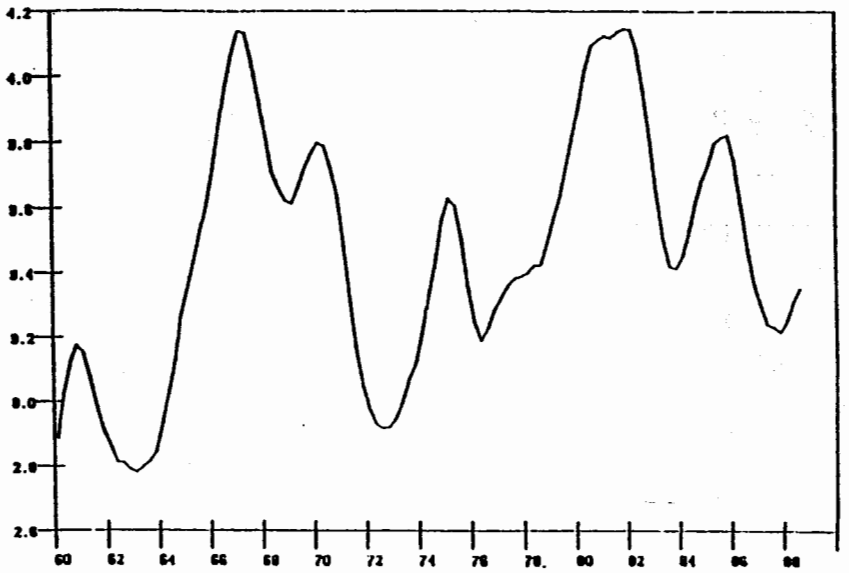
Electronics Trade Balance (Billions of dollars)[a]

Year	Semicon	Telequip	RadioTV	Computer
1972	.140	—.010	.353	1.341
1973	.230	—.013	.152	1.717
1974	.287	—.002	.190	2.198
1975	.251	.105	.259	2.229
1976	.293	.133	—.256	2.588
1977	.151	.128	.193	3.264
1978	.156	.155	.745	3.424
1979	.180	.129	.840	4.516
1980	.143	.136	.832	6.427
1981	.010	.158	.564	6.967
1982	—.374	.203	.229	6.764
1983	—.621	—.419	.020	6.070
1984	—2.337	—1.040	—.113	5.677
1985	—1.491	—1.196	—.810	5.679
1986	—1.138	—1.335	—.795	3.542
1987	—1.006	—1.450	—.750	3.466

[a] These estimates of the electronics trade balance are based on Department of Commerce numbers reported in the 1988 edition of *Industrial Outlook*. Because of the exclusion of many kinds of electronics products, such as electronic componentry other than semiconductors, and consumer electronics products other than radios, televisions and related products such as VCRs, these estimates are based on a narrow definition of the electronics sector. A broader definition, such as the one used in Figure 4, suggests a much larger trade imbalance in electronics. Both definitions show the U.S. trade position deteriorating over time even on computers, an area in which the U.S. has a technological and competitive advantage.

FIGURE 1

New P&E Expenditures by Business—Manufacturing as a % of GNP



88:2 & 88:3 based on planned expenditures published by the BEA.

Assumed 7% GNP growth in 3rd qtr. of '88

4 quarter moving average

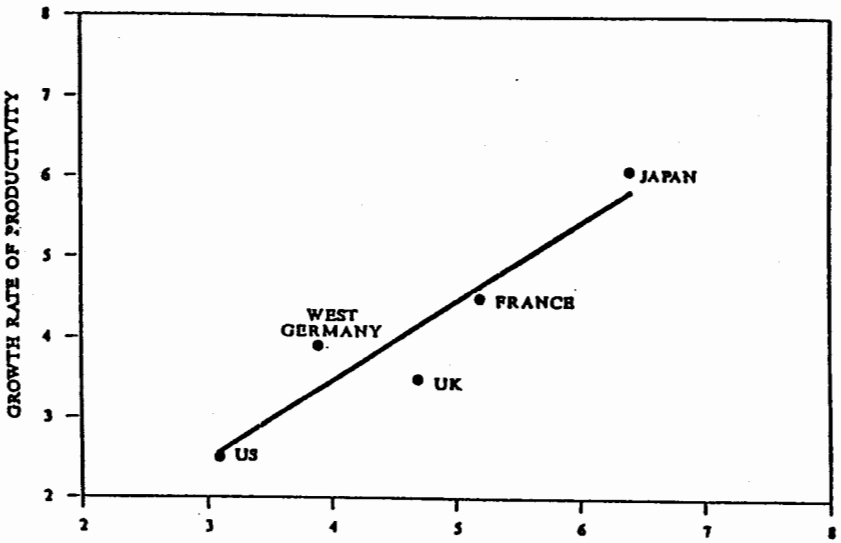
The sharp appreciation of the dollar not only depressed exports; it also squeezed the manufacturing investment share of GNP.

Source: David Hab, Kemperer Financial Services.

FIGURE 2

PRODUCTIVITY VS. THE CAPITAL-LABOR RATIO IN MANUFACTURING

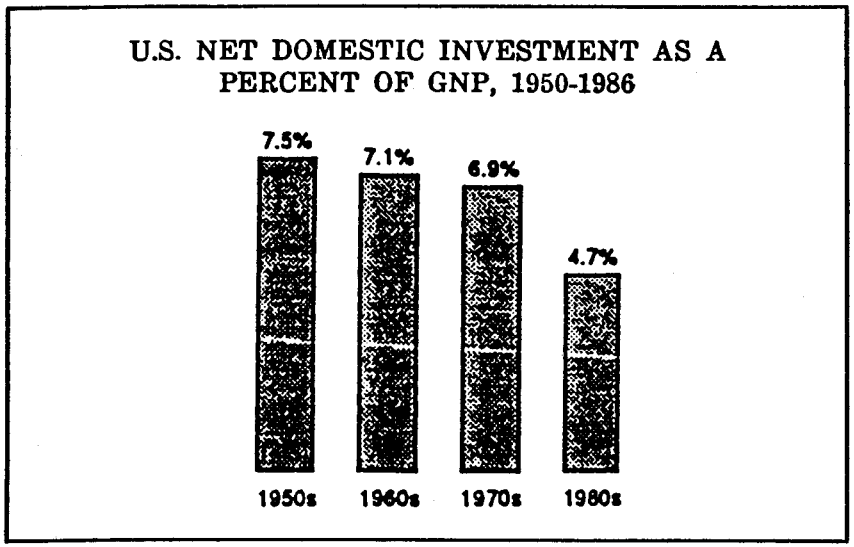
(AVERAGE ANNUAL GROWTH RATES, 1970-1986)



Sources: U.S. Department of Labor, Bureau of Labor Statistics
U.S. Department of Commerce, Bureau of Economic Analysis
Organization for Economic Cooperation and Development

Source: George Hatsopoulous, Paul Krugman and Larry Summers, "Beyond the Trade Deficit," *op. cit.*

FIGURE 3



Source: *Economic Report of the President*, 1987

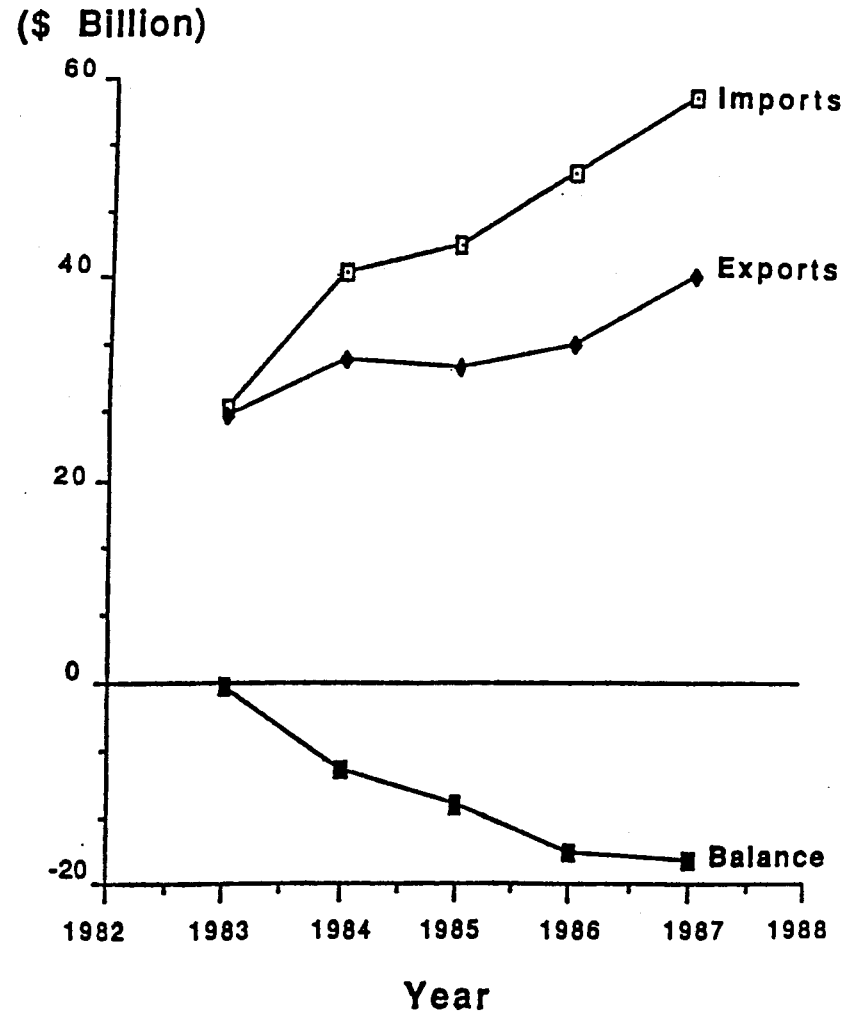
Source: *The Cuomo Commission Report* (Simon and Schuster, 1988).

FIGURE 4

U.S. BALANCE OF TRADE

Total Electronics Industries

1983—1987

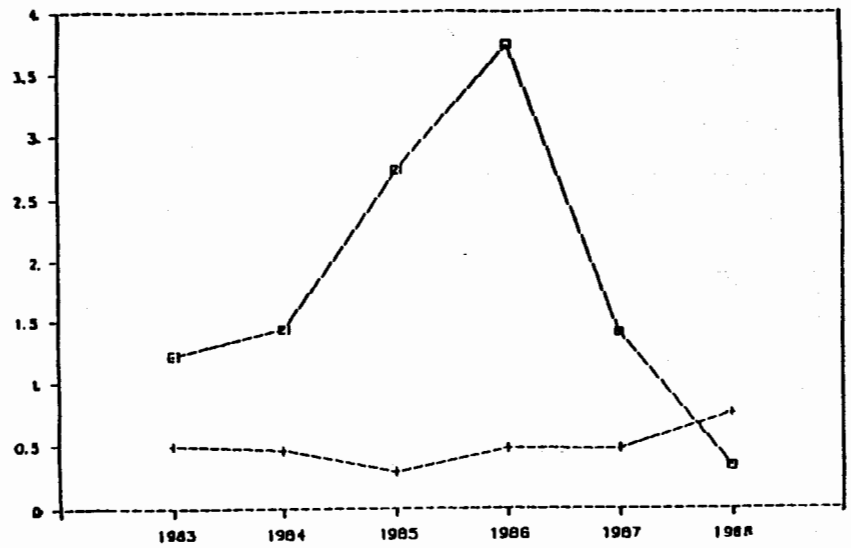


Source: Susan Walsh Sanderson graph based on Department of Commerce data.

FIGURE 5

U.S. INDUSTRY COLOR TUBES/KITS

Imports & Exports



YEAR

□ IMPORTS + EXPORTS

(Units in Millions)

Source: Joseph Donohue, Thomson Consumer Electronics

APPENDICES