Originally Processed With FOIA(s):
2005-0336-F

FOIA Number:
2005-0336-F

FOIA MARKER

This is not a textual record. This is used as an administrative marker by the George Bush Presidential Library Staff.

Record Group/Collection: George H.W. Bush Presidential Records
Collection/Office of Origin: Science and Technology Policy, Office of (OSTP)
Series: Bromley, D. Allan, Files
Subseries: General Science Files

OA/ID Number: 62035
Folder ID Number: 62035-003

Folder Title:
Industrial: General [3 of 6] [1992]

Stack:	Row:	Section:	Shelf:	Position:
	0	0	0	0

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9202388
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS
****

FROM: DANIELMEYER, HANS: SIEMENS AG

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/31/92

SUBJECT: ENCLOSED JUNE REPORT OF THE EC TASK FORCE ON PLANNING FOR THE FOURTH FRAMEWORK PROGRAMME.

****

DIRECTORATE ASSIGNED:

STAFF ASSIGNED:

ACTION REQUIRED:

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE:

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: INDUSTRIAL
D. Allan Bromley

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 08/14/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

HANS G. DANIELMEYER
Senior Vice President of Siemens AG

Dr. Allan Bromley
Assistent to the President
for Science and Technology
Old Executive Building, Rm 358
Executive Office of the President
1600 Pennsylvania Ave. North West

Washington D.C., 20500
USA

Munich, July 31, 1992

Dear Dr. Bromley:

Please find enclosed the June Report of the EC Task Force on Planning for the Fourth Framework Programme. As a 1966-74 immigrant to the US I would like to see a balance of technological strength in the triad.

Sincerely yours,

Otto-Hahn-Ring 6 · D-8000 München 83 Telefon (089) 636-41300 Telefax (089) 636-44054

EUROPE 2000:

REQUIREMENTS FOR THE FOURTH FRAMEWORK PROGRAMME

EC TASK FORCE ON PLANNING

June 1992

		Page
SCOPE AND CONTENTS OF THIS REPORT		3
1.	EUROPE IN THE WORLD CONTEXT: A PRAGMATIC APPROACH TO THE QUESTION OF FREE TRADE AND INDUSTRIAL POLICY	5
1.1	Commitment and Consensus at work in Japan	9
1.2	Economic Changes in the US	15
1.3	Developments in Europe and Comparison with other Countries	19
2.	EUROPE'S OPPORTUNITIES AFTER MAASTRICHT	25
3.	REQUIREMENTS OF TECHNOLOGY USERS	29
4.	RECOMMENDATIONS	31
4.1	The Responsibility of European Industry	31
4.2	Policy Recommendations (Ground Rules)	33
4.3	General Recommendations	35
4.4	Framework Programme Recommendations	39
ACKNOWLEDGEMENTS		45
APPENDIX I	List of Sources and References	45
APPENDIX II	Alphabetical List of Key Words	46
APPENDIX III	Task Force Members	47

SCOPE AND CONTENTS OF THIS REPORT

The EC Task Force on Planning was suggested by Directorate-General XIII (Telecommunications, Information Industries and Innovation) of the Commission of the European Communities to support the preparation of the Fourth Framework Programme 1993-97 (for List of Members, see Appendix III) . The original priority was to be placed on Information Technology, embedded in a sound European industrial base.

In the light of the Maastricht agreements and the additional time needed in the political process towards specific actions, the Task Force has concentrated its efforts on two aspects: on policy issues of immediate importance and on specific action aspects, based on inputs from users, associations, individuals and public authorities in Europe, Japan and the US (for List of Sources and References, see Appendix I).

In the course of the Task Force's work three topics became central issues to the extent that they could have been forged into three additional papers: Manufacturing competence, industrial and R&D policy, and project evaluation. Key aspects of these issues are indexed in Appendix II.

As a follow-up to the work of the Task Force, further proposals for specific actions relating to the contents of the Fourth Framework Programme may subsequently be made.

This document contains four main sections:

1. **Europe in the world context** - an analysis of the competitive strengths and weaknesses in the triad US-Europe-Japan: There is every reason to be optimistic about Europe's future if social coherence and regional differences are allowed to coexist and if **Europe finds an answer to Japan's explicit industrial policy**.

2. **Europe's opportunities after Maastricht** (e. g., Article 130 F of the Treaty) - a unique window in time for a winning policy in social cohesion and global competitiveness: **European solutions to global problems**, fostering high technology, notably information and communications technologies.

3. **Requirements of users** including those of information and communications technologies - a European market base attractive for volume products, new innovative products, and services: **European visions for global leadership** (management of change, timely intellectual property, manufacturing competence).

4. **Recommendations** - a European industrial policy of regional and global concern: Including commitment, coherence and efficiency (simplicity) of operations, flexibility, and **timely procedures for the management of the Fourth Framework Programme**.

1. EUROPE IN THE WORLD CONTEXT: A PRAGMATIC APPROACH TO THE QUESTION OF FREE TRADE AND INDUSTRIAL POLICY

The following four sections show and compare the structural changes which have taken place and continue to take place in the economic development of Japan, the US and Europe (France, Germany and the UK). The historical developments are based on data collected and evaluated by the OECD for the period 1970 through 1986 (OECD, 1991). Current developments have been registered in many discussions of the Task Force on Planning with industry and government agencies in Japan, the US and Europe in January through April 1992 (see Acknowledgements and List of Sources at the end of the document).

The following data and discussions support five key messages which underpin the requirement of a European industrial policy:

- The economic structures of the countries in the Triad have evolved differently, due to a large extent to different policies of concertation and coordination of objectives by industry and government.

- Structural changes don't just happen, they are made and take a long time to mature.

- Japan has executed the most explicit industrial policy, successfully shifting its manufacturing composition from high use of material resources to high added value, such as information technology products.

- The lack of an explicit industrial policy does not mean that there is no de facto industrial policy at all. Quite often any indirect action of one type (e. g., laws, taxes, subsidies, educational and other infrastructure) say in one economic sector may have a stronger impact on this sector or another economic sector than any direct action.

- R&D policies aim in particular at the composition of the manufacturing industry; they push for revival, generation of new and secure jobs, and for future competitiveness. Subsidies aim at maintaining the status quo. In principle, R&D policies are the antidote to subsidies. If managed a priori within a sound industrial policy, R&D policies pay for themselves by avoiding subsidies.

High Technology	Medium Technology	Low Technology
Aerospace Computers and Office Machinery Communication & Semiconductors Pharmaceuticals Instruments Electrical Machinery	Motor Vehicles Chemicals Other Manufacturing Non-electrical Machinery Rubber & Plastics Non-ferrous Metals Other Transport	Stone, Clay & Glass Food, Drink & Tobacco Shipbuilding Petroleum Refining Ferrous Metals Fabricated Metal Products Paper & Printing Wood, Cork & Furniture Textiles, Footwear & Leather
R&D intensity: 11,4 %	R&D intensity: 1,7 %	R&D intensity: 0,5 %
Note: R&D intensity defined as R&D expenditure / output		

TFP-source: OECD, 1986 / 1991

Fig. 1: The Technology Intensity Groups

The comparison of economic development in the five countries has been facilitated by OECD's definition of eleven economic sectors, of which three belong to manufacturing: high, medium and low technology manufacturing. The three are differentiated by their R&D intensity. Fig. 1 shows the businesses which constitute these three respective sectors and the resulting average R&D intensities. R&D intensity can provide guidance for the decision of where public involvement is required (see section 4.3).

In order to appreciate the changes in manufacturing composition which have led to the present competitive frictions in the Triad, Table 1 compares the development of manufacturing as a whole in the five countries considered:

Country	Manufacturing as a share of GNP (%)		GNP	Average Annual Growth Rate in GNP (%)
	1980	1988	1988	84-89
Japan	29	29	365 Trill Yen	4.4
US	22	18	4840 Bill $	3.6
UK	26	23	400 Bill £	3.8
France	24	22	5690 Bill FF	2.7
Germany	32	31	2095 Bill DM	2.6

Table 1: Manufacturing as a share of GNP (%), total GNP and annual GNP growth rates at constant prices
Source: Statistical Year Book Germany 1991 and EUROSTAT 91

Except for Japan and Germany, where manufacturing steadily contributes nearly a third of GNP, manufacturing has declined by 2 to 4 percent and contributes now less than a quarter of GNP in France, the UK and notably in the US, where the manufacturing sector has lost 20 % of its former volume.

It would be desirable to have comparable data for all European member states. The OECD has only evaluated the data on the eleven economic sectors, however, for the five countries in Table 1, Australia and Canada.

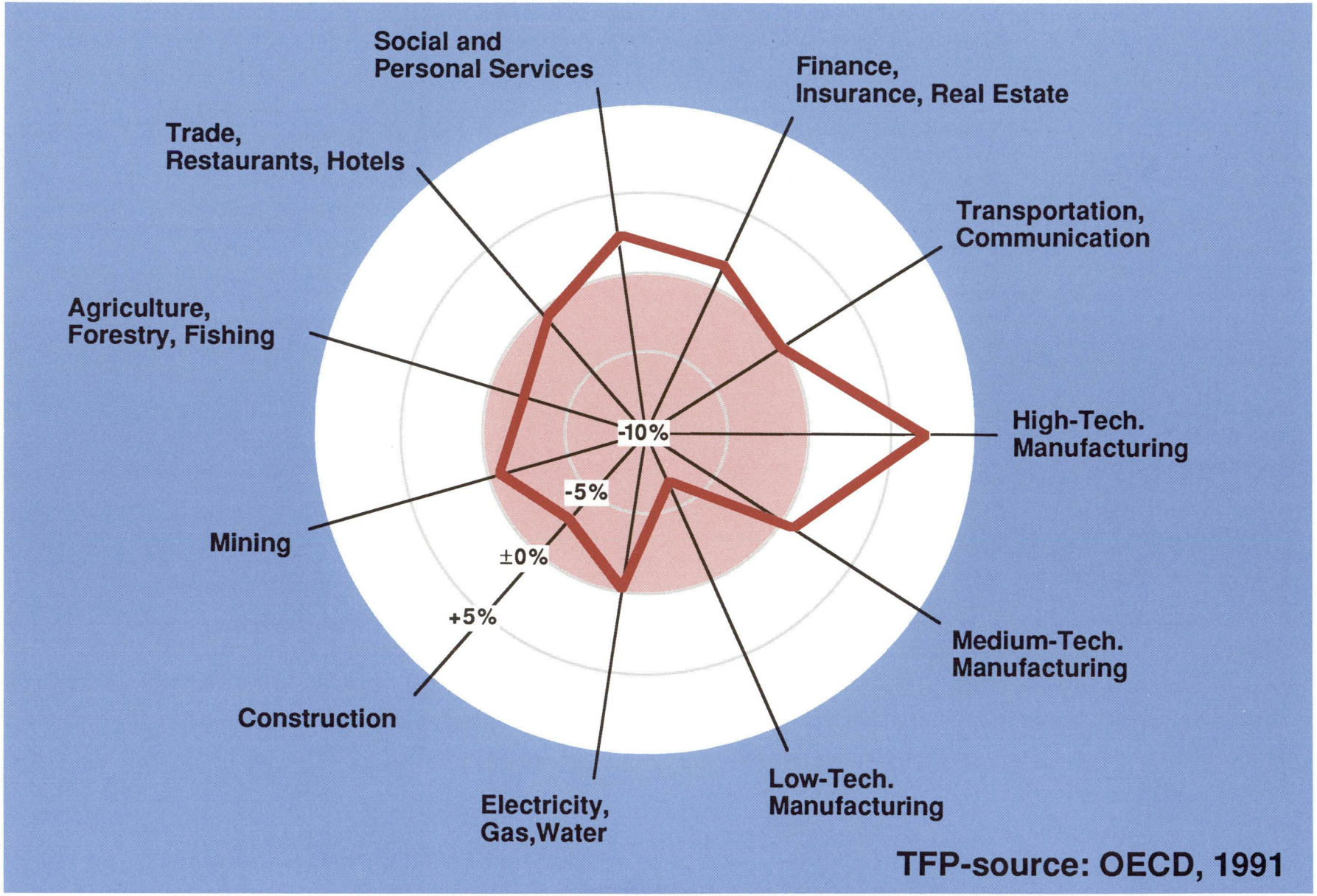


Fig.2: Structural change in Japan`s economic sectors, 1970 - 1985

1.1 Commitment and Consensus at work in Japan

Fig. 2 describes structural change for the eleven sectors evaluated by the OECD. It shows that Japan has consistently expanded its high technology manufacturing sector at the expense of its low technology manufacturing sector. Since this figure will reappear for the US and Europe, a detailed explanation is now given.

It should be noted that the Figs. 2, 3 and 4 show "gross output" of the sectors as defined by the OECD, i.e. the total of factory production or shipments. For example, in manufacturing the gross output is equivalent to the unit price of a product multiplied by the number of units produced. It includes some double counting as compared to GNP specifically in businesses with low value added. On the other hand the gross output method retains the profile of the mixture of inputs from other sectors to a particular sector. It is not possible to assemble internationally comparable and internally consistent data on a value added basis at the detailed level of, for instance, the three manufacturing sectors.

The ± 0 %-circle in Fig. 2 is the reference mark of zero change for the contribution of any of the eleven economic sectors to the total gross output of the country. The centre marks a loss of 10 %, the outer circles a corresponding gain. For example, over the period considered, "High-Technology Manufacturing" captured 7.2 more percentage points of Japan's total gross output, while "Low-Technology Manufacturing" lost nearly the same share. The sum of all changes must be zero. In fact, the 3 % gains in "Social and Personal Services" and "Finance, Insurance, Real Estate" are offset by the 3 % losses of "Agriculture, Forestry, Fishing" and "Construction". "Electricity, Gas, Water" maintained its share. The 2 % gain in "Medium-Technology Manufacturing" is offset by 1 % losses in "Mining" and "Trade, Restaurants, Hotels".

The growth in GNP as a whole at the rate of approximately 4.4 % per year in real terms (compare Table 1) is not relevant for Fig. 2 which shows only the relative sectoral changes.

The unique achievement and corresponding sacrifices for Japan's creation of a leading high technology manufacturing industry can be judged by the following analysis (Table 2):

Country	Period	Total Change (100 %)	Manufacturing Change as %age of total change	High-Tech.Mfging. Change as %age of total change
Japan	1970-85	228 Trill. Yen ('75)	49 %	20 %
USA	1972-85	1661 Bill $ ('82)	24 %	14 %
UK	1968-84	111 Bill £ ('80)	4 %	7 %
France	1972-85	1221 Bill. FF ('80)	24 %	11 %
Germany	1978-86	403 Bill. DM ('80)	25 %	11 %

Table 2: Changes in gross output at constant prices (OECD, 1991)

The High-Tech. Manufacturing sector grew in the period 1970-85 by 47 Trill. Yen which corresponds to 20 % of the total growth in Japan's gross output. As a rule of thumb the creation of one dollar annual sales in a new business requires in high technology manufacturing one dollar of investment. Depending on the product life time (say 5 to 10 years) and the growth dynamics (say linear or exponential), the investment required for Japan's high technology manufacturing sector in 1970-85 was at least in the order of 100 Trill. Yen (1975 prices). According to statistics of the Japan Development Bank the Japanese industry invested in 1986-91 approximately 130 Trill. Yen in Total Manufacturing (1975 prices). Today 100 Trill. Yen are equivalent to about 540 BECU (1990 prices). Clearly Japan has built up a tremendous strength in high technology manufacturing, which will put it in a very favourable situation, independent of momentary difficulties.

In certain areas of information and communication technologies, the investment in products and services is particularly intense. For instance, according to MITI, Japanese industry is now investing 40 Billion $ per year in mechatronics for the rest of the decade. By 1990, Japanese industry had installed 180,000 robots, compared to 60,000 in Europe and 42,000 in the US. It is estimated that Japanese industry will more than double this total in the next two years, up to 465,000 by 1995.

This development supports the view that there has been a coherent and explicit industrial policy at work, as stated in the beginning of this chapter, and that it has taken a 20 year commitment to reach the excellent competitive position that Japan's high technology manufacturing industry has achieved today. There were sufficient warnings about that commitment already in the late sixties by US and European experts.

Discussions by the Task Force in Tokyo have confirmed that the commitment to strengthen lower resource consumption and high value added businesses, especially information technologies, will continue. There have been and will continue to be many indirect and direct incentives for R&D resulting in a high visibility of R&D within companies, banks, government, the press and public opinion, still leading to increased R&D investments in all industries in spite of expected lower earnings and tighter budgets. Amongst these incentives can be counted:

- A tax bonus of 20 % of the annual increase in R&D resources, limited to 10 % of total tax;
- A tax bonus of 7 % of investments for fundamental research, limited to 15 % of total tax;
- A tax bonus of 6 % of R&D for small and medium sized enterprises (SMEs) limited to 15 % of total tax;
- Direct R&D programmes by MITI and NTT, the latter including pilot production as NTT has no production facilities of its own;
- Collaboration by government, banks and industry in joint R&D, e.g.: creation of small, dedicated, temporary R&D establishments; special conditions for R&D labs in regional science cities;simple management of joint projects; continuing low interest rates for loans; patient capital.

Based on discussions with executives of Japanese industry, it may be concluded that the government controls less than expected and finances much more than is made known. This has facilitated the large investments in high technology manufacturing industry. The Task Force recommends an analysis of the cumulative tax benefits to high technology manufacturing in Japan.

Direct public funding has indeed played a small role in the R&D climate of Japan. Even MITI's role as a source of funding has been and will continue to be limited here. On the other hand, its power may well continue as a strong mediator between technology and market forces in true pursuit of its mission, enshrined in its name: Ministry of "International Trade and Industry".

That power may not be affected by its change of emphasis after Japanese industry has achieved mature competitiveness and global standing. MITI's declared goals for the nineties are:

- Contributing to the international community and promoting internal innovation;

- Realizing a comfortable and affluent life style in Japan;

- Securing a foundation for long-term economic development.

These goals also reflect initial results of the "Structural Impediment Initiative" set up by the US and Japan in order to smooth out imbalances in their social structures. They result from observable and anticipated loss of national equilibria, and are thought to be amplified by world trade dynamics, unless counteracted by social cohesion policies.

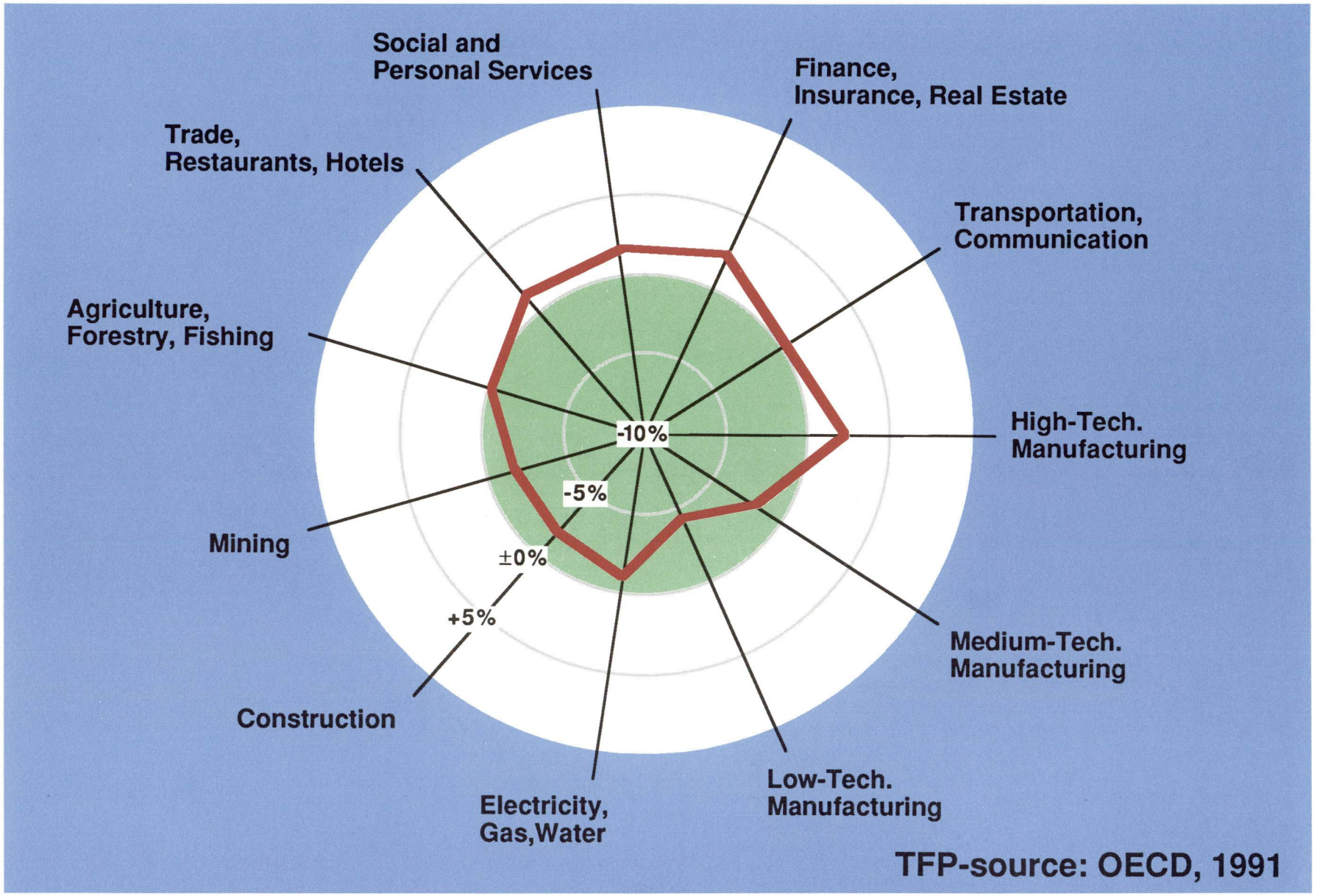


Fig.3: Structural change in economic sectors of the USA, 1972 - 1985

1.2 Economic Changes in the US

The structural changes shown in Fig. 3 are less radical than in Japan. This correlates with the traditional reluctance of the US to formulate and execute a national economic policy of change, not to speak of an industrial policy. The federal government's control of over 40 % of the total R&D in the US, mostly through the DoD (Department of Defense), has had little impact on the commercial competitiveness of industry, except for the aircraft industry. However, the world must appreciate and acknowledge its effectiveness in preserving and restoring a democratic world in which added value, free trade and commitment to the common good are at least negotiable terms of civilization. The DoD's effectiveness was directly related to its role as the major technology "customer" of private industry.

If any distinct pattern can be extracted from Fig. 3, it is the expansion of the four service sectors from "Trade, Restaurants, Hotels" through "Transportation and Communication" at the expense of the six industrial sectors. Although "High-Technology Manufacturing" has gained 2 % mainly through computers, software and aerospace in that period of time, total manufacturing has continued to decline to less than 18 % of total GNP.

This has caused a lot of internal concern, for "in the long run a society cannot live on products it cannot produce competitively". Stimulated by Mr. Packard and headed by Mr. Young of Hewlett-Packard a large group of CEOs and R&D executives drawn from all US manufacturing companies with annual sales exceeding 0.5 Billion $ met over three years. They produced a set of proposals for urgent actions amounting to a US national economic policy. Included are improvements in the quality of education and training as well as a list of key technologies accentuating the list of critical technologies of the US, and of Japan's top technologies. Policy changes which have been discussed include:

- Shorter write-off periods for R&D;
- Lower barriers to joint ventures, consortia and mergers;
- Higher tax credits, quality standards and technical standards.

According to the Task Force's discussions in Washington, the US recognises the need to be faster and more efficient in production technologies. The military innovation cycle of some 15 years does not fit the commercial cycle time of two to seven years. Simultaneously the remaining 60 % of R&D invested by US industry must at least in part be released from the short return on investment rule which, in contrast to the Japanese approach, now negatively affects even the world-class corporate industrial laboratories in the US.

We conclude that the US industry has split its time horizon into two equally weighted peaks: one (the R&D cycle) seems to be too long and the other (immediate return on investment) too short for this world. The lesson which may be drawn and which is equally valid for Europe is that both too much stress on immediate return on investment and too long-range a view, far away from a potential commercial market, do not lead to sustainable industrial growth. The strategic time frame for the commercial innovation cycle is two to seven years. **The Fourth Framework Programme must have an intermediate time horizon which allows for sufficient market relevance of results.**

President Bush's pledge to "create a climate in which industries can invest in the R&D that will keep them competitive" is well formulated, but reflects the long term public budget squeeze predicted by the congressional budget committee and the general lack of patient capital. The OSTP (Office of Science and Technology Policy) proposal of a "Civil Technology Agency" to support a coherent policy of commercially important technologies with a budget of approximately one Billion $ is, in view of Japan's industrial investment (see section 1.1), just a drop in the ocean. The trend towards protectionism and internalization in the administration is - hopefully only temporarily - on the increase.

At present a formal cooperation in industrial R&D programmes between the US and the EC is difficult to establish. However, global alliances between companies are encouraged. In non-critical areas with respect to national security and independence like video communication, high speed computing and large distributed data library networks, international cooperation is said to be welcome.

Essentially it is the responsibility of industry to revive itself, to generate new high quality jobs, and to provide for future competitiveness. On the other hand it is acknowledged that US industry is in a less favourable position now as compared to the seventies, and that in the long run a comfortable service sector can only exist on top of a healthy manufacturing sector. **Real money must be earned the hard way. Manufacturing competence cannot be leveraged ad infinitum by continuously softening the composition of enterprises, economies, and societies.**

A climate for investment is needed. The US requires an industrial policy now for internal reasons, and not only because Japan has quite a successful one.

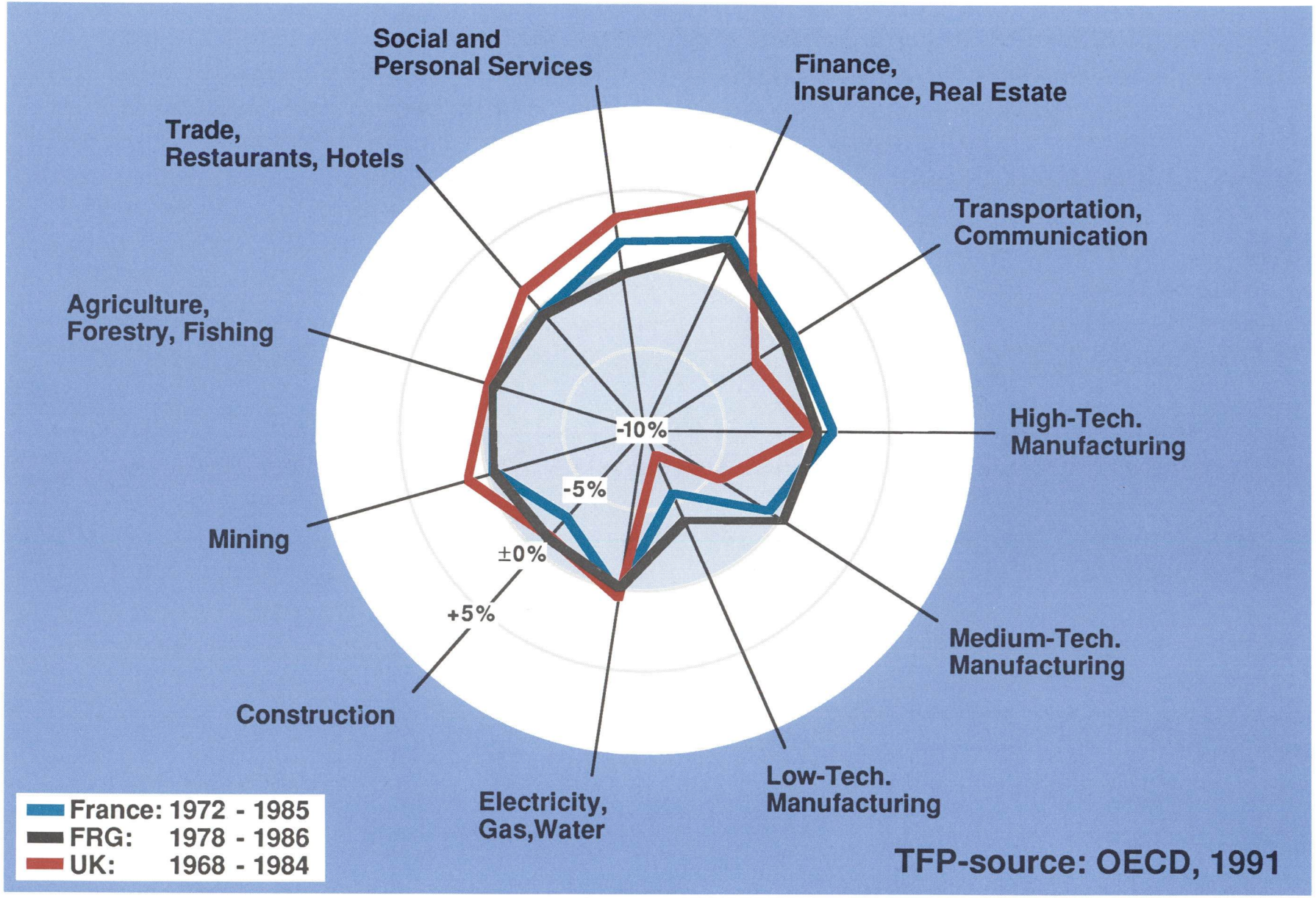


Fig.4: Structural change in economic sectors of three EC-countries

1.3 Developments in Europe and Comparison with other Countries

The comparable data available for France, Germany and the UK reveal two prominent features (Fig. 4):

- The dramatic (and presently problematic) expansion of the "Finance, Insurance, and Real Estate" sector in the UK which gained 7 % of UK's gross output, and a dramatic net loss of 10 % in the three manufacturing sectors. It seems that expansions in the health service and "Trade, Restaurants and Hotels" were paid for by reductions in infrastructure such as "Construction" and "Transportation and Communication". There is some similarity with the sector dynamics in the US reflecting perhaps an anglosaxon reluctance to pursue any positive industrial policy of change or conservation (except with respect to oil supply). The UK features the largest dissimilarity with the sector dynamics in Japan.

- The similarity and "smoother" evolution of the French and German economies in spite of quite different social, industrial, administrative and educational structures and approaches (e.g., the contrast between "French Centralism" and "German Federalism" which in fact means the opposite, decentralism). It seems that both countries have been adhering to a conservative approach, stabilizing and sometimes subsidizing the status quo rather than allowing and sometimes pushing structural change.

The previous analyses of countries indicate the direction and pace of structural change. The OECD study concludes that for nearly all the analyzed countries financial services and high-technology manufacturing represented the two "engines of growth". Ranking of the ten industrial sectors with the fastest growth in output underlines the significance of high-technology manufacturing sectors. Among these a cluster consisting of "computers and office equipment", "communication services", "communications and semiconductor equipment" makes the most important contribution. It is to be expected that this trend will continue.

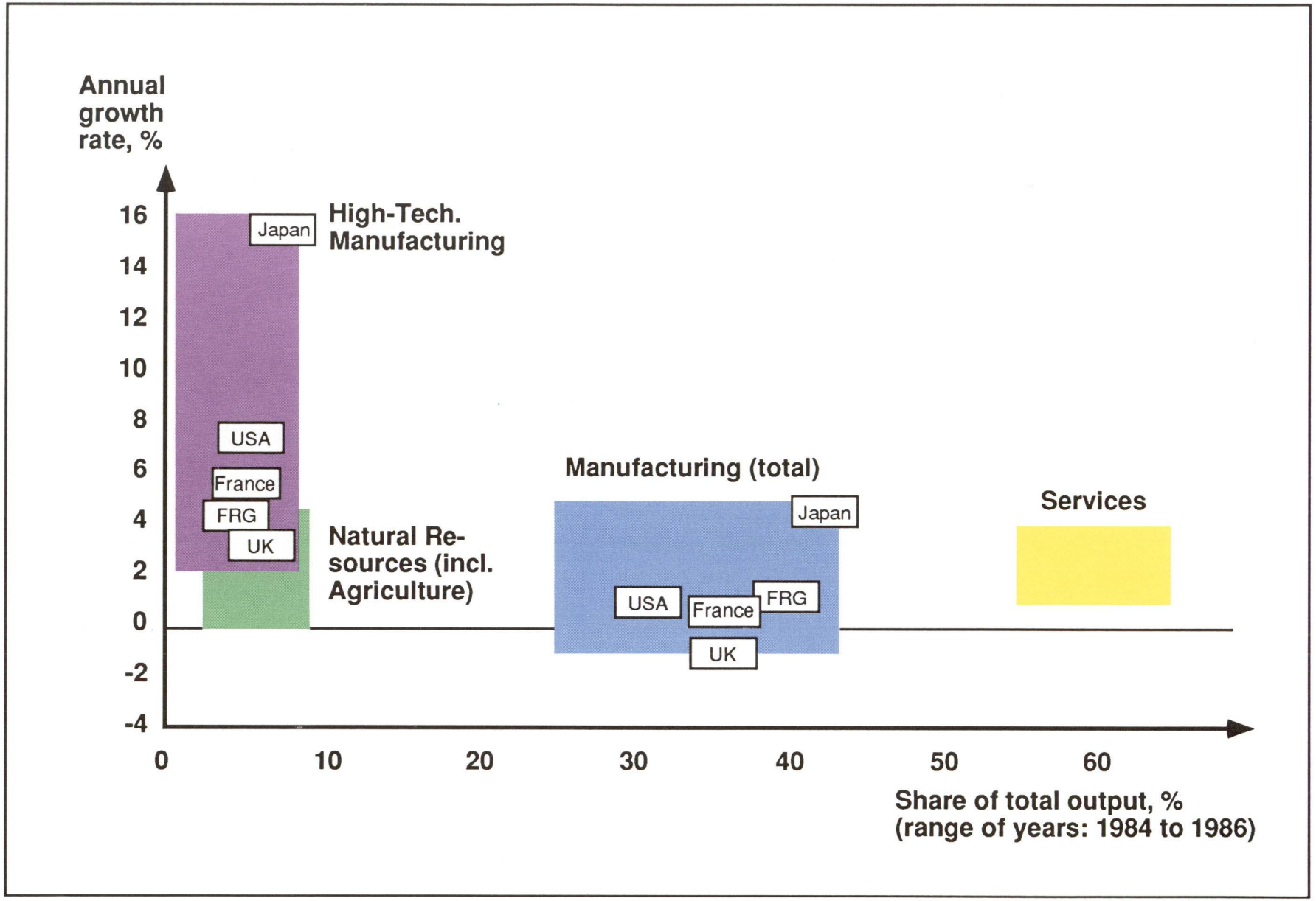


Fig.5: Growth rates and sector shares of total output

Fig. 5 indicates the composition of the countries' economies in the mid-eighties. It shows the ranges of the two natural resources sectors, the three manufacturing sectors (with a separate representation of "High-Technology Manufacturing") and the six service and infrastructure sectors within the group of countries, both as share of total gross output and annual growth rates in the periods used for Figs. 2, 3 and 4. The positions of the countries in total and in high-technology manufacturing are explicitly indicated.

Analyzing the past can provide insight into where the momentum of future growth might be: "Natural Resources", for instance, are likely to retain a relatively small and mostly declining share of output. By the mid-eighties every country had more than half of the output originating from "Services" and roughly a third from "Manufacturing". Estimates from the OECD and other sources suggest that "Services" and "High-Technology Manufacturing" will continue to grow, while "Manufacturing" as a whole will remain about constant in terms of output. In terms of employment, however, the share of "Manufacturing" will decrease in future due to productivity gains, while the share of "Services" is likely to increase.

The following quotation from a recent analysis of the relative merits of a service-based economy (Freeman et al., 1991) underlines the opinion of the Task Force that the trend of declining importance of manufacturing and increasing importance of services cannot be accepted for the EC as a whole. "While it does seem probable from all the work which has been done on technical change and employment in the OECD countries in the 1980s that the slow secular decline of manufacturing employment will continue, it is a fallacy to jump ... to the conclusion that it no longer matters to a national economy whether there is a manufacturing sector or not ... A healthy manufacturing sector is essential for the EC ... There is an obvious and direct dependence of many, if not most, service activities such as wholesale and retail distribution, transport and financial services on the flow of manufacturing production and vice-versa ... Manufacturing thus acts as a dynamo within the core economy and we depend upon this dynamo to create the wealth to support other services such as health, education and administration on which our quality of life depends." **Thus, maintaining a healthy manufacturing sector must be one of the prime goals of European industrial policy.**

Area	1990 Production / Consumption	2000 Production / Consumption	1990 R & D
Japan	25 / 19.5	106 / 73	3.5
USA	18 / 14.5	60 / 59	2.4
W Europe	5 / 9.5	20 / 33	1.5
ROW (4T)	2 / 6.5	14 / 35	0.6
World $ Billion	50	200	8.0

TFP-source: Dataquest, BMFT

Fig. 6: Microelectronics and Semiconductor World Market

All countries subsidize their agriculture by most peculiar procedures. There seems to exist a global law of conservation in politics: The magnitude of subsidies awarded to an economic sector is in inverse proportion to the sector's contribution to the gross national output. There is a clear mismatch in agriculture which receives around 50 % of all Community budgetary resources, while it accounts for less than 5 % of output. **No one can support a rationale for allocating tax money where such subsidies dwarf the funds allocated to R&D policies for revival, innovation, new jobs, and future competitiveness of the manufacturing industry.**

Japan's industrial policy sticks out clearly. Japan has placed its investment in the highest growth rate sector - the high technology manufacturing industry, and specifically the electronics industry. An extrapolation to the year 2000 shows that Japanese companies will be the only net suppliers of semiconductors, producing over half of the world's annual consumption of 200 Billion $, four times the 1990 level (Fig. 6). **In fact, Japan will be the high technology manufacturing centre of the world, if the patterns in the Triad do not change soon.**

Commitment Appropriations (BECU 1992)		1992	1997
I.	Common Agricultural Policy	35.3	39.6
II.	Structural operations (including the Cohesion Fund)	18.6	29.3
III.	Internal policies (other than structural operations)	4.0	6.9
IV.	External action	3.6	6.3
V.	Administrative expenditure (and repayments)	4.0	4.0
VI.	Reserves	1.0	1.4
	TOTAL	**66.5**	**87.5**

TFP-source: CEC

Fig. 7: Breakdown of Proposed Community Funding

2. EUROPE'S OPPORTUNITIES AFTER MAASTRICHT

The years of the EC's Fourth Framework Programme in science and technology are a historic window of opportunity for Europe.

This statement is based on three major developments:

- The US economy is under structural strain, specifically with respect to its manufacturing base. Considering the long term nature of structural change US industry must seek cooperation. The US government will gradually find a pragmatic approach navigating between a hands-off policy and its responsibility for a coherent economic policy; perhaps this will take the form of a shared responsibility, acknowledging that it is better in the long run to have a policy at the front end of manufacturing skills instead of having to police trade at the rear end.

- The Japanese industrial policy has created an edge in its economic balance which is presently very rewarding. In the long run it raises two questions: How long will the Japanese accept personal sacrifices in the name of global leadership? How expandable is the size of the global high technology market knowing that the Japanese home market may be over-extended?

- Europe of 1992 is at a critical stage of integration, competitiveness, and social needs.

But the Maastricht Treaty has for the first time opened the door to connect R&D with an industrial policy for Europe.

The analysis of the total Community funding requires, however, a careful scrutiny of the largest areas of funding, which will be the agricultural and structural funds (see Fig. 7). Their size can be justified only if we envisage a position in which

- **Europe 2000 will develop European solutions to global problems.**

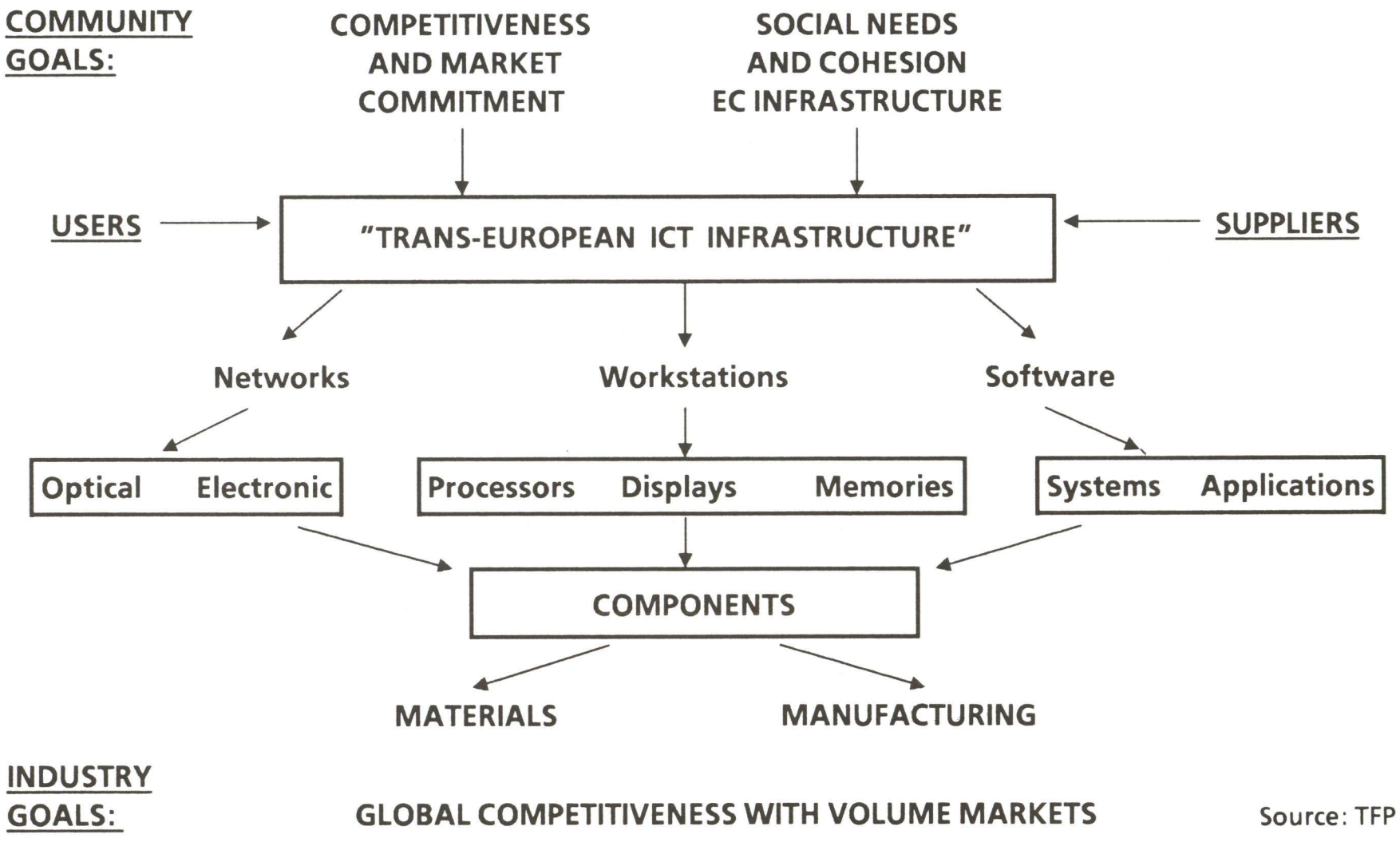


Fig. 8: European Needs and Opportunities for IT Industry

The principle of subsidiarity, as set out in the Maastricht agreements, requires that the allocation of funds should favour those projects for which the European level is a natural and necessary step between their national or local level and the global dimension. A smooth way of dovetailing different national attitudes into a European policy has yet to be found, but one requirement seems to be essential if Europe is to grasp the opportunity offered by Maastricht :

- **Europe 2000 must be an attractive home market for European companies, including the market for volume products.**

Considering the possible scenario of a globally competitive Europe for volume products under the Community goals, the information and communication technology (ICT) industry also offers the largest growth rate for Europe, plus beneficial cross fertilisation for other industries. Fig. 8 shows a European framework matching Community goals of integration and cohesion with industry goals of global competitiveness and social needs. ICT can meet these objectives in the form of a high-functionality "Trans-European Information and Communication Infrastructure", for a high-bandwidth network serving suppliers and users. It is a unique opportunity to prepare the architecture and standards of this infrastructure within the Framework Programme for subsequent realization by users and suppliers. This infrastructure developed by Europe is an excellent example of the opportunities for Europe 2000. Such a framework could help achieve a volume market for European suppliers of the main technologies depicted and simultaneously provide a springboard for global reach. Similar frameworks will exist with other users and suppliers of technology:

- **Europe must foster such frameworks for European development.**

The semiconductor industry is a sector with substantial prospects for growth (see Fig. 6). This industry feels the need for strategic alliances, long term strategies, vertical integration, tax incentives, patient capital, regional R&T centres, realization of economies of scale. Much more important for Europe, however, is better systems integration, especially for SMEs, but also for the divisions of large companies. The long-term industrial expansion of ICT as a whole is dependent on microelectronics. Microelectronics is unique in the whole spectrum of scientific and technological endeavour in the range of skills, disciplines and financial resources which need to be brought to bear and integrated for achieving results. Microelectronics also plays a critical role in consolidating the intellectual asset base in Europe. As such, microelectronics and allied products and services of European creation generate intellectual resources. To remove this creation from the economy as a whole through dependence on either foreign supply or ownership would mean to condemn Europe to a low-tech future. Joint ventures will provide natural solutions to many of the inherent challenges and difficulties of the microelectronics sector. This is also one of a series of recommendations of the US National Committee on Seminconductors.

- **The microelectronics area requires a special approach based on its uniqueness as an enabling technology.**

3. REQUIREMENTS OF TECHNOLOGY USERS

The demand for products - market pull - is the strongest motivator for innovation in the high technology business. The Task Force requested and has obtained a comprehensive response concerning user requirements in the field of ICT (Information and Communication Technology). The following examples are extracted in view of their relevance for a European policy.

(1) The banking sector is along with other service sectors one of the best customers for high technology products in office automation, data processing and networking. In 1990 the banking, insurance and financial service business accounted for 21 % of the ICT expenditure in the European Community (CEGOS, 1991). Among banks' immediate needs are low-cost high-speed computers. Future requirements include speech recognition, automatic translation, and speech synthesis.

(2) The machine tool industry requires access to a European microelectronics source without loss of access to Japanese products. Current bottlenecks are software and interfaces for production testing and quality assurance. European programmes should be more easily accessible to SMEs, and bring their development together with the expertise of some major suppliers. Young European engineers should learn from Japan, and should spend some time there. Total manufacturing industry accounted for 23 % of the ICT expenditure in Europe in 1990 (CEGOS, 1991).

(3) The electricity utilities will operate on a truly global basis by the year 2000. Technological progress is the key to environmental damage confinement. New developments are needed in fuel cells, storage, photovoltaics, coal gasification, nuclear power, superconductivity, large scale networks, global considerations and more fundamental approaches.

(4) The chemical industry stresses existing areas of R&D (new materials, catalysis, recycling, renewable resources) as well as new areas: modelling reactor characteristics, and natural product chemistry; finding new methods for crop protection; studying organized supermolecular systems, catalytic antibodies, carbon dioxide utilization, boundary surface chemistry, non classical conditions, non-linear dynamic systems, and improved scientific computing for molecular and biological modelling.

(5) The mail order houses expect and urgently require a GATT resolution. They appear to suffer most from the administrative requirements which shift the burden of keeping track of European and national import quotas as well as accounting problems onto business itself. There are immediate benefits expected from speeding up via Transeuropean Networks the coordination between Member States, and from teleordering after mail ordering. The trade sector also recommends that the challenge of Eastern European cost structures for some southern European Member States should be addressed. Retail and wholesale distribution accounts for 9 % of the ITC expenditure in Europe.

(6) The automotive industry is one of the key strategic sectors for the application of information technologies. The electronic volume of electronics in vehicles is increasing continuously. At the same time, automotive manufacturers use IT to handle the increasing complexity of their production plants and the integration of functions which cannot be undertaken by subsidiaries and suppliers. Manufacturers are interested in traffic control systems because they know that traffic congestion will limit future sales of cars. Finally, environmental concerns require serious action regarding recycling and the development of advanced propulsion systems. Some of the critical technologies and R&D needed to tackle these problems are: advanced materials for light-weight vehicles, lean production technologies, optoelectronics, display technology, microelectronics, simulation and modelling tools.

(7) In addition, although not contacted by the Task Force, public administrations and services constitute a large market with currently moderate expenditure per employee. The market for ICT products and services shows good potential for growth, comparable (per capita) to manufacturing and retail/wholesale distribution (CEGOS, 1991). Finally, European citizens will increasingly demand ICT products and services for their private use. Although high-volume electronic products and services for this sector will have to be specifically tailored to the intended use, they will exhibit a strong technological commonality with the more professional sectors.

As a first conclusion, the requirements of the users clearly support a policy which aims at the European high technology manufacturing industry, and specifically emphasizes information technologies.

4. RECOMMENDATIONS

The following four sub-sections address industrial responsibility for global competitiveness, policy recommendations (ground rules) for the EC, some recommendations considered to be of general relevance and, finally, initial recommendations for the contents of the Fourth Framework Programme.

4.1 The Responsibility of European Industry

To achieve global competitiveness is the prime responsibility of industry itself. It is no secret that there are many opportunities for continued improvements in performance. Some of them will be important with a view to successful participation in the Fourth Framework Programme. For Europe wants to be sure that the R&D funds are used effectively for revival, innovation, generation of new and secure jobs, and increased global competitiveness.

- The most important attribute for today's competitiveness is the capacity to adjust to and to manage change - in marketing, manufacturing and technology. This includes motivating and retraining the work force to win in global competition. The work force scores the goals, the first level managers coach their teams, and top management decides on missions and strategies.

- In many high-technology manufacturing businesses R&D has become the top contributor of value added, ahead of manufacturing and marketing. It is therefore no longer acceptable to treat R&D only as a cost factor to be minimized under all circumstances. An effective accounting practice considers the ratio of added value to cost. The added value of R&D is always accountable: either in a volume component which has a market price or in a key component (hardware or software) which has a strategic price.

- There cannot be a successful R&D strategy without a sound marketing strategy. Since time to market is an essential competitive parameter, the traditional business functions of sales, R&D and manufacturing must team up much better than before within an explicit business strategy. It is a good competitive practice to keep the fundamental development of products and manufacturing processes together.

- It is essential to protect intellectual property. It is a strategic asset in global competition.

- High Technology Manufacturing differs significantly from Medium and Low Technology manufacturing. It requires a social and professional blend between workers and researchers which can be considered as the antithesis of the division of labour in a traditional factory order. This blend certainly gave Japan a clear advantage in expanding its high technology more rapidly than other leading countries.

4.2 Policy Recommendations (Ground Rules)

The complexities of procedures within Europe itself, the Europe of Nations, the Europe of Regions, the Parliament, the Council and the Commission should not distract us: There are a number of ground rules which are quite independent of the level of complexity. They should be followed or taken into account in any case. The Task Force has opted to limit the number of such recommendations to ten:

(1) Global competitiveness of Europe can be achieved at best if national industrial policies are a generic, integral part of a European Industrial Policy. This policy should encourage a healthy competitive climate in Europe and discourage the cultivation of national and European champions.

(2) The role of the Regions shall be harmonized towards European integration building on local differences. We should look upon the diversity of Europe as a competitive advantage as well as a challenge.

(3) Europe will encourage growth sectors and enabling technologies; Europe 2000 will have phased out support for lost causes.

(4) Europe will support the management of change and the strong link of R&D and manufacturing with global marketing.

(5) Europe will be committed to a long term policy including a European Venture Fund supplying patient capital.

(6) The Commission will set up simple, effective procedures from planning through evaluation of the success of the Framework Programme. These will include efficient links between Directorates-General and their programmes.

(7) Each European company shall be considered on its own merits irrespective of company size and home base. That includes European Manufacturing and R&D in vertical integration, not necessarily European ownership, if the non-European home base applies the same practice for European owned companies.

(8) The EC will focus actions in key technology projects but also continue generic basic R&D.

(9) Europe will develop human resources through European curricula, local relay centres, networks of excellence, and encourage mobility of professionals.

(10) Europe will be aware that its demanding goals cannot be reached if all claims are satisfied at each level, such as "juste retour", equal participation of all companies per Member State, indiscriminate coverage of all technologies, and automatic continuation of former programmes.

4.3 General Recommendations

(1) Europe must preserve and encourage use of its existing skills and abilities. First priority must be given to maintaining the competitiveness of our existing businesses, which can compete worldwide. This requires in addition to R&D and diffusion related measures a comprehensive approach addressing the general business environment, external relations, as well as training and education. In general, the principle of non-discrimination of partners in the world trade system must be pursued. Concerning specifically R&D and high technology, special attention and sufficient resources are needed because it is here that the ground is being prepared for future economic growth. **Therefore, the envisaged budget increase for the Fourth Framework Programme must be supported.**

(2) **In practice, subsidiarity in the Fourth Framework Programme requires that only those projects be supported, where the participating firms intend to exploit the European market as the strategic competitive level on the way from a national or local activity towards the full international dimension.** A mere extension of local business mentality and practice is insufficient. All proposals should be required to give adequate proof of the necessity of the European dimension.

(3) **With respect to differentiating the role and importance of the various user groups, it is proposed that priority be given to those industries (as listed in Fig. 1) demonstrating high R&D intensity i.e. R&D expenditure above 10 % of output.** For industries exhibiting a medium R&D intensity, the decision should be taken on a case-by-case basis. Industries registering a low R&D intensity i.e. R&D expenditure below 1 % of output, should not, as a rule, be considered for Community action.

(4) In the Fourth Framework Programme the role of technology users needs to be increased by defining a user role and a supplier role, funding and monitoring both. **It is essential for global competitiveness to think and to organize "vertically integrated".** For each cluster of research projects an initial investigation should identify the principal users for whom substantial benefits could accrue from the technology concerned. Subsequently, representatives of these users would be invited to become "associate" participants in the relevant project cluster in order to pave the way for take-up of technical results within a receptive market environment. This includes the cooperation of large with small and medium-sized enterprises, which is one of the most important sources of innovation. It is furthermore proposed to strengthen the role of users on the Commission's consultative bodies of leading experts in the field of ICT, thus better integrating their views at the level of strategic guidance and monitoring of programmes.

(5) **Europe needs an infrastructure which simultaneously helps to satisfy cohesion and social needs and provides a market framework in which European industry can compete successfully.** The framework demonstrated in Fig. 8 shows how such an infrastructure could draw suppliers and users together in common R&D goals, feeding through into broader Community goals.

(6) Information Technology remains a key sector for economic growth and employment in Europe. **The Task Force recommends continuity in support for IT, and, in addition, urges the Commission to prevent by all means a gap opening up between the Third and Fourth Framework Programmes which are crucial for Europe's competitiveness.**

(7) If the Fourth Framework Programme is to achieve its goals - strengthening European cohesion and industrial competitiveness including volume products - large investments will have to be made (compare the investment for the expansion of Japan's high technology manufacturing sector in sub-section 1.1). The European Investment Bank's power will be limited. **The Task Force recommends a Joint European Venture Fund with sufficient business instinct and marketing proficiency in order to handle the volume effectively and with appropriate risk.**

(8) Social cohesion, personal mobility and technical competence on a European 2000 level require more compatibility in European education. Primary education and university curricula are quite difficult to change. **The Task Force recommends to develop a curriculum for a European Diploma of Technology, and to initiate in at least one university per Member State one centre teaching and conferring that degree.** The curriculum will integrate Electrical Engineering, Computer Science, Physics and Materials Science. In industrial practice on-the-job learning has become so important that after three to five years the original education no longer matters except for the fundamental methods and principles. These are, however, so widely overlapping that a European Diploma of Technology is an attractive alternative to academic specialisation. One foreign language, preferably English, and half a year's practice in another Member State's laboratory participating in the Fourth Framework Programme will round off a truly European education. The centres can act as national relay centres for a European Network of Excellence. If combined with an excellent medical faculty, the network can be used simultaneously for telematic health care.

(9) The importance of the Fourth Framework Programme for Europe, its connection to industrial policies in the Triad, and the dynamics of change require a creative exchange of information and ideas at the highest level of European competence. **The Task Force recommends the establishment of an independent European Council of Experts (ECE), truly committed to the European cause.** It will have ordinary and senior members, appointed for a longer time to serve in specific as well as in broader temporal missions for the EC. Beyond serving as a source of advice its members can assess the success of the EC Framework Programme, increase its effectiveness, assist in creating the curriculum for the European Diploma of Technology, and serve as referees for the last immediate recommendation the Task Force wishes to make:

(10) **Establish a European Innovation Prize.**

It may be awarded for the

- European SME of the year making the best contribution to competitiveness;
- Most striking example of management of change in business and/or administration;
- Best European solution to a global problem;
- Outstanding contribution of the year to the Framework Programme.

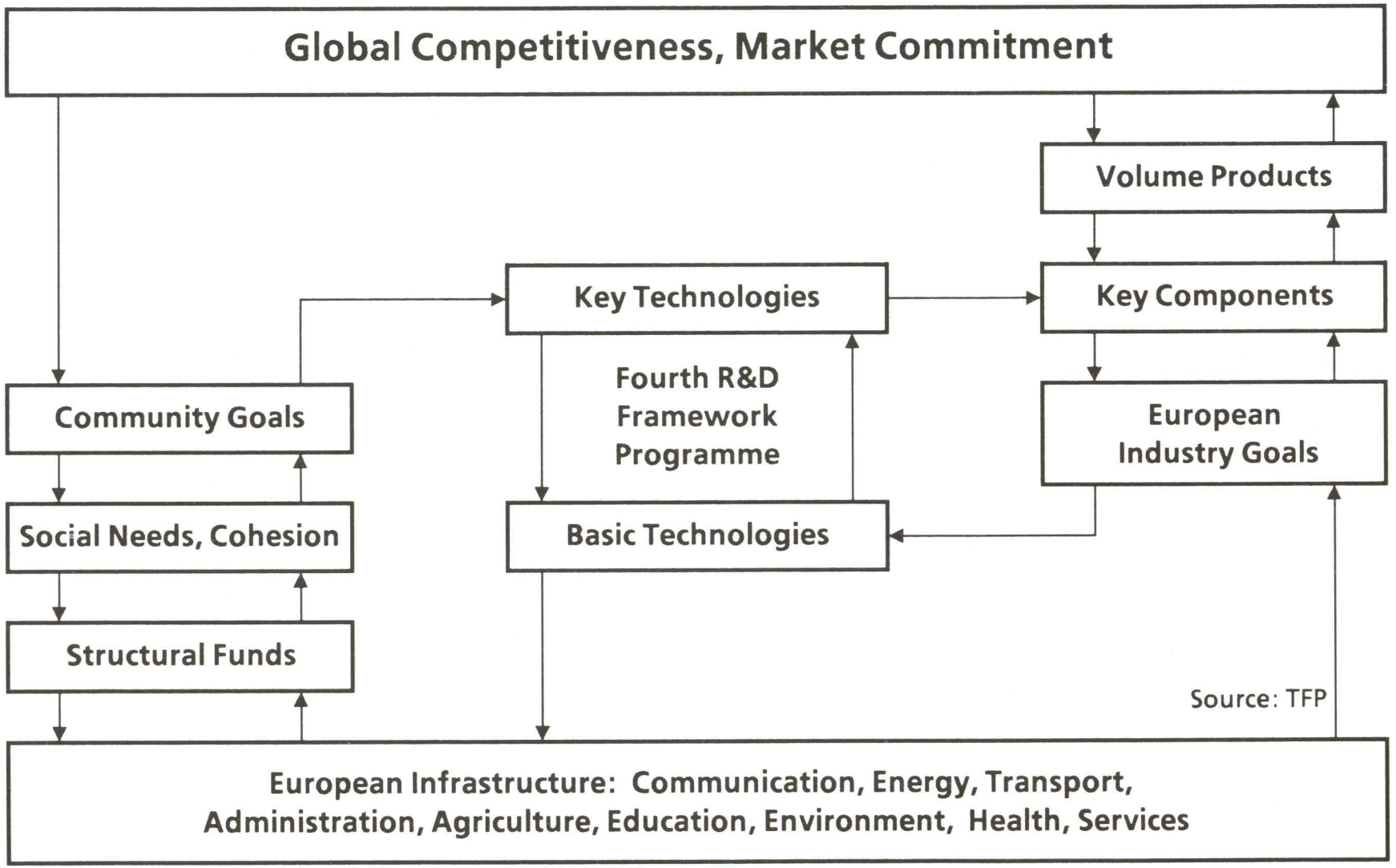


Fig. 9: Integration Processes for the EC Framework Programme

4.4 Framework Programme Recommendations

The integration of the Fourth Framework Programme in the social, industrial and global context, as set out in the preceding sections of this document, is shown in Figure 9. The left hand column represents the activities which are normally attributed to the public sector; in different contexts, the "Community goals" could apply at the European as well as the national or regional levels. The right hand column represents the activities which are the prerogative of industry itself - the actual activities would vary according to the specific industrial sector.

It is evident that the processes of Programme Formulation and Programme Evaluation should each be vertically integrated - both bottom-up and top-down. The Task Force recommends that this process be continuous: Technology is evolving so rapidly that the only rational way to proceed is for project details to be defined "just-in-time" i. e. just before projects start. Likewise, projects should be terminated as soon as it becomes evident that the results aimed at cannot be achieved, or cannot be achieved in time. This places particular importance on the clarity of the goals that will serve as the framework for evaluation.

The role of the structural funds as a possible amplifier of the effect of R&D programmes is also evident in the diagram. If the high quality aimed at by the Framework Programme is to result in global competitiveness for all parts of the Community, the Commission should make every effort to combine these two types of support, each for its own purpose, to achieve this synergetic effect.

The Task Force recommends that the Framework Programme should distinguish between projects in two categories:

- **Basic Technologies** which are precompetitive in nature: They aim to increase European competitiveness through improvements in the European infrastructure, as well as the technologies needed for later product development. Their time horizon to market is typically 5 to 15 years.

- **Key Technologies** aim at strategically important components which are needed by several businesses in different environments. Their time to market horizon is typically 2 to 7 years (see section 1.2, page 16). A key technology project should not be supported unless at least two European manufacturing companies are determined and capable of the volume production of resulting components.

In programme formulation, assessment, and project reviews the independent European Council of Experts would play a key role, since conflicts arising from committee members being potential project participants should be avoided.

There should be close vertical links between the two categories to facilitate transfer. This implies strong links between the directorates responsible for the activities to ensure rational transfer and cross-fertilisation, both top-down and bottom-up. Furthermore, the Task Force suggests that the recommended activities should always be considered in their entirety. For instance, the local relay centres needed for a "European Network of Excellence" could simultaneously be the university-industrial nuclei for several of the following programme activities: High performance computing and networking, distance learning, the European Diploma of Technology, telematic health care and multimedia standards and technology, featuring early ATM and other standards. Synergies between several activities will save costs, link infrastructure needs with building up common competence in industry, and speed up European competitiveness.

Based on the needs of European users, and with knowledge of all the programmes in the "triad", the Task Force has identified the following non-exclusive Framework Programme activities:

Agriculture and Biotechnology

- Satellite monitoring of agriculture and forestry
- Molecular genetics
- Fishing and aquaculture

Energy

- Nuclear reactor safety
- Fusion
- Energy saving
- Energy distribution
- Energy storage
- Fuel cells
- Additive and renewable energy

Environment

- Global change
- Air, water and soil pollution

Health

- Safe and convenient medical images
- Preventive health care
- The hospital of the future
- Telematic health care
- Pharmaceuticals

Manufacturing Competence

- Advanced manufacturing (professional blend and automation)
- Management of change
- Function integration
- Product/equipment development
- Total quality

Materials and Processing

- Advanced materials
- Recycling
- Catalysis
- Molecular Modelling
- High temperature superconductors

Transport

- Rail-, road-, and air-traffic systems
- Advanced propulsion systems
- Urban habitat

From the user requirements (section 3), the emphasis needed in the Information and Communications Technologies activities of the Framework Programme becomes evident. For the following activities approximately 45 % of the total framework budget should be allocated (asterisks signifying key technologies):

Information and Image Processing, Multimedia

* LCDs
* HDTV
- Best software practice in software engineering
- Multimedia standards and technolgoy
- Speech processing
- High-density information storage

Microelectronics

- CMOS
✳ ASICS
- Open microprocessor systems
- MMICS

Networks and Systems Integration

- Mobile and personal communications
- Hand-held batteries
✳ Photonics
- Intelligent networks
- Opto-electronic components
- Microsystems
- Computer Integrated Manufacturing Systems
- Information exchange between administrations
✳ High performance computing and networking
- Systems security

Finally, the horizontal activities of the Fourth Framework Programme must take into account the infrastructure needed for a competitive Europe:

Education and Mobility

- The European Diploma of Technology
- Distance learning
- Industry-academia exchange
- International cooperation
- Science and innovation prizes

Transfer

- European Venture Fund for large and small companies
- User-supplier vertical links
- Responding to the needs of the market and society

The amount allocated to each activity may range between 50 and 500 MECU, depending on what is needed for reaching global European competitiveness in marketable technology through the projects carried out within each activity. The allocation will depend on the vote of the independent European Council of Experts having regard to the quality and relevance of the actual proposals. This again points to the need for a framework, i.e. for flexibility of the allocation of funds.

ACKNOWLEDGEMENTS

The Task Force is grateful to all persons, committees and institutions which have supplied information and expressed without exception great interest in Europe's future policies. Special thanks are due to the ESPRIT Advisory Board, officials of DGXIII, and the OECD.

APPENDIX I

List of Sources and References:

USA: DoE, NAS, DoD (Pentagon), OTA, AT&T, HP, IBM, CMU, MIT, University of Princeton

JAPAN: MITI, JIPDEC, MEC, Gaimusho, GEC-Marconi Japan, Hitachi, NEC, Sumitomo Electric, Toshiba, Hoechst, Siemens, Tokyo University, GMD, Embassies of: European Community, France, Germany, United Kingdom, and United States.

EUROPE: CEC, ABB, Alcatel, Bull, Daimler-Benz, DECHEMA, EDF, Fiat, Philips, Quelle, Siemens, Thomson, VDMA, Schweizerische Bankgesellschaft, Logica, OECD, Governments of Germany, France, Greece, Italy, Spain, and the United Kingdom.

CEGOS (1991): Information and Communication Technologies. Towards a Partnership with Users. Study commissioned by DG XIII. CEGOS, Boulogne Billancourt.

Freeman, C., M. Sharp, W. Walker (1991): Technology and the Future of Europe. Pinter Publishers, London.

OECD (1991): Structural Change and Industrial Performance. DSTI/STII/IND (91)2, Paris.

APPENDIX II

Alphabetical List of Key Words

A. Industrial and R&D Policy	page
Coherent commitment	11
Competitiveness	37, 39
Conservatism	19
DoD spending effect	15
European infrastructure	39
Intermediate time horizon	16
Japan's success	23
Keep existing strengths	35
Key components	38
Marketing strategy	32, 39
MITI's role	12
OECD technology intensity groups	6
Revival versus subsidies	5
Small and medium-sized enterprises	12, 36, 37
Two peak US Policy	16, 25
User requirements	29
Vertical integration supplier - user	36

B. Manufacturing	page
Automation	11
Comparison of 5 countries	20
Competence	17
GNP share of 5 countries	7
High technology	10
Human resources	34, 35, 37
Importance	21
Industries	6
Innovation prize	37
Integration of functions	32
IT market	26
Japan	9
Key components	31, 38
Management of change	31
Retraining work force	31
Social blend	32
US	15, 16
Volume products	27

C. Project Evaluation for ECE

	page
Added value / cost ratio	31
Added value shift	5
Basic / Key technologies	39, 40
Bottom up / Top down	39
Clear goals for assessment	39
Competitiveness	33
Effective EC procedures	34
European Council of Experts (ECE)	37, 40, 44
European level / subsidiarity	35
Independence of home base and company size	34
Marketing essential	33
No perfect justice possible	34
Lost causes	33
R&D intensity	1, 30
Termination of projects	39

APPENDIX III

Task Force Members:

H. G. Danielmeyer (Chairman)
F. Aldana
F. P. Carrubba
P. G. Gili
N. W. Horne
J. L. Lions
E. de Robien
H. Steinmann
A. J. Hooker (Secretary)

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9202291
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: O'BRYON, LINDA: THE NIGHTLY BUSINESS REPORT

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/30/92

SUBJECT: ENCLOSED COPY OF THE TRANSCRIPT FOR THE BROADCAST, THE NIGHTLY BUSINESS REPORT.

****

DIRECTORATE ASSIGNED: STAFF ASSIGNED:

ACTION REQUIRED: STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

****

COPIES TO: INDUSTRIAL
D. Allan Bromley

****

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:

REMARKS:

OSTP RECEIVED: 08/10/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

2291

THE NIGHTLY BUSINESS REPORT

Produced by
NBR Enterprises/WPBT2
P.O. Box 2
Miami, FL 33261-0002
(305) 949-8321
Fax: (305) 949-9772

July 30, 1992

RECEIVED
92 AUG 10 P2:23
OSTP
MAIL ROOM

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology
Room 358
17th & Pennsylvania Avenue, N.W.
Washington, D.C. 20500

Dear Dr. Bromley:

Many thanks for your participation in The Nightly Business Report/Fortune special, "Keeping America #1." Your presence on the panel of interlocutors provided an excellent forum for a lively exchange with the CEOs. I was pleased to have the opportunity to co-moderate a program with such enlightened dialogue, focusing on strategic topics for business, the presidency and the electorate at large.

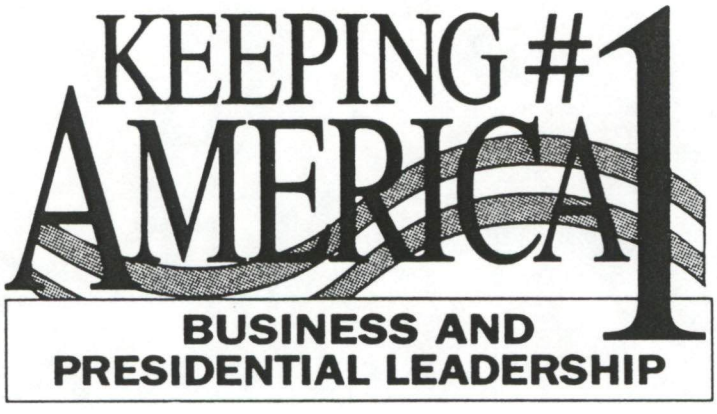
Enclosed is a copy of the transcript for the broadcast.

Sincerely,

Linda O'Bryon

Linda O'Bryon
Senior Vice President
and Executive Editor

LOB:rjs
enclosure



Presented By

FORTUNE

and

THE NIGHTLY BUSINESS REPORT

In Association With

Center for the Study of the Presidency

Sponsored By

The Nasdaq Stock Market℠

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9202187
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS
****

FROM: JASINOWSKI, JERRY: NATIONAL ASSOCIATION OF MANUFACTURERS

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/28/92

SUBJECT: ENCLOSED REPORT ON MANUFACTURERS, 1992

****
DIRECTORATE ASSIGNED: STAFF ASSIGNED:

ACTION REQUIRED: STAFF ACTION:

****
SENDER'S DUE DATE:
OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

****

COPIES TO: INDUSTRIAL
D. Allan Bromley

****

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:
REMARKS:

OSTP RECEIVED: 08/04/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

2187

National Association
of Manufacturers

Jerry J. Jasinowski
President

July 28, 1992

Mr. Allan Bromley
Asst. to the President
The White House
1600 Pennsylvania Avenue, NW
Washington, DC 20500

Dear Mr. Bromley:

The enclosed "Report on Manufactures, 1992," marks the bicentennial of Alexander Hamilton's ground-breaking treatment of the subject and reaffirms his insight that manufacturing is at the heart of America's economic strength and national security.

Rather than being in decline, American manufacturing's strong performance in productivity growth, exports and quality improvements is the success story of recent years.

The report also documents, however, that manufacturing performance has been poor relative to historical and international benchmarks in the key areas of profits, the growth rate of industrial R&D spending and investment in equipment. These problems, in turn, are related to excessive Federal budget deficits and out-of-control regulatory and legal costs.

This type of information about U.S. manufacturing's real strengths and weaknesses is critical if business and government are to move forward with the pro-growth public policy agenda the nation needs.

That's why the administration -- pursuant to NAM's request -- has agreed to expand upon our "Report on Manufactures, 1992" with a more extensive study of the role of manufacturing in the U.S. economy. Commerce Secretary Barbara Franklin just informed me she will ask the Department's Economics and Statistics Administration to take on this exciting project, scheduled for completion in early 1993.

We all have much to learn about the ways manufacturing conveys economic benefits to the American people. I hope you will find NAM's "Report on Manufactures, 1992" a good first step. Please contact me directly if you have comments on the report, or wish to have more information about modern manufacturing.

Sincerely,

Jerry J. Jasinowski

1331 Pennsylvania Avenue, N.W.
Suite 1500 - North Tower
Washington, DC 20004-1703
(202) 637-3106
Fax: (202) 637-3182

REPORT ON MANUFACTURES 1992

by Jerry Jasinowski
President, National Association of Manufacturers

May 1992

National Association of Manufacturers

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9202187
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: JASINOWSKI, JERRY: NATIONAL ASSOCIATION OF MANUFACTURERS

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/28/92

SUBJECT: ENCLOSED REPORT ON MANUFACTURERS, 1992

8/10 - Charlie, I'm returning the document for your perusal! Many

****

DIRECTORATE ASSIGNED: STAFF ASSIGNED:

ACTION REQUIRED: STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

****

COPIES TO: INDUSTRIAL
D. Allan Bromley

****

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:

REMARKS:

OSTP RECEIVED: 08/04/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

National Association
of Manufacturers

Jerry J. Jasinowski
President

July 28, 1992

Mr. Allan Bromley
Asst. to the President
The White House
1600 Pennsylvania Avenue, NW
Washington, DC 20500

Dear Mr. Bromley:

The enclosed "Report on Manufactures, 1992," marks the bicentennial of Alexander Hamilton's ground-breaking treatment of the subject and reaffirms his insight that manufacturing is at the heart of America's economic strength and national security.

Rather than being in decline, American manufacturing's strong performance in productivity growth, exports and quality improvements is the success story of recent years.

The report also documents, however, that manufacturing performance has been poor relative to historical and international benchmarks in the key areas of profits, the growth rate of industrial R&D spending and investment in equipment. These problems, in turn, are related to excessive Federal budget deficits and out-of-control regulatory and legal costs.

This type of information about U.S. manufacturing's real strengths and weaknesses is critical if business and government are to move forward with the pro-growth public policy agenda the nation needs.

That's why the administration -- pursuant to NAM's request -- has agreed to expand upon our "Report on Manufactures, 1992" with a more extensive study of the role of manufacturing in the U.S. economy. Commerce Secretary Barbara Franklin just informed me she will ask the Department's Economics and Statistics Administration to take on this exciting project, scheduled for completion in early 1993.

We all have much to learn about the ways manufacturing conveys economic benefits to the American people. I hope you will find NAM's "Report on Manufactures, 1992" a good first step. Please contact me directly if you have comments on the report, or wish to have more information about modern manufacturing.

Sincerely,

Jerry J. Jasinowski

1331 Pennsylvania Avenue, N.W.
Suite 1500 - North Tower
Washington, DC 20004-1703
(202) 637-3106
Fax: (202) 637-3182

REPORT ON MANUFACTURES 1992

by Jerry Jasinowski
President, National Association of Manufacturers

May 1992

National Association of Manufacturers

The President
The White House
Washington, D.C. 20500

Dear Mr. President:

It was two centuries ago that Alexander Hamilton, in his famous *Report on Manufactures*, pointed to the path whereby the United States was to attain wealth and power beyond the dreams of its founders:

> "Not only the wealth but the independence and safety of a country appear to be materially connected with the prosperity of manufactures."

These words are still true today. Manufacturing industries are still the foundation of America's economic strength and national security. As you recently said regarding our improved international competitiveness: "American manufacturing exports are leading the way."

Yet, as we mark the bicentennial of Hamilton's insight on manufacturing's importance to the economy, the nation's manufacturers believe it necessary for the government to inquire carefully into the current status of American manufacturing. We must have a clearer understanding of where we are in order to do better.

We are, therefore, requesting that the administration conduct such an inquiry to reduce controversy and misinformation regarding the health of American manufacturing, wrongly believed by many to be in decline, as well as to provide a factual foundation for examining the impact and adequacy of government policies affecting manufacturing.

To assist you in launching this effort, we are providing you with NAM's *Report on Manufactures, 1992*. While recognizing manufacturing's improved performance in certain areas, this report also acknowledges several structural problems that act as a brake on industrial expansion and economic growth.

Manufacturing performance has been strong in the following areas:

- The contribution to economic output comprised by value added in manufacturing has, over the past four decades, remained relatively stable at slightly more than a fifth of GNP, with no evidence of secular deindustrialization.

- In the manufacturing sector, the rate of productivity growth has been at least three times higher than in the rest of the economy. Further, the level of manufacturing productivity is still higher in the United States than in most other industrial countries, although faster productivity growth rates abroad have caused our advantage to narrow.

- Manufacturing's contribution to improved U.S. trade performance is remarkable. Merchandise exports have accelerated dramatically since 1987, growing at an average annual rate of 11 percent. During the 1990-91 recession, improvement in net exports reduced the severity of the economic contraction by about one-third. Clearly, manufacturing has demonstrated its ability to compete in the global marketplace.

Unfortunately, our report also shows that in some key respects manufacturing performance has been poor relative to historical and international benchmarks, with new government burdens and neglect likely to worsen this situation further:

- Manufacturing profit margins have undergone a significant decline over the past two decades, from 9.2 percent in the 1960s to 8.4 percent in the 1970s and 6.8 percent in the 1980s. Coupled with this compression of margins, higher leverage has further reduced the cash flow of manufacturing firms.

- At the same time, increasingly unnecessary regulatory costs constitute a mounting burden on manufacturing profits, employment and general performance. For example, estimates of industry's share of pollution abatement and control in 1991 range from a low of $61 billion to a high of $75 billion. Some estimates show that the cost of pollution abatement and control reduced economic growth by about 6 percent during the period 1972-90.

- While manufacturing's historical contribution to technological innovation has been enormous, since the mid-1980s the growth rate of industrial R&D spending has slowed due to depressed corporate cash flows. Such a slowdown implies a corresponding weakening in manufacturing's ability to innovate rapidly.

- While equipment investment by U.S. manufacturers has kept pace with historical rates, such investment has been lower, on average, than in other industrialized countries. In particular, the investment share of gross domestic product (GDP) in the United States is currently about one-third lower than in Japan.

We offer the findings of NAM's *Report on Manufactures, 1992* as a preliminary input for your own investigation into the state of American manufacturing. The full resources of the federal government can produce the more complete report we think is needed. We respectfully request that you direct the Secretary of Commerce to conduct a thorough analytical review of manufacturing and report the findings of this review to you by the end of this year.

Following such a report, we hope that you will establish an interagency review group to look into its findings and recommend government policies that would further strengthen manufacturing. Manufacturing is the most fundamental wealth-creating sector of the economy that provides the products and resources that enable the nation to improve its standard of living and fund its public activities. Some of NAM's preliminary recommendations along this line are summarized in the enclosed report.

Mr. President, America's manufacturers appreciate the leadership and support you have provided in the past in the matter of U.S. international competitiveness. We believe a report on manufacturing by your administration would prepare the way for even greater progress.

Sincerely,

Jerry J. Jasinowski

Jerry J. Jasinowski
President
National Association of Manufacturers

Dexter Baker

Dexter F. Baker
Chairman
National Association of Manufacturers
Chairman, Executive Committee
Air Products and Chemicals, Inc.

CONTENTS

Executive Summary i

1. Introduction 1

2. Deindustrialization and the Manufacturing Share of Output 2

3. Manufacturing at the Intermediate Stage 4

4. Manufacturing Productivity Growth 5

5. Productivity: International Comparisons 7

6. Manufacturing and Technology 9

7. Investment Flows in Manufacturing 11

8. Manufacturing and International Trade 13

9. Manufacturing and Price Stability 15

10. Regulatory Costs 16

11. Employment and Compensation 18

12. Profitability and Solvency 20

13. Internal Financial Structure 22

14. Conclusions 24

EXECUTIVE SUMMARY

THE MANUFACTURING SHARE OF GNP

While some commentators have issued warnings of deindustrialization, the ratio of output in manufacturing to GNP has remained stable over time. The reasons for this stability are obvious: Manufacturing generates increases in productivity and technology, which raises economic growth directly. The resulting growth in the rest of the economy generates the demand for manufactured goods. Hence, manufacturing and GNP will trend together over time, although industrial output is more cyclically volatile. A rise in the ratio of manufacturing to output would be possible in the event of a sustained rise in exports, enabling industrial output to grow on the larger scale of global demand. This actually took place in the late 1980s, when manufacturing reached a peak of 22.8 percent of GNP in 1988. At the same time, the manufacturing share of output will be under downward pressure as a result of the downsizing of the defense sector.

THE CONTRIBUTION OF MANUFACTURING AT THE INTERMEDIATE LEVEL

The role of manufacturing at the intermediate rather than the final sales level — *i.e.*, at the level of inputs that are netted out in the computation of GDP — is also considerable. Manufacturing comprises 37 percent of production at the intermediate stages. Its contribution to demand in other sectors can also be gauged at the intermediate level. Manufacturing demand for services constitutes 26.1 percent of total production of services at the intermediate stage. Industrial demand for total inputs constitutes 44.7 percent of all intermediate production. Industry's key role in intermediate production generates substantial employment and income gains in other industries which, in turn, raises output at the final sales level.

PRODUCTIVITY

In the manufacturing sector, the rate of labor productivity growth (output per man-hour) has been consistently higher than in the rest of the economy. For the period 1948-90, productivity rose by 2.8 percent per year in the manufacturing sector, compared with 1.8 percent annually in the nonfarm business sector. In 1979-90, this differential widened: Manufacturing productivity rose by 3.1 percent per year, compared with 1.0 percent annually in nonfarm business as a whole. The differential in growth rates was primarily attributable to faster increases in multifactor productivity, output per unit of capital and labor. In 1979-90, multifactor productivity rose by 2.4 percent per year in manufacturing, compared with 0.4 percent in nonfarm business. The causes of higher multifactor productivity growth in manufacturing have had to do with faster technological advance, as well as economies of scale and efficiencies in the use of labor and intermediate inputs.

The level of manufacturing productivity remains higher in the United States than in the other industrial countries, although faster productivity growth rates abroad have caused this gap to narrow. In labor productivity, Canada stands at 81 percent of the United States, followed by France, Germany and Italy, which range between 71 percent and 78 percent of the American level. Japan and the United Kingdom, which had the fastest rates of productivity growth during the 1980s, still have the lowest levels relative to the United States, ranging from 61 percent to 67 percent.

TECHNOLOGY

One way to measure the rate of technological advance is through R&D spending. The contribution of the manufacturing sector to technological advance has been considerable. On average, about 69 percent of total R&D performance takes place in private industry, with the remainder accounted for by universities, nonprofits and the government. Since the mid-1980s, the rate of growth in industrial R&D has decelerated due in large measure to depressed corporate liquidity and higher debt service costs. Such a slowdown implies a corresponding weakening in manufacturing's ability to innovate rapidly.

EQUIPMENT INVESTMENT

The recovery in manufacturing equipment investment in 1983-90 was only marginally slower than during prior postwar expansions, despite high interest rates and lower overall growth. It was enhanced by a combination of tax incentives and the decreasing relative price of computers, both of which lowered the user cost of capital. The investment share of output in the United States has, however, been lower on average than in the other industrial countries. In particular, the investment share of GDP in Japan rose to more than 30 percent in 1990, about 12 percentage points higher than in the United States.

INTERNATIONAL TRADE AND EXPORTS

Merchandise efforts have accelerated dramatically since 1987, growing at an average rate of 11.3 percent per year. During the last major period in which the exchange rate was low, 1978-80, exports rose at an annual rate of 9.0 percent. The balance on net exports of goods and services improved by $137 billion in constant 1987 dollars in 1986-91. Clearly, manufacturing has demonstrated its ability to compete effectively in international markets. The earlier trade deficits were largely a result of policy mistakes that overvalued the dollar. As the economy has slowed over the past few years, exports have provided an important source of countercyclical stimulus. Exports accounted for 35 percent of growth in 1988-89, and more than 80 percent in 1990. In the 1990-91 recession specifically, the improvement in net exports reduced the severity of the GDP contraction by about one-third.

RELATIVE INFLATION RATES

The rate of inflation in manufacturing has been consistently lower than in the service sector, by slightly less than 1 percentage point for the entire period from 1959 onward. This differential became especially pronounced in the 1980s, when inflation in services exceeded inflation in goods-producing sectors by more than 4 percentage points. This differential has been attributable to several factors, including the recovery in manufacturing productivity and the effects of high unemployment on manufacturing wages. This favorably affects consumers, who benefit from lower prices, but puts downward pressure on industrial profit margins.

REGULATORY COSTS

For the period 1972-89, on average 58.5 percent of outlays for pollution abatement and control (PAC) were spent by private industry. With the enactment of

the Clean Air Act amendments, pollution abatement spending is projected to increase by up to $50 billion per year in the early 1990s. Private-sector estimates place total PAC spending in current dollars at $129 billion in 1991. Estimates of the share of PAC paid by industry range from a low of $61 billion to a high of $75 billion. By the year 2000, total annual costs will approach $200 billion, with $117 billion paid by industry. Estimates of the impact of regulatory costs on the economy indicate that real GNP was depressed by up to 5.8 percent below the levels it would otherwise have attained during the period 1972-90.

EMPLOYMENT AND WAGES

Employment in manufacturing has fallen on average, with a loss of about 1.2 million jobs relative to the average for the 1970s. On the other hand, compensation has been consistently higher in manufacturing than in the private-business sector as a whole. Nevertheless, unit labor costs in the United States have declined relative to other countries. Finally, from an input point of view, unacceptable education and skill deficiencies characterize too much of the labor force.

PROFITABILITY AND SOLVENCY

The profit margin and rates of return on equity and assets in manufacturing were lower on average during the 1980s than during prior decades. In the 1980s, the profit margin averaged 6.79 percent, compared with 8.375 percent in the 1970s, 9.22 percent in the 1960s and 8.08 percent for the overall period 1957-90. The solvency of manufacturing corporations, as measured by the ratio of current assets to current liabilities, was lower on average in the 1980s than during any prior decade. The ratio of cash flow to assets also declined relative to the 1970s. The implication is that imposition of external costs on manufacturing, through regulation and mandated benefits, has reduced profit margins and would further weaken balance sheets at a time when they are already fragile.

FINANCIAL STRUCTURE

Since the late 1950s, the financial structure of American firms has shifted from equity to debt. The escalation in indebtedness was viewed in some circles as creating the preconditions for a financial crisis; in actual experience, however, it has operated more as a constraint on growth. The increase in leverage was particularly marked during the 1980s. The implication is that the tax code, which currently subsidizes debt financing, should treat debt and equity financing more equally.

QUALITY IN MANUFACTURING

The degree to which advanced technologies and processes have been introduced to the factory floor is an important indicator of the state of American manufacturing. A new report, "Technology on the Factory Floor," has been completed by Paul M. Swamidass, in cooperation with the National Association of Manufacturers. This April 1992 report examines the extent of manufacturing's implementation of many new technologies, including computer-aided design and "just-in-time" inventory management ,in far greater depth than possible in this report.

POLICY IMPLICATIONS

To boost the long-term growth of the industrial economy, a concerted strategy on both the demand and supply sides is necessary. On the demand side, consumption is likely to remain subnormal because of constrained consumer balance sheets. Consequently, a key element of boosting output will come from export expansion. This will involve keeping the exchange rate at levels consistent with continued export gains, as well as other policy measures. On the supply side, the economy's production function can be raised by raising investment in equipment, R&D and worker training.

More specifically —

(1) Macroeconomic policies should be made more stable. In particular, monetary policy should aim at keeping the economy on a path of stable growth with non-accelerating inflation. The fiscal deficit should be reduced to lower long-term interest rates, mitigate the crowding-out problem in credit markets and free resources for the private sector. Inasmuch as a more restrictive fiscal policy will hurt the defense industry in the near term, care should be taken to ensure an orderly transition to nondefense activities.

(2) The exchange rate should be set at a level consistent with sustained growth in exports. Other measures should be taken to raise exports, such as removal of existing legal barriers to exporting and negotiated reductions in nontariff barriers in foreign countries. Econometric simulations demonstrate that a 10 percent devaluation of the exchange rate, coupled with removal of current-law export controls, would raise exports by about 16 percent over a seven-year forecast horizon. The combined effect of higher exports and lower imports would raise real GDP by 1.47 percent above its path with no policy changes.

(3) Measures should be taken to stimulate additional capital formation. Reduction in the fiscal deficit will lower the cost of capital by reducing long-term interest rates. At the same time, investment tax measures should be considered. These include reform of the Alternative Minimum Tax and restoration of the investment tax credit (ITC). A 5 percent ITC for equipment would increase real business fixed investment by 5.4 percent over five years. Over the same time horizon, nonresidential fixed investment would increase by 7.5 percent and real GDP by 1.24 percent. Larger ITCs show correspondingly higher gains in real output.

(4) Measures should be taken to increase the rate of technological advance. In this respect, making the incremental R&D tax credit permanent will raise real R&D spending by upwards of $1 billion a year. Econometric simulations indicate that an annual increment of one-third in the rate of technological advance would raise real GDP by 2.45 percent above its current-law path over a nine-year time horizon.

(5) A comprehensive reform of the regulatory process should be undertaken, to reduce regulatory burdens and cut the costs of pollution abatement. Outdated regulations should be repealed. A regulatory budget, cost-benefit analysis and improved risk assessment should be part of a broad regulatory reform strategy. Further, business should be given greater flexibility in meeting environmental and workplace safety targets. Employee benefits such as health care should not be mandated, since this represents only an additional cost on the private sector.

(6) The primary education system in the United States must improve the quality of entrants to the manufacturing work force. Companies need to increase training to upgrade the skills and performance of existing workers.

1. INTRODUCTION

It was two centuries ago that Alexander Hamilton, in his famous *Report on Manufactures,* argued that both the wealth and military power of nations were materially connected with their specialization in manufacturing. In prior studies, we have made the case that this still holds true today, outlining a series of benefits pertaining both to economic growth and global political power that are associated with specialization in industry. In this paper, we present a more balanced picture of the strengths and weaknesses of manufacturing. While this overview encompasses many of the arguments as to the economic benefits of manufacturing, we do not maintain that the performance of manufacturing has been an unqualified success. In particular, we highlight some areas in which improvement is clearly warranted, if overall economic growth is to be improved.

Sections 2 through 11 focus for the most part on macroeconomic results: the share of gross output comprised by manufacturing, the demand for intermediate inputs implied by manufacturing growth, the growth of industrial productivity, investment, the rate of technological advance, performance in international trade, relative rates of inflation, and trends in employment and compensation. Sections 12 through 13 focus on microeconomic conditions: measures of profitability, solvency and financial structure.

2. DEINDUSTRIALIZATION AND THE MANUFACTURING SHARE OF OUTPUT

One thesis that was frequently advanced during the 1980s was that the United States was in a period of secular industrial decline; the phrase "deindustrialization" was often used. Advocates of the deindustrialization hypothesis alleged that factors such as import penetration and depressed manufacturing productivity in the late 1970s were symptoms of a chronic industrial deterioration. Empirically, however, this argument was undermined by the fact that the official statistics on the manufacturing share of output compiled by the Bureau of Economic Analysis (BEA) at the U.S. Department of Commerce consistently showed this ratio to be well within its postwar norms during the mid-1980s.

For this reason, some writers questioned the reliability of the BEA statistics, primarily on the grounds that the deflators used to compute real value added failed to take into account shifts in import prices. In response, the BEA substantially revised these statistics. The revisions demonstrated that changing the deflators had only a negligible effect, leaving the new values in the same range as those previously estimated.

Figure 1 presents the ratio of real value added in manufacturing to GNP for the period 1948-89, using the revised data. Because the rebasing of the national income accounts to constant 1987 dollars has not yet been completed for manufacturing, the data are expressed in constant 1982 dollars. The rebased data may affect the year-to-year movements in this ratio, but are unlikely to alter the fundamental implications.

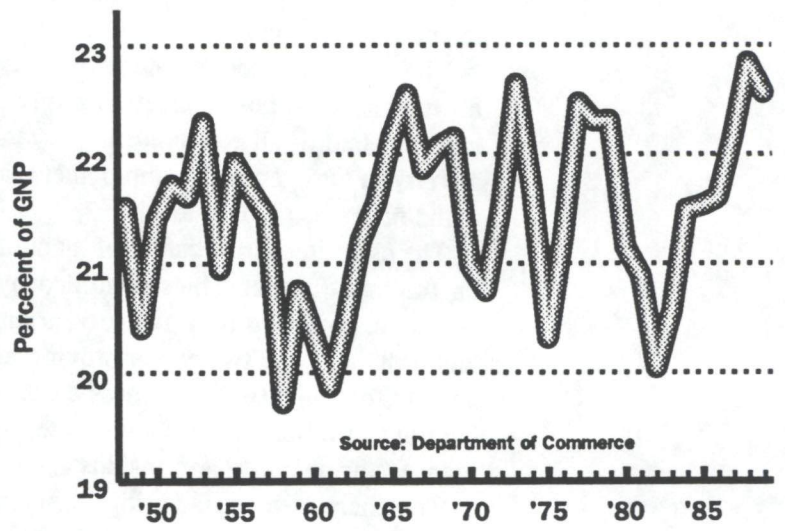
Figure 1 demonstrates that this ratio merely oscillates around its mean over the business cycle. Statistical tests indicate that it is completely trendless. The reasons why it should be trendless are readily apparent. Historically, manufacturing has generated the productivity increases and technological advances that are responsible for raising the production function of the economy as a whole. Simultaneously, the growth of the rest of the economy generates the employment and income which leads to increases in demand for manufactured goods. The result is that manufacturing and GNP will, on average, trend together over time.

Since industrial activity is more cyclically sensitive than services, the manufacturing share of output rises during periods of sustained expansion, while declining during recessionary episodes. Several phases are clearly visible. For instance, this ratio fell sharply in 1957-61, when two recessions occurred in a period of about four years. During the prolonged expansion of 1961-69, however, which lasted for more than eight years, this ratio rose to a new peak. The extraordinary cyclical volatility experienced during the next decade led to corresponding fluctuations in this ratio. Nevertheless, it is noteworthy that in the aftermath of the exceptionally deep 1974-75 recession, this ratio regained and then surpassed its previous peaks during the late 1970s.

The prolonged recessionary period of 1980-82, which witnessed two downturns in three years, drove down this ratio to its prior lows of 1958 and 1961. The slow pace of expansion during the 1980s meant that it did not recover as rapidly as during the previous decade. In fact, as the economy slowed in 1985-86, this ratio also leveled off below its previous peaks. But with the export boom of 1987-88, it actually achieved a new peak of 22.8 percent of GNP, although declining slightly the following year. In essence, there was no secular deindustrialization. There was only temporary weakness in this ratio during the period when the dollar was overvalued, and this was corrected later on.

The reasons for this peak in 1988 are significant: The low dollar led to a sustained boom in merchandise exports, which meant that the demand for manufactured goods became more dependent on worldwide economic growth rather than growth in the domestic economy alone. In this respect, it has been the historical dependence of the manufacturing sector on domestic demand that has been responsible for keeping its share of GNP approximately level. If this share is to increase in the 1990s, what would be required would be a shift in the source of demand toward the export sector, in which case manufacturing output would grow as a function of foreign as well as domestic activity.

FIGURE 1
RATIO, MANUFACTURING OUTPUT TO GNP, 1948-1989



One important finding from this analysis is that the health of manufacturing in general is closely connected to the cyclical performance of the economy. In this respect, numerous studies have noted that goods-producing industries are typically more vulnerable to cyclical fluctuations than service sectors. The implication is that policy makers should pay greater attention to smoothing out cyclical fluctuations in economic activity. The "boom and bust" cycles that characterized the economy during the decade from the early 1970s to the early 1980s were clearly inimical to manufacturing. While industry prospered during the reflationary boom periods, it was also forced to bear the brunt of the ensuing disinflationary recessions. An environment characterized by low inflation rates and stable growth would be more conducive to sustained industrial growth than a return to cyclical volatility. For this reason, fiscal and monetary policies should pay greater attention to smoothing out cyclical fluctuations.

3. MANUFACTURING AT THE INTERMEDIATE STAGE

Another aspect of the importance of manufacturing in the economy has to do with its role at the intermediate stages of production. Because this may not be familiar to noneconomists, some explanation is in order. GNP or the now-preferred measure, Gross Domestic Product (GDP) is not a total production concept but a value-added concept, which is measured at the stage of final demand. All intermediate inputs to production are netted out in the calculation of GDP. In other words, value-added is conceptually equal to total spending, less all purchases of intermediate inputs. This becomes clearer when it is borne in mind that GDP is defined as the sum of consumption expenditures, business fixed investment, government purchases and net exports; none of these categories include intermediates.

The fact that intermediate activity is netted out in the computation of GDP, however, should not be taken to imply that it is irrelevant. On average, slightly less than half of all economic activity takes place at the intermediate level. This activity in turn generates employment and spending, which contributes to output at the final sales (GDP) level.

The estimated contribution of manufacturing at the intermediate stage is based on the input-output tables compiled by the Department of Commerce. These tables are compiled only at five-year intervals; the most recent data are for 1987 and 1982. These two years provide a useful basis for comparison since they depict the trough of the business cycle and a state of relatively high capacity utilization; in other words, they define a parametric range for the contribution of manufacturing during expansions and recessionary periods.

The share of manufacturing in intermediate activity came to 37.1 percent of all intermediate use in 1982 and 41.9 percent in 1987. This increase is consistent with the evidence presented in Figure 1 demonstrating a rising manufacturing share at the peak of the cycle.

The demand for service inputs by manufacturing, as a share of total service use at the intermediate level, came to 21.8 percent in 1982 and 26.1 percent in 1987.

The demand for all intermediates by manufacturing, as a share of total intermediate use, came to 46.3 percent in 1982 and 44.7 percent in 1987. The fact that the use of intermediates by manufacturing went down slightly, despite the fact that manufacturing production rose as a share of output, is surprising. The most likely explanation has to do with rising efficiency in the use of inputs. This finding is consistent with the evidence of large increases in multifactor productivity in manufacturing in the 1980s, as detailed in chapter four.

4. MANUFACTURING PRODUCTIVITY GROWTH

Another way of accounting for growth at the final sales (GDP) level is through productivity, the ratio of output to labor. Table 1 presents productivity data for manufacturing and private nonfarm business, averaged over the business cycle.

Over time, productivity growth has been consistently higher in manufacturing. Stated another way, total growth in manufacturing has been based more on increases in output per manhour, while growth in overall nonfarm output has been based more on additions of labor. In 1948-90, the growth rate of labor productivity in manufacturing averaged 2.8 percent per year, compared with 1.8 percent in private nonfarm business.

Perhaps the most notable development in 1979-90 has been the revival in manufacturing productivity, which accelerated to 3.1 percent per year, above its prior historical trend of 2.9 percent over the 1948-73 period. Further, the disparity between manufacturing and the rest of the economy grew during the 1980s: In 1979-90, productivity grew by only 1.0 percent in nonfarm business at a whole.

TABLE 1:
GROWTH IN LABOR AND MULTIFACTOR PRODUCTIVITY, 1948-90

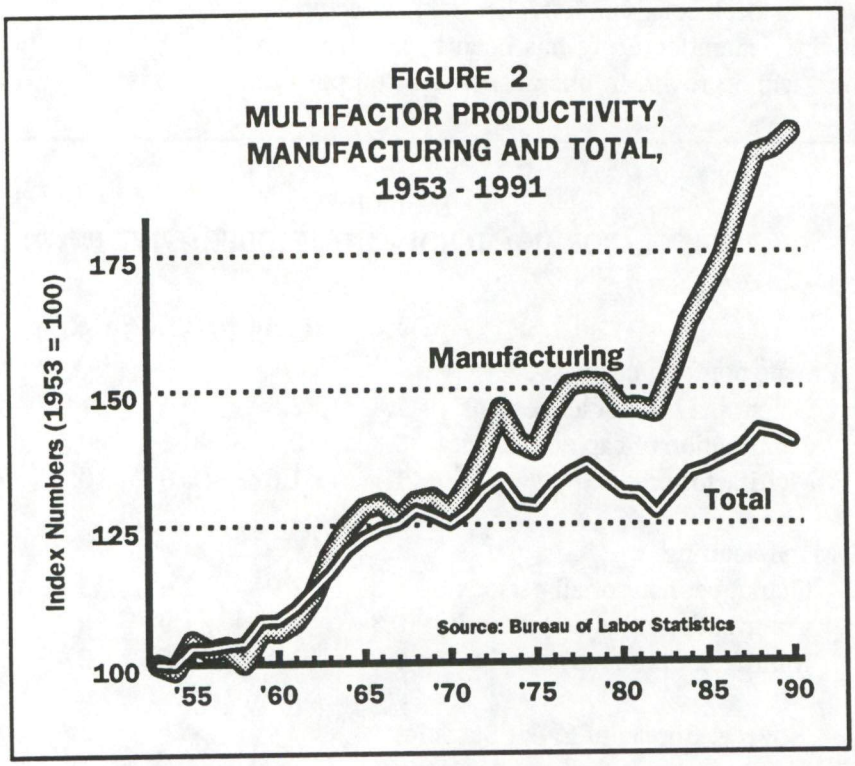
	1948-90	1948-73	1973-79	1979-90
Private nonfarm business				
Output per hour of all persons	1.8	2.5	0.6	1.0
Contribution of capital intensity	0.8	0.9	0.6	0.5
Multifactor productivity	1.1	1.6	0.0	0.4
Manufacturing				
Output per hour of all persons	2.8	2.9	1.4	3.1
Contribution of capital intensity	0.8	0.8	1.0	0.7
Multifactor productivity	2.0	2.1	0.5	2.4

Source: Bureau of Labor Statistics

In accounting for the differential between productivity in manufacturing and aggregate nonfarm output, it is interesting to note that the rise in capital intensity has been identical in both sectors. The differential, therefore, cannot be explained by faster gains in capital investment. Instead, it is accounted for by multifactor productivity (output per unit of labor and capital). In manufacturing, this grew by 2.4 percent per year in 1979-90, compared with 0.4 percent in nonfarm business. Figure 2, which shows the index of multifactor productivity (benchmarked in the early 1950s) in both sectors, clearly indicates that in the 1980s, the disparity widened appreciably.

Because multifactor productivity is a residual term, *i.e.*, it is output less inputs of capital and labor, it can be influenced by any number of factors. The prevailing interpretation is that it is determined mainly by technological advance. In fact, in many econometric models, it has been common to approximate techno-

logical advance by fitting a linear trend to multifactor productivity. More recent studies have attempted to disaggregate multifactor productivity into its various components either by analyzing correlations with empirical measures of technological advance, such as R&D spending, or directly measuring other components such as economies of scale. To date, this issue remains unresolved. While it is understood that technological advance comprises a major share of growth in multifactor productivity, other important influences include greater efficiency in the use of labor and intermediate inputs, and returns to scale, *i.e.*, increases in output per unit of input associated with concentration of the productive structure and market deepening.



The most important explanations for the surge in multifactor productivity during the 1980s have to do with decreased labor inputs. A secondary cause was greater efficiency in the use of intermediate inputs, which resulted in part from the decline in the relative price of many intermediate materials during the disinflationary conditions of the 1980s. Since the growth of the R&D stock actually slowed in the 1980s, it is difficult to attribute the rise in multifactor productivity to technological advance at this time. Nevertheless, some studies have recently argued that other factors such as increased computerization led to an unobserved increase in technological advance; this has been based on correlations between the growth rate of investment in computers and the growth of multifactor productivity. Because of the overall historic importance of technological advance in accounting for multifactor productivity, however, the growth of industrial R&D spending is examined in greater detail later in this report.

5. PRODUCTIVITY: INTERNATIONAL COMPARISONS

It is also of interest to examine the productivity performance of the United States relative to the leading industrial countries. Since productivity is measured as an index, it can normally be compared across national boundaries only in rate of change form. Recently, however, new data from the Organization for Economic Cooperation and Development (OECD) has made it possible to compare productivity in levels, using purchasing power parities. Table 2 presents the OECD data for the seven largest industrial nations.

As Table 2 indicates, despite widely publicized data showing that productivity growth rates have been higher in most of the other industrial countries, the level of productivity in the United States remains substantially higher. As of 1988, the most recent year for which data are available, productivity in Canada stood at 81 percent of the United States, followed by France, Germany and Italy, which range between 71 percent and 78 percent of the American level. Japan and the United Kingdom, which experienced the fastest growth rates of productivity during the 1980s, still had the lowest levels relative to the United States. It should be noted, however, that the gap has steadily declined. For instance, between 1970 and 1988, Japan moved from 40 percent to 69 percent of the American level.

TABLE 2:
LABOR PRODUCTIVITY LEVELS FOR THE TOTAL ECONOMY, 1950-88

	1970	1973	1975	1979	1985	1988
Canada	75	77	77	79	80	81
France	55	59	62	69	70	74
Germany	56	58	60	67	69	71
Italy	57	60	61	69	70	74
Japan	40	46	47	55	64	69
UK	NA	54	53	56	60	64
USA	100	100	100	100	100	100

Source: OECD

Since these statistics refer to aggregate labor productivity, it is also of interest to compare the results for multifactor productivity in the manufacturing sector. Here, the OECD data do not permit comparison in levels for all the industrial countries. Germany and Japan are shown individually, while the remaining industrial nations are aggregated into a single category. Further, these statistics permit greater detail by sector. Table 3 shows the comparisons.

In the manufacturing sector as a whole, Japan has achieved the greatest progress relative to the United States. Its level of multifactor productivity has risen to 91 percent of the American level. In basic metals and chemicals, Japan is significantly higher than in the United States. In machinery and equipment, Japan has almost pulled even with the United States. But in sectors such as nometallic minerals, printing, food and textiles, as well as other industries, Japan

ranks significantly behind the United States. The level of industrial productivity in Germany and the other industrial nations has remained significantly lower than both Japan and the United States. as of 1988, multifactor productivity in German manufacturing stood at only 62 percent of the American level, while in the other industrial countries, it stood at 59 percent.

TABLE 3:
MULTIFACTOR PRODUCTIVITY LEVELS BY MAJOR SECTOR AND INDUSTRY, 1970-88

	MFP Relative to U.S., 1988 (Index number, with U.S. =100)			Gain in Relative MFP, 1970-88		
	Japan	Germany	Other	Japan	Germany	Other
Total Economy	85	78	81	1.39	1.19	1.20
All Manufacturing	91	62	59	1.80	1.19	1.29
Basic Metals	193	64	72	2.04	1.15	1.28
Chemicals	147	69	68	1.98	1.21	1.64
Nonmetallic Minerals	65	63	64	0.91	1.21	1.26
Medium Industries						
Machinery & Equip.	93	53	55	2.65	1.13	1.29
Paper, Printing, Publishing	66	61	67	1.11	1.11	1.18
Food Beverages, Tobacco	50	58	64	0.62	0.99	1.20
Textiles	50	59	60	1.44	1.21	1.22
Other Industries	59	38	40	1.15	0.90	1.12

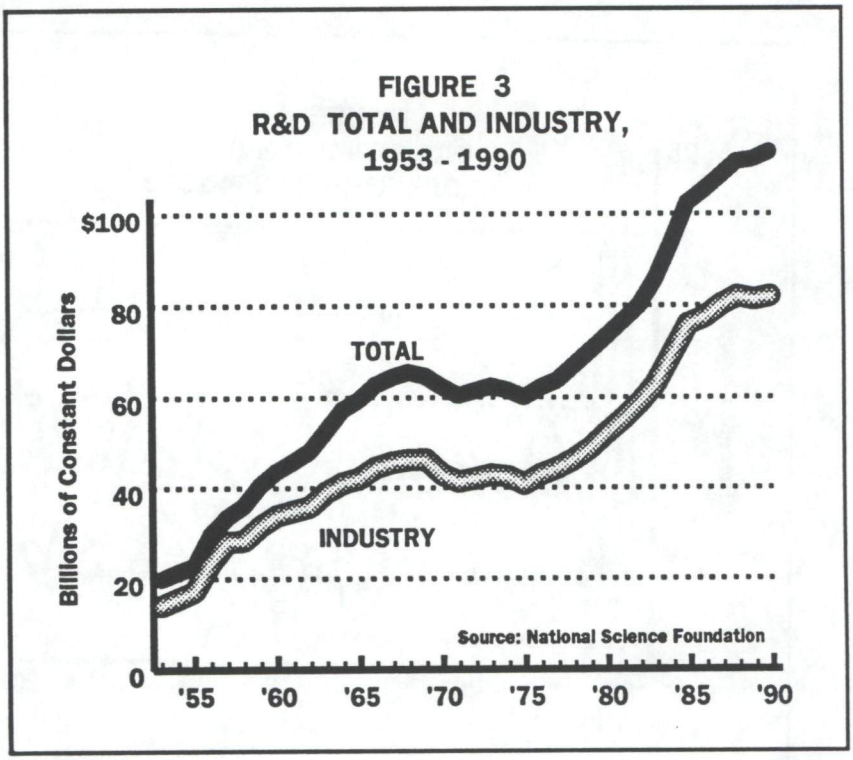
In sum, the United States has retained the highest absolute level of labor and multifactor productivity among the seven largest industrial countries. It has been overtaken, however, by Japan in particular industries. It continues to enjoy levels of productivity that are significantly higher than those in Western Europe.

Nevertheless, in terms of rates of change, the performance of the United States has been only in the mid-range of the industrial countries, although better than some commentators have suggested. For instance, in the period 1982-90, the cumulative increase in manufacturing productivity in the United States was 36.6 percent. Three countries achieved larger increases in 1982-90: the United Kingdom (45.1 percent), Italy (38.8 percent) and Japan (38.1 percent). During this period, however, the performance in the United States was still superior to France (27.7 percent) Germany (24.8 percent) and Canada (21.2 percent).

6. MANUFACTURING AND TECHNOLOGY

One measure of technological advance that is empirically quantifiable is expenditure for R&D. Several studies have indicated that R&D is reasonably well correlated with the trend in multifactor productivity growth, suggesting that the two are measuring (or at least proxying for) the same process.

Figure 3 presents the historical data on R&D performance spending in constant dollars. There is no standard series for R&D spending in the national income accounts; these data are compiled by the National Science Foundation. The upper line is total R&D, which includes performance by universities, nonprofits and the government. The lower line is R&D spending in private industry, which is defined a bit more broadly than manufacturing, *i.e.*, it includes mining and telecommunications. On average, 95 percent of industrial R&D spending takes place in the manufacturing sector.

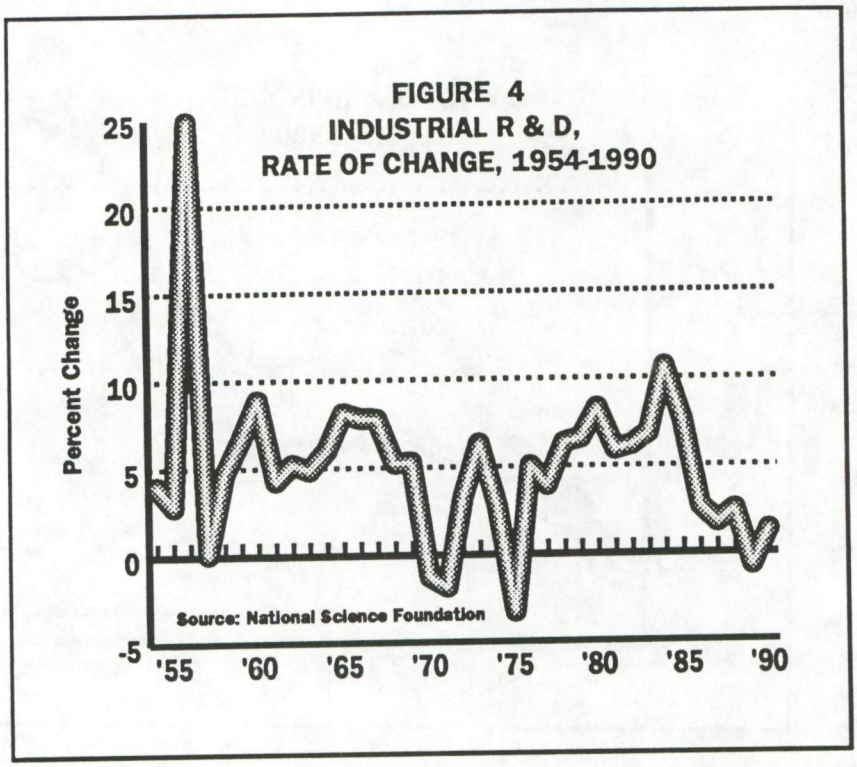


What this graph clearly shows is that a large component of total R&D activity was performed in industry; the mean value for 1953-90 is 69 percent. This does, of course, include research funded by the federal government, which is carried out by private industry. Nevertheless, measured in terms of funds originating rather than actual performance spending, private industry still accounts for just under 50 percent of R&D. This graph also indicates some unusual trends in terms of historical rates of change. Unlike aggregate private output and its components, industrial R&D exhibits long swings that are not highly correlated with the business cycle. For instance, rapid increases were visible in 1953-66 and 1976-83, with an extended period of decline in 1968-75 and a deceleration in the late 1980s.

This pattern of irregular cycles that are not closely correlated with the conventional business cycle is even more apparent in Figure 4, which shows the annual rate of change. Apart from some anomalous spikes (the early 1950s) and troughs (the early 1970s), the average rate of change in R&D spending seems to have

undergone four main phases, with the demarcation dates as noted above. The recent decrease in R&D from the early 1980s onward may, however, reflect a series of causal factors that did not come into play on prior occasions. As the sequel will demonstrate, profit margins in manufacturing were lower than average during the 1980s, while leverage tended to increase and the ratio of cash flow to assets decreased. The combination of depressed liquidity and higher debt service costs may have diverted funds away from R&D spending.

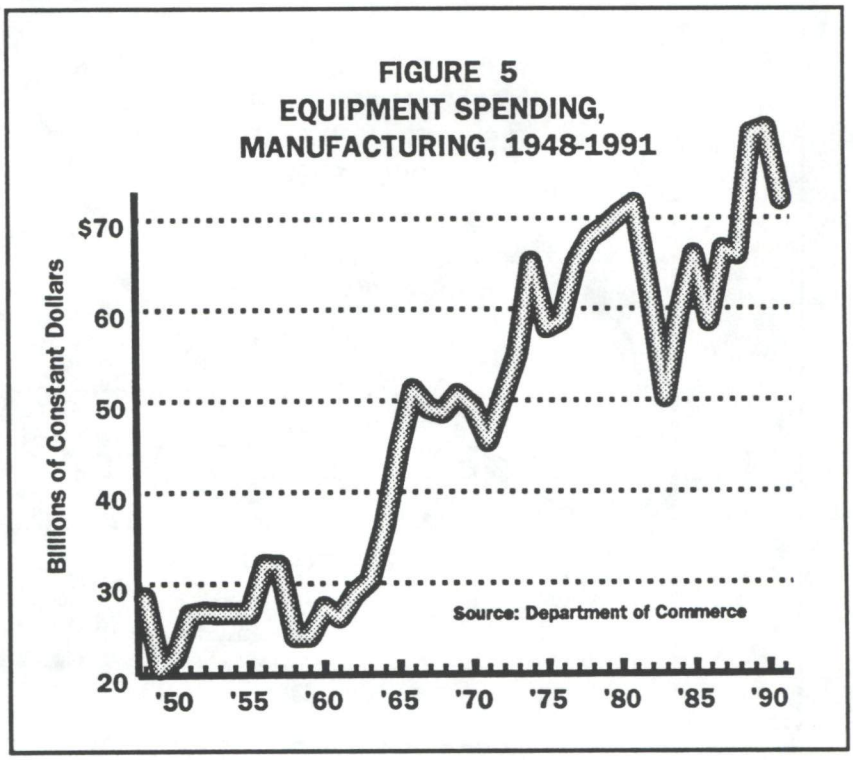
The implications are unfavorable. A slowdown in the rate of R&D spending implies a corresponding slowdown in the rate of technological advance. This implies a slowdown in the economy's potential growth rate. A major policy concern in the 1990s, therefore, will be to achieve an acceleration in the rate of R&D growth. At the very least, the R&D tax credit enacted in 1981 should be retained. Calculations at NAM indicate that it has raised annual R&D spending by about $1 billion per year since its enactment.



To gauge the effects of an increase in the rate of technological advance on economic growth, NAM conducted an econometric simulation using the Washington University macromodel. The model approximates technological advance by fitting a statistical trend to multifactor productivity. In the baseline simulation, multifactor productivity is assumed to rise by 0.92 percent per year, in the 1990s, which would represent a small advance from recent historical trends. In the simulation, the rate of multifactor productivity growth is gradually raised to 1.25 percent over three years and is then held at this level until the end of the decade. In the simulated counterfactual path, GDP gradually diverges above its baseline path and, at the end of the forecast horizon, it is 2.45 percent higher in constant dollars. On a national income accounts basis, all the improvement comes in the form of higher domestic spending. Because the rise in output comes on the supply side in the form of additional technological advance rather than labor inputs, the effects on employment are small; this is, of course, to be expected. Technology (here expressed as multifactor productivity) originates primarily in the manufacturing sector, which generates high value added, but relatively small increases in employment. Hence, the effects of faster technological advance show up primarily in GDP rather than jobs.

7. INVESTMENT FLOWS IN MANUFACTURING

While Table 1 reported the average change in capital intensity in manufacturing over several business cycles, there is some interest in also looking at an investment flow concept: equipment spending. Investment in equipment has been accorded a higher role in the long-term growth process in some studies, primarily because a component of technological advance is embodied in changes in the quality of equipment. Figure 5 reports spending for producer durables in the manufacturing sector, in billions of constant 1987 dollars.



The most rapid increases occurred during the early 1960s and, subsequently, in 1971-73. The contraction during the 1980-82 recessionary period was deeper than during any prior downturn, leaving equipment investment well below its level at the trough of the 1974-75 recession. The recovery in 1983-90 witnessed a rapid rebound, although some of this can be interpreted as a reaction to the depth of the cyclical downturn.

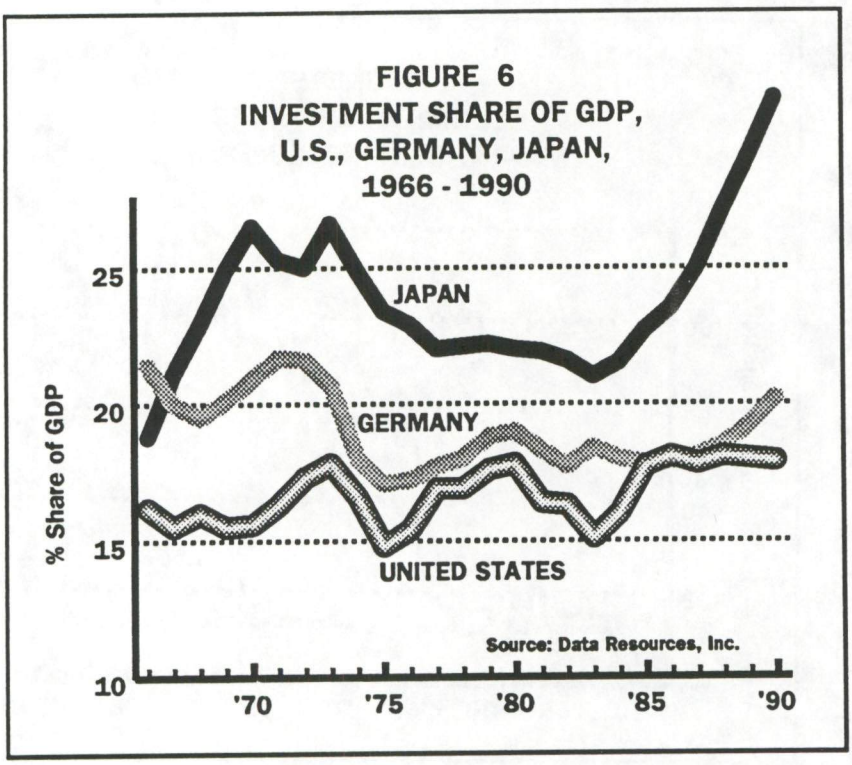
The contribution of tax policy may also have been significant. From 1981, with the passage of the Economic Recovery Tax Act, through 1986, with the passage of the Tax Reform Act, the United States enjoyed one of the most favorable tax treatments of capital investment among the industrial countries, due to the combination of accelerated depreciation and the investment tax credit (ITC). On average, equipment investment is estimated to have been about 25 percent higher as a result of these tax incentives than it otherwise would have been.

The increase achieved during the 1983-90 period also reflects the decreasing relative price of computers. According to BEA estimates, the deflator for computers decreased by about 15 percent since the late 1970s, and this may actually understate the decrease in relative prices associated with qualitative improvements in information processing. In sum, the recovery in equipment investment in 1983-90 is well-characterized as reflecting a combination of tax incentives and relative price changes, both of which worked to lower user cost of capital.

The implication is that tax incentives for investment should be restored, preferably through an investment tax credit. A 5 percent ITC for equipment would increase real business fixed investment by 5.4 percent over five years. Over the same time horizon, nonresidential fixed investment would increase by 7.5 percent and real GDP by 1.24 percent. Larger ITCs show correspondingly higher gains in real output.

Further, the ITC should be applicable against the Alternative Minimum Tax (AMT). At the very least, the AMT should be modified to remove some of its existing disincentives to investment.

It is also of interest to compare investment flows across national boundaries. Figure 6 shows gross and net private investment as a share of GDP in the United States, Germany and Japan for selected years. Historically, the United States and England have lagged behind Germany and Japan in the private investment share of GDP. In 1984-90, the investment share in the United States was in the same general range as in Germany, although still below Japan.

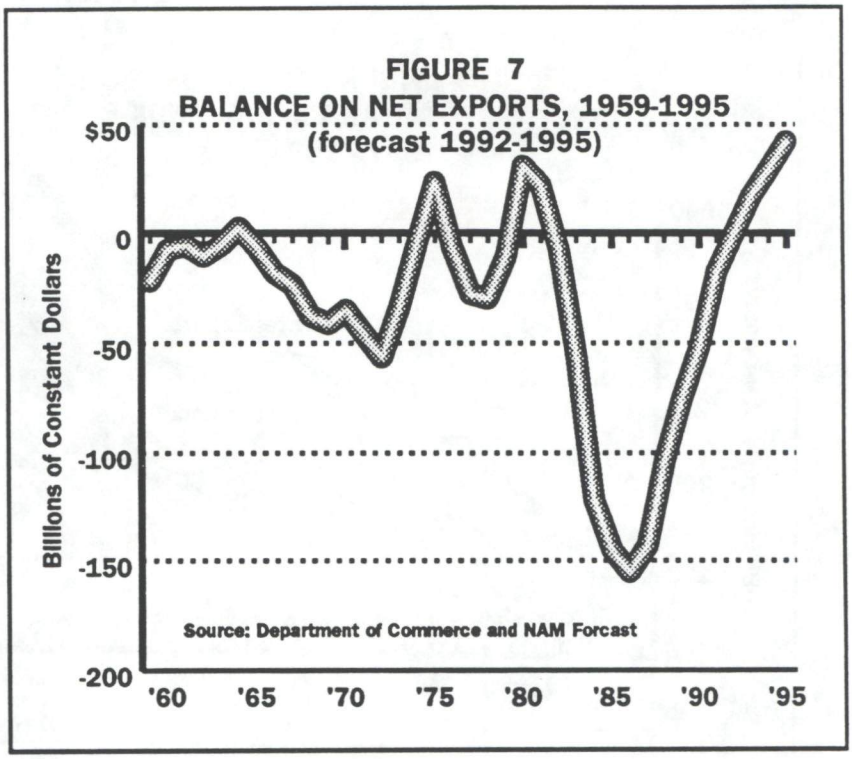


It should be borne in mind here that the investment flow data do not measure capital intensity. Since capital inputs to the production function are measured using the flow of services from the capital stock, the productivity comparisons in levels demonstrate that the United States is more capital-intensive in most industries than its competitors. Instead, the interpretation of the investment flow data is that if the share of GDP comprised by business fixed investment remains consistently higher in other countries, the United States will eventually be overtaken in capital intensity.

8. MANUFACTURING AND INTERNATIONAL TRADE

The merchandise trade balance and the growth rate of manufactured exports have also gone through several distinct cycles during the postwar period. Unlike productivity and capital investment, these have not coincided with the conventionally defined business cycle but, instead, have been dependent more on changes in the exchange rate and in global demand.

More specifically, the Bretton Woods fixed exchange rate regime in force from 1946 to 1971 led to the dollar being overvalued relative to purchasing power parity from the late 1950s onward, which delayed the emergence of the United States as a major industrial exporter. Subsequently, the unusually high real interest rates associated with large fiscal deficits led to a massive appreciation of the dollar in 1981-86. During both periods of overvaluation, the relative price of American tradables in world markets was sufficiently unfavorable that exports stagnated while imports tended to displace domestic production, generating large deficits in net exports (Figure 7). This was particularly dramatic during the past decade. The combination of an overvalued dollar and policies that stimulated rapid growth in demand in the United States led to the largest trade deficits ever recorded — both in constant dollars and as a share of GDP — in the early 1980s.

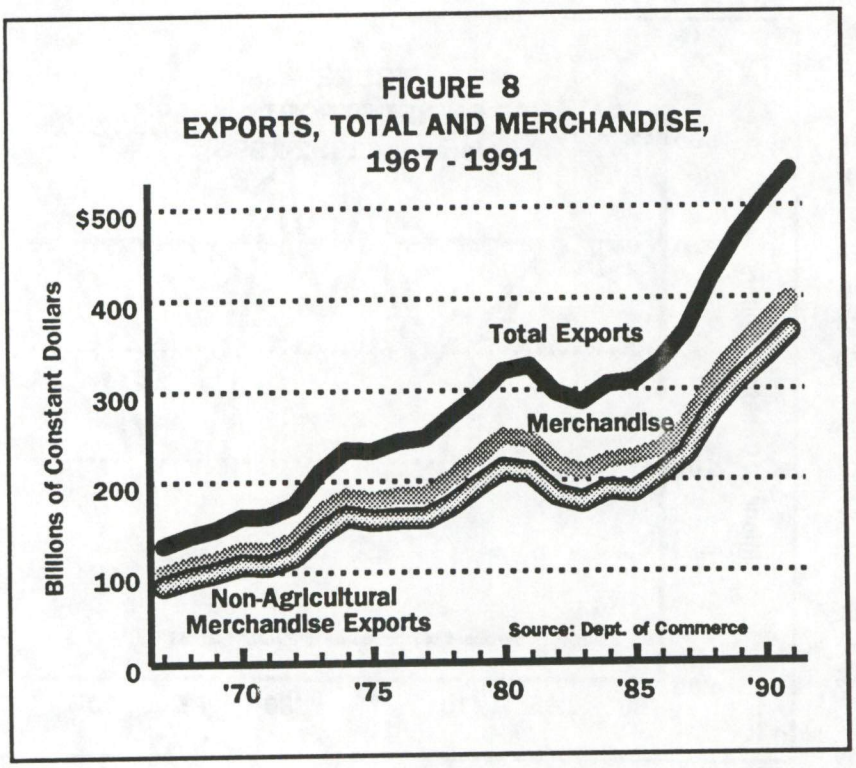


Nevertheless, when the dollar was allowed to fall to more realistic levels, as it was in 1973, 1978-80 and 1987-91, the trade imbalance was invariably reversed. In each instance, export booms followed these devaluations, in 1974, 1978-80 and 1988-90. Once the dollar was brought down, in 1985-87, improvement in the net export deficit was as dramatic as the earlier deterioration (see Figure 7).

It is not generally recognized that in the aftermath of the widely publicized trade deficits of the early 1980s, substantial progress has been made on the trade side. Since the devaluation of the dollar in 1987, exports have boomed. In 1987-91, exports grew at an average rate of 11.3 percent per year. During the last major period in which the exchange rate was low, 1978-80, exports rose at an annual rate

of 9.0 percent. The balance on net exports of goods and services improved by $137 billion in constant 1987 dollars in 1986-91. Clearly, manufacturing has demonstrated its ability to compete effectively in international markets. The earlier trade deficits were largely a result of policy mistakes that overvalued the dollar.

As the economy has slowed over the past few years, exports have provided an important source of countercyclical stimulus. Exports accounted for 35 percent of growth in 1988-89 and more than 80 percent in 1990. In the 1990-91 recession specifically, when GDP fell by some $75 billion, net exports improved by just over $47 billion. In other words, without the improvement in trade, GDP would have declined by at least $122 billion, and probably much more since the trade gains helped maintain domestic employment and spending.



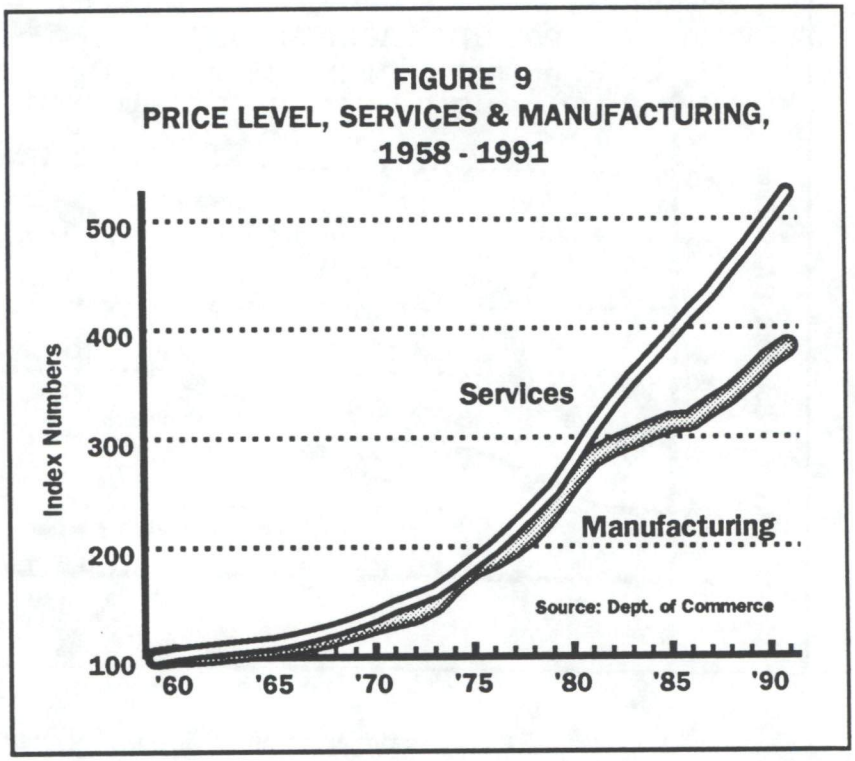
It is also interesting to note that on an accounting basis, exports of nonagricultural merchandise — manufactured goods — comprise about 65 percent of total exports. The upper line of Figure 8 gives total exports of goods and services in constant 1987 dollars. The next line gives merchandise exports and the third line gives exports of nonagricultural merchandise.

At the current time, the dollar exchange rate remains favorable to the United States. The sluggishness of domestic demand growth during the period since 1989 has also worked in favor of the trade improvement, by suppressing demand for imports and inducing industrialists to shift toward foreign markets. The improvement has temporarily been held back by slow growth overseas, but this should be reversed as the European economies emerge from their current slowdown and achieve a normal cyclical recovery. For this reason, Figure 7 includes a forecast of the net export deficit through 1995, computed using the Washington University Macromodel. The forecast projects that with only moderately favorable assumptions about the exchange rate and trade, the United States will achieve a large surplus on net exports by the middle part of the decade.

During the 1990s as a whole, the United States should continue to benefit from the low dollar and should probably be able to raise its exports somewhat more rapidly than the other industrial countries. This will, in turn, largely offset the anticipated slower growth rate of consumption spending. Consequently, the ability to compete effectively in export markets will be critical in maintaining industrial growth in the 1990s.

9. MANUFACTURING AND PRICE STABILITY

A fact that has received considerable recent attention in the debate over the monetary policy is that inflation rates have tended to be lower in manufacturing than in services, particularly since the 1980s. Figure 9 shows the price level in services and goods-producing industries for the period 1959-91, with the indexes normalized to a common benchmark in 1959. The overall inflation rate for goods-producing industries is a weighted average of the implicit deflators for durables and nondurables published by BEA.

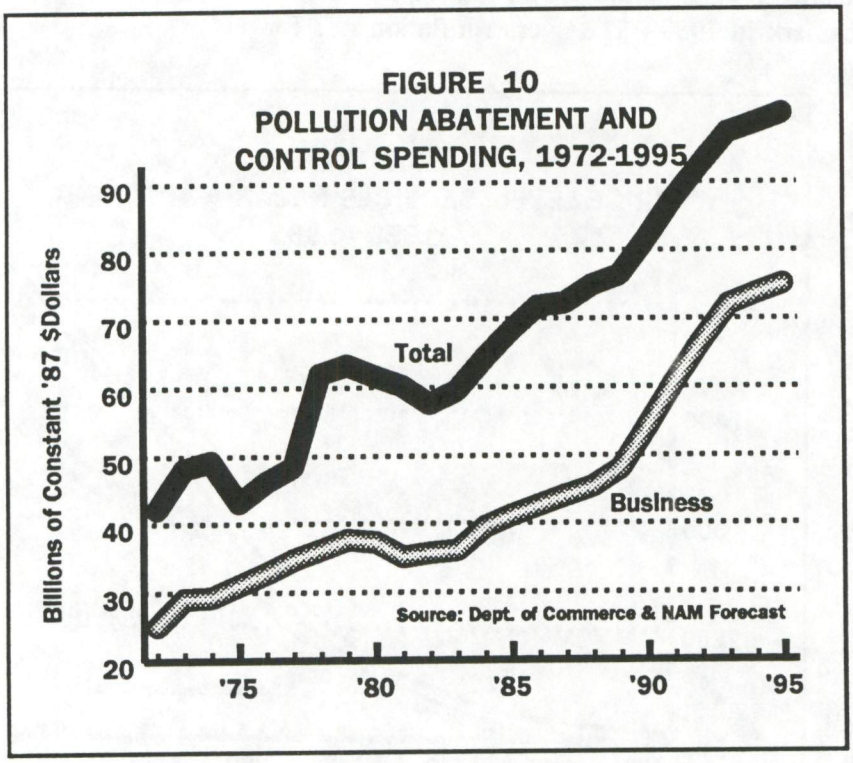


The price levels tended to roughly parallel each other until 1981. Starting in 1981, however, the price paths diverged sharply, with services rising much more rapidly than manufacturing. The differential between these two inflation rates increased from an average of 1 percentage point for the entire period to an average of more than four percentage points in 1981-91.

The lower inflation rate in manufacturing should be viewed primarily as a reflection of three factors. First, higher productivity growth rates depressed wage costs. Second, higher job losses during the 1980-82 recessionary period created greater unemployment among manufacturing workers, putting downward pressure on wages through Phillips Curve mechanisms. Third, services are largely autarkic, while manufacturing is subject to import competition. The overvaluation of the dollar during the early 1980s caused lower import prices to be arbitraged into the sale prices of domestically produced goods that competed with imports. The implications of this development are rather ambiguous. Since real output is by definition nominal output less inflation, the lower rate of inflation implies higher real activity. At the same time, however, this puts downward pressure on industrial profit margins. The constraint on profit margins is one of the factors responsible for lower industrial employment in the 1980s, since increases in costs cannot be absorbed in the form of lower margins, but, instead, must be shifted back to labor merely to keep margins at their current, rather narrow levels.

10. REGULATORY COSTS

The major regulatory costs faced by the manufacturing sector have to do with the environment (pollution abatement and control) and workplace safety. Data on the impact of OSHA regulations are not readily available; some private estimates, still unpublished as of the time of this paper, have gauged the cost of implementing OSHA regulations as being in the area of $30 billion per year.



The BEA has published a constant dollar time series for pollution abatement and control (PAC) expenditures for the period 1972-89, and this will shortly be updated to reflect more recent developments and recomputed to constant 1987 dollars. Based on the BEA numbers, of total PAC spending over the period 1972-89, 58.5 percent on average has been spent by private industry.

NAM projected the cost of PAC out to 1995 as follows. First, it was assumed that the cost of implementing the Clean Air Act amendments will increase by up to $50 billion per year, in current dollars. This assumption was used to project the BEA series in nominal dollars. The implicit deflator for PAC was projected out to 1995. The entire nominal dollar series was then converted to constant 1987 dollars using the projected deflator. The results are depicted in Figure 10. The upper series is total PAC expenditure by business, consumers and the public sector; the lower line is expenditure by business alone. These data do not specifically distinguish between manufacturing and other business activity, although most of the spending can be assumed to take place in industrial rather than service-oriented activities.

A second set of estimates of the cost of pollution abatement has been constructed by Management Information Services, using the BEA data but applying somewhat different definitions. These data, in constant 1991 dollars, including forecasts out to the year 2005, are given in Table 4. The cost of PAC is estimated at $129 billion in 1991, reaching $194 billion by the year 2000. The contributions of business specifically would be in the area of $75 billion and $117 billion in 1991 and 2000 respectively. Note that these numbers do not correspond with those in Figure 10 because the deflators are benchmarked at different dates. Specifically, in 1991, the NAM forecast of the BEA estimate is in the area of $61

billion. This range, from $61 to $75 billion, can be interpreted as the upper and lower boundary for pollution abatement and control spending.

Several studies have been conducted on the cost of regulation to the economy. Analysis of the productivity slowdown during the 1970s concluded that increased regulatory costs played a role; estimates run using the Data Resources model concluded that PAC spending subtracted 0.3 to 0.5 percentage points per year from productivity growth during the period 1973-79.

TABLE 4:
HISTORICAL AND FORECAST POLLUTION ABATEMENT AND CONTROL SPENDING, 1970-2005

(billions of 1991 dollars)

	1970	1975	1980	1985	1991	1995	2000	2005
Pollution Abatement & Control, Total	22.8	44.2	69.5	88.8	129.0	160.1	194.9	240.4
Air Pollution Control	6.6	13.1	21.1	27.9	34.8	44.9	55.2	72.7
Radiation Pollution Control	.1	.2	.2	.2	.5	.7	1.0	1.4
Water Pollution Contro	17.8	18.1	29.6	39.7	53.6	64.2	76.9	90.4
Land Pollution Control	8.0	11.7	16.3	19.0	35.7	44.5	55.3	67.1
Chemical Pollution Control	.8	.2	1.0	.9	2.2	2.9	3.4	4.4
Multi-Media Pollution Control	9	.7	1.0	.8	2.3	2.5	2.7	3.1

Source: Management Information Services, Inc.

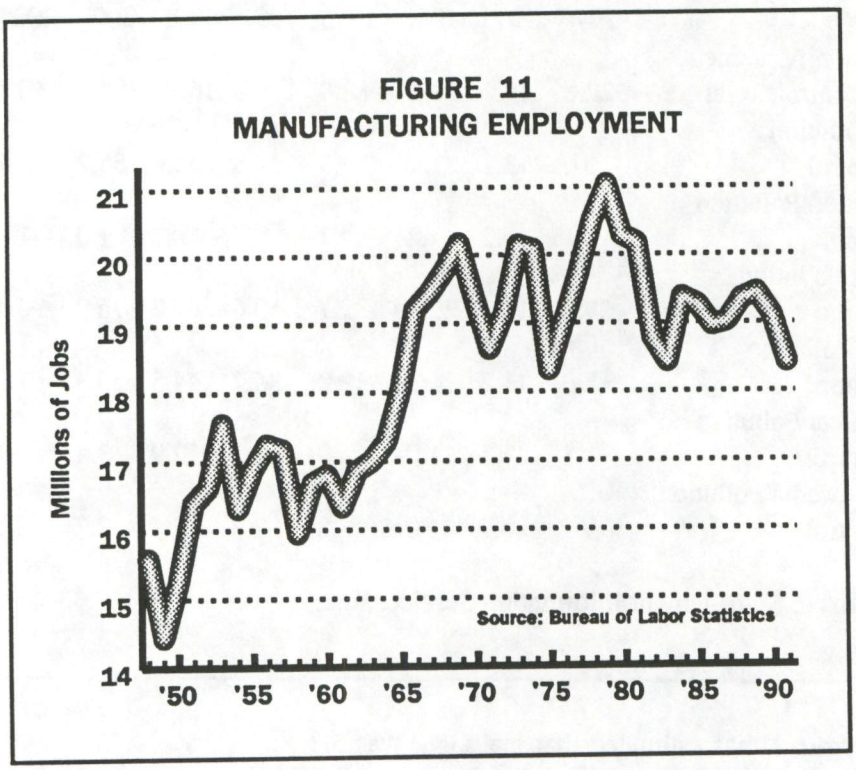
Recent academic studies by Jorgenson and Wilcoxen *(see footnote1)* have quantified the cost of regulation in terms of lost output. Jorgenson and Wilcoxen find that over the period 1970-85 the cost of PAC spending lowered real GNP by 2.6 percent, relative to the levels it would otherwise have attained. A study by Hazilla and Kopp *(see footnote 2)* has estimated that real GNP was 5.8 percent lower in 1990 than it would have been as a result of environmental regulations. Because these two studies differ as to the magnitude of the output loss, they can be thought of as defining a parametric boundary for the effect of actual PAC expenditures. Even the indirect costs of PAC in terms of lost output, however, may understate its total effect inasmuch as they do not measure lost economic opportunities resulting from regulatory barriers or, stated another way, industrial activity that never took place because it was deterred by environmental regulation.

Footnotes: 1. Dale W. Jorgenson and Peter J. Wilcoxen, "Impact of Environmental Legislation on U.S. Economic Growth, Investment, and Capital Costs" in American Council for Capital Formation, *U.S. Environmental Policy and Economic Growth: How Do We Fare?* ACCF Monograph Series on Tax and Environmental Policies and Economic Growth. Washington, D.C., 1992.

2. Michael Hazilla and Raymond Kopp, "The Social Cost of Environmental Quality Regulation: A General Equilibrium Analysis" in *Journal of Political Economy*, Volume 98, #4, August 1990, pp.

11. EMPLOYMENT AND COMPENSATION

The obverse of the high rate of productivity growth in manufacturing has been a decrease in labor inputs during the 1980s. As Figure 11 indicates, manufacturing employment underwent two major periods of increase, in 1961-69 and 1975-79, achieving a peak of 21.0 million. It then dropped to 18.4 million in the wake of the 1980-82 recessionary period. By 1989, it had recovered to only 19.4 million and, in 1991, in the wake of the 1990-91 recession, it had again declined to 18.4 million. This placed it about 1.2 million below the average levels of the 1970s. The only parallel in the postwar experience took place in the 1950s. After a rapid rise in jobs during the Korean War boom, the number of manufacturing jobs declined on average from 1953 until 1961.



The lower level of manufacturing employment in the 1980s was caused by two factors, the business cycle and the trade deficit. Specifically, successive downturns in the business cycle were responsible for the actual job losses, and pressure from import competition during the subsequent expansion prevented the jobs from being regained. Similarly, during the period 1953-61, the decline in industrial employment was a direct result of the fact that three recessions occurred in eight years. The implication is that the decline in manufacturing employment was not a result of gratuitous layoffs to maximize profits or a manifestation of class warfare by management against labor. Rather, it was a result of deep recessions caused by the earlier buildup in inflationary pressures and by policy mistakes such as the overvaluation of the dollar.

Even making reasonably sanguine assumptions about the future growth rate of the economy in the 1990s, however, it appears unlikely that most of the job losses will be regained. The need to cut costs in order to remain competitive has forced manufacturers to keep payrolls low. Increases in regulatory and other costs will have to be passed back in the form of reduced spending on other inputs, such as labor. Mandated benefits such as health care will increase costs

inputs, such as labor. Mandated benefits such as health care will increase costs per worker, creating additional disincentives for employment. Even if continuous growth at a trend rate of 2.6 percent per year is assumed out to the year 2000 (an optimistic assumption), the implied increase in manufacturing employment would be only in the range of 1.1 million by the end of the decade.

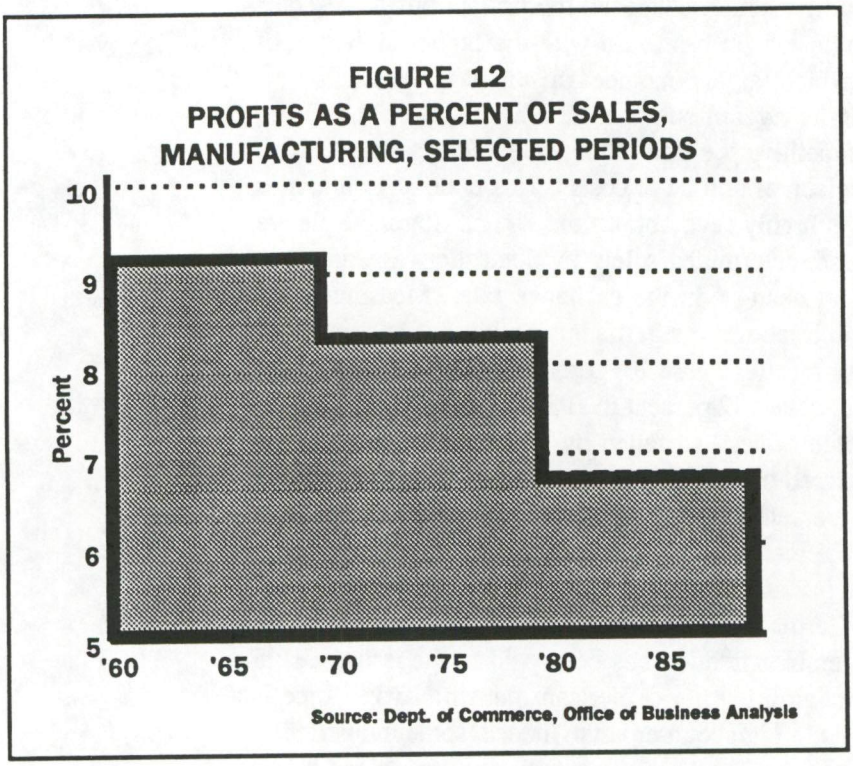
Compensation in manufacturing has, in general, been somewhat higher than wages in other industries. On average, manufacturing wages have been about 7 percent higher than in the nonfarm business economy. The figures for total compensation indicate a higher differential. Total compensation in manufacturing exceeded the private business sector average by 17.7 percent in 1960, falling gradually to 10.7 percent in 1973, before rebounding to 17.3 percent in 1979. As of 1991, total manufacturing compensation exceeded the private business sector average by 15 percent. The main reason has to do with the higher skill-mix of the manufacturing work force, which largely excludes unskilled workers.

It should be noted that the higher level of compensation has not been associated with any deterioration in the competitive position of the United States *vis-a-vis* foreign countries. In fact, a comparison of unit labor costs across national boundaries demonstrates that the situation is highly favorable to the United States. Relative unit labor costs are not, of course, determined solely by domestic wage and productivity trends, but rather reflect changes in the exchange rate. Measured on a dollar basis, American relative unit labor costs in manufacturing fell 15 percent in 1973-1979, when the exchange rate fell; rose 37 percent in 1980-85 when the exchange rate appreciated; and declined 42 percent in 1986-90. As of 1990, manufacturing labor costs in the United States had fallen by 32 percent relative to the other industrial countries. Measured on a national currency basis, unit labor costs in manufacturing decreased 4.5 percent in the United States in 1982-90. This was a bit better than in Japan (-3.5 percent), and significantly better than in Canada (+21.6 percent percent), France (+22.6 percent), the United Kingdom (+26.1 percent), Italy (+51.4 percent) and Germany (+17 percent).

In the past few years, considerable attention has been paid to the issue of skill levels, with some studies maintaining that the American industrial work force is inadequately trained relative to its foreign counterparts. Indeed, some industrialists have complained of an inability to find workers with adequate training and skills, even during periods of slack in labor markets. In the production function, the contribution of labor can be disaggregated into the increase in hours and the effect of skill levels, that can be approximated using wage differentials. Some estimates have suggested that about one-fourth of the total labor input to production reflects increases in labor force quality, and this percentage is likely to be higher in manufacturing. Assuming this to be the case, a major priority for industrialists in the coming decade will be to invest in education and work-force training. The use of the term investment emphasizes that this expenditure may be thought of as a means of accumulating human capital, which may, in turn, generate spill-overs in terms of productive efficiency. Further, greater investment in education by state and local governments, with a particular emphasis on science, math and engineering skills, may also generate substantial long-term benefits for manufacturing.

12. PROFITABILITY AND SOLVENCY

The profit margin (net income/net sales) measures the percent of profit per sales dollar. As Figure 12 indicates, profitability has declined over time. After peaking in the mid-1960s at more than 10 percent, profitability fell in the 1970s, and declined again in the 1980s, remaining much lower on average than in any of the previous decades. Over the past five years, the profit margin has been only 6.5 percent. In the 1980s, the profit margin averaged 6.79 percent, compared with 8.37 percent in the 1970s, 9.22 percent in the 1960s and 8.08 percent for the overall period 1957-90.



The decrease in manufacturing profit margins is notable if, for no other reason, because it highlights the cash squeeze confronted by industrial firms in the current economic environment. It is also noteworthy because the public has tended, on average, to overestimate the profitability of industrial corporations. Some comparisons are, therefore, in order. As of 1988, the pre-tax current dollar profits of manufacturing corporations peaked at $117.5 billion, before declining to $82 billion in 1991. These rather meager numbers should be compared with the regulatory costs faced by industry — a range of $61 to 75 billion in 1991, and with health care costs, approximately $60 billion in 1991 — merely in order to illustrate the degree to which manufacturers are not likely to be able to absorb additional increases in costs.

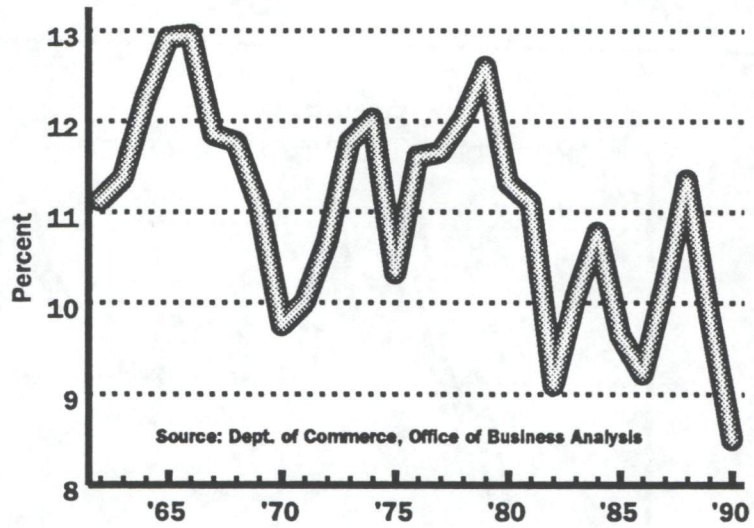
Another interesting comparison is provided by the ratio of profits in manufacturing to the total profits of business corporations. This ratio averaged 48 percent in the 1960s, 41 percent in the 1970s and 34 percent in the 1980s. In other words, the observed compression in manufacturing profit margins is paralleled by a corresponding decline in the ratio of industrial to total profits.

The diminution in profitability has also been accompanied by a decrease in solvency. One measure is the ratio of cash flow to total assets (net income after tax plus depreciation / total assets), shown in Figure 13. This measure typically peaks during the middle-to-late years of the business cycle, while

declining during periods of slow growth. The periods of high cash flow occur during the mid-1960s and late 1970s; in the 1980s, cash flow is lower on average relative to total assets.

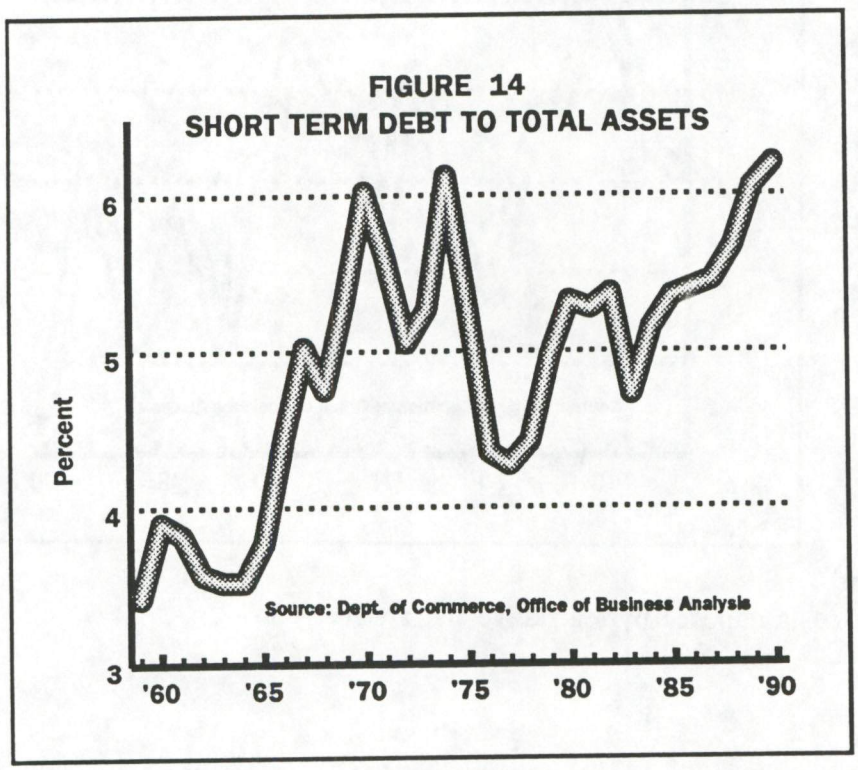
The implications of the decline in profitability and solvency lie primarily with the effects that would result from current legislation imposing additional costs on business. In addition to regulatory costs, a case in point has to do with current attempts to mandate health care benefits for workers. In theory, corporations can respond to an increase in costs by passing it through to prices, absorbing it in the form of lower profit margins, or shifting it back in the form of reductions in labor inputs. At the current time, passing costs forward to prices is effectively precluded by competition from imports. Sustaining decreased profit margins at a time when profitability is already at a postwar low is also impossible. Under the circumstances, the only way to deal with cost increases will be to shift them backward. The result is that mandated benefits and other costs imposed by legislative fiat are likely to result in decreased employment.

FIGURE 13
RATIO, CASH FLOW TO ASSETS



13. INTERNAL FINANCIAL STRUCTURE

A further notable development during the 1980s has been the increasing leveraging of corporations. Figure 14 presents the ratio of short-term debt to total assets. This ratio rose rapidly from the late 1950s to the early 1970s, reaching peaks during the 1969-70 and 1974-75 recessionary periods. A major reliquification occurred during the mid-1970s. Short-term debt, therefore, began to rise again in the late 1970s, due to expectations of higher inflation. Although some further reliquification took place in 1983-84 due to the strength of the initial recovery, indebtedness rose sharply during the mid- to late 1980s and, as of 1991, had surpassed its previous peak.



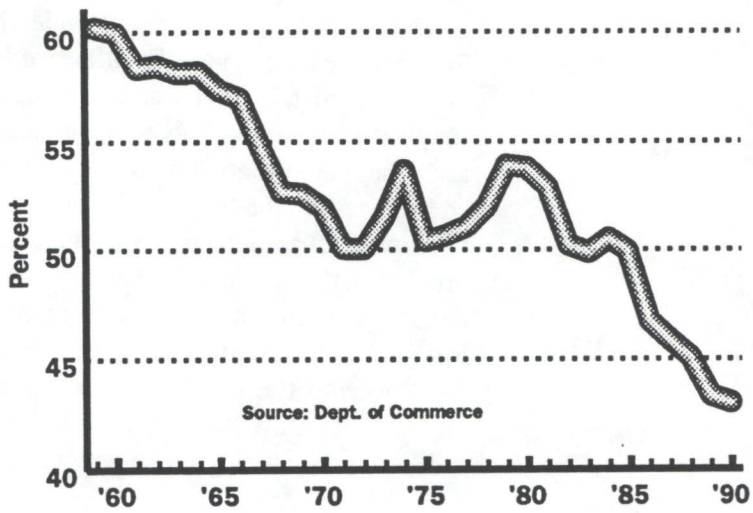
Several other ratios show parallel developments. The ratio of long-term debt to total assets shows a more gradual increase, but nonetheless points to increasing indebtedness culminating in the late 1980s, when the debt/assets ratio was roughly twice its level of 1965. The ratio of debt to equity also increases consistently, by a factor of more than 300 percent since the late 1950s. By comparison, the ratio of equity to total assets declines consistently, from more than 67 percent in the late 1950s to only 40 percent at the end of the 1980s. Other measures confirm this trend toward leverage. The ratio of liabilities to assets has approximately doubled since the late 1950s. The ratio of liabilities to equity, which measures the relationship of debt to equity financing, has risen by almost 300 percent since the 1950s, and by almost 50 percent in the 1980s alone. The structure of debt has, however, been weighted primarily toward long-term rather than short-term obligations. Figure 15 presents the ratio of current to total liabilities, which indicates that reliance on short-term as opposed to long-term debt has decreased by about 50 percent.

The implications have been widely regarded as unfavorable. Some authors have warned that the increase in indebtedness was creating the preconditions for a financial crisis, similar to the "debt deflations" that accompanied the depression of the 1930s and prior depressions in the late 19th century. These

warnings now appear to have been overstated. Other studies, however, have concluded that high debt loads constitute a constraint on long-term growth. In this respect, the recent trend toward paying down of debt and restoration of equity financing is likely to be a favorable one for the performance of the economy in the 1990s.

One way in which the problem of excessive reliance on debt financing can be addressed is through the tax code. At the current time, the tax treatment of debt and equity is grossly unequal. Because of the double taxation of corporate income — once at the firm level and once at the investor level — the effective tax rate on equity financing may be considerably higher than the statutory rates applied to corporate profits and payments of dividends and capital gains. By comparison, the effective tax rate on debt, may under certain circumstances, be negative.

FIGURE 15
RATIO, CURRENT TO TOTAL LIABILITIES, 1959-1990



While this disparity has sometimes impelled efforts to equalize the tax treatment of equity and debt by limiting the deductibility of interest payments, this approach is also inequitable inasmuch as payments of interest represent a normal cost of doing business, particularly for small firms that depend more on loans and do not have access to national equity markets. Consequently, one approach would be to allow corporations to deduct payments of dividends from their taxable income. It would also be possible to mitigate double taxation by exempting dividends received by stockholders from taxation, but this would not affect financial decisions at the firm level. Allowing dividend deductibility could radically shift the financing of American corporations from debt to equity and, in this sense, go quite far in restoring greater solvency.

14. CONCLUSIONS

The major strengths in the recent performance of manufacturing include the cyclical upturn in its share of total output during the late 1980s, the export boom from 1987 onward that followed the devaluation of the dollar and the sustained rise in productivity. Given the fact that productivity growth in manufacturing was higher than many of the other large industrial countries, it appears likely that the United States will continue to enjoy the highest absolute level of productivity of the advanced economies.

The prognosis in areas such as technology and capital investment is less certain. Technological advance will continue to be held back by high debt loads, depressed profitability and the scheduled expiration of the R&D tax credit. Investment spending has been depressed by the extended period of slow growth in 1989-92 and by the deletion of the ITC from the tax code. Policy makers can significantly boost technological advance and capital investment by restoring the R&D credit and the ITC.

The employment situation in manufacturing remains depressed. The blame for job losses, however, should properly be laid not on industry itself, but rather on policy mistakes such as the overvaluation of the dollar in the early 1980s. Employment is also likely to be reduced in the 1990s in the event that health care and other benefits are legally mandated, since these additional costs will be shifted backward in the form of diminished labor inputs.

Additional arguments against mandated benefits can be found in the depressed profitability and solvency of manufacturing corporations. With cash flow already poor, industry is not in a position to easily absorb a new round of regulatory and benefit cost increases. Regulatory costs have already been responsible for lowering the level of output below the levels it would otherwise have attained. Finally, the increased indebtedness of manufacturing firms could be reduced by equalizing the treatment of equity and debt in the tax code.

National Association of Manufacturers
1331 Pennsylvania Avenue, NW
Suite 1500 - North Tower
Washington, DC 20004 -1703
(202) 637-3108

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9202188
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS
****

FROM: MCCULLOUGH, E.J.: THE UNIVERSITY OF ARIZONA

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/14/92

SUBJECT: LETTER REGARDING FEDERAL FUNDING FOR THE UNIVERSITY AND DEPARTMENTAL COMMENTS.

****

DIRECTORATE ASSIGNED:

STAFF ASSIGNED:

ACTION REQUIRED:

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE:

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
INDUSTRIAL

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 08/04/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

2188

College of Arts and Sciences
Faculty of Science
Office of the Dean

THE UNIVERSITY OF
ARIZONA
TUCSON ARIZONA

Gould-Simpson 1025
Tucson, Arizona 85721
(602) 621-4090

July 14, 1992

Dr. D. Allan Bromley
Assistant to the President
for Science and Technology
Executive Office of the President
The White House
Washington, DC

RECEIVED
92 JUL 30 A8:
OSTP
MAIL ROOM

Dear Dr. Bromley:

Your letter to President Pacheco was referred to us, among others, due to the large amount of federal funding in Science and our extensive contacts with federal agencies. I have passed it on to our departments for their comments and possible attendance at the scheduled public meetings. Here I would like to add some comments primarily from an administrative point of view.

In general: University funding is obviously a major problem with state government being hard pressed all across the country. Part of the problem is simply lack of funds. Part of it, however, especially universities taking larger cuts than other state agencies, reflects a crisis in faith about public universities. Among other things, the public perceives research universities as bloated, over-administered, high-overhead operations. The Arizona legislature, for instance, referred to one major cut as a performance incentive adjustment. Unfortunately, the large and increasing effort we spend on federal paperwork and preparing for federal audits, effort not spent on getting the job done, supports this perception.

We must make the federal-university relationship a more cooperative, less burdensome one with fewer mandates, more flexibility and requirements with clearer purpose. Now, accounting is becoming an increasing problem as:

a. Accounting requirements on trivial amounts are far more expensive in overhead than any possible recoveries or probabilities of losses.

b. A21 interpretation at this university is probably technically correct but discourages the sharing of equipment and encourages redundant capital purchases on both state and federal accounts. The wastage the policy should prevent is offset by inefficiencies and the overhead of complying with regulations. For instance, this university has made establishing *operating cost* auxiliaries that would encourage sharing of equipment so burdensome that we have virtually given up. Why? We are told that is the only way they can ensure compliance with A21.

c. Federal policy may not actually require some of this burden. The recent enthusiasm of auditors to make their mark a la Stanford has our university accountants scared of their own shadows. The result is a policy mind-set driven by the intention of *never* having a disallowance rather than on getting the job done. The problem in

arguing the point is that federal policy is sufficiently arcane that academics do not win in internal debates on these issues.

In short, policy must be simpler and clearer with a clear statement of purpose. There should be a provision that encourages universities to request what may look like exceptions to the accountants but are simply common sense if you are trying to economize on resources.

A different issue is indirect policies have the perverse effect of rewarding those that have a large funding base or are inefficient. The more you spend, the more you get. This biases the process away from both efficiency and from new, rapidly growing institutions that have not developed a strong funding base. ICR policies ought to reflect not just what you actually spend but also the output per unit of input. This would encourage efficiency and support those that are stretched to the limit.

Point 3: The more basic research is, the more speculative it is. There is a strong bias at the state level towards immediate payback projects. Federal programs offset this to the extent they take a longer term approach. Equally important, however, is the need for a national articulation of the need for and nature of basic research and the payoffs of such research.

Point 4: National data on institutions receiving support and other information on standing and performance would be valuable in clarifying performance issues and planning. This is something that national agencies are uniquely able to provide almost in passing and that it is costly and burdensome for universities to provide on their own. We would do a much better job of fighting the PR battles if the government would provide more of the intellectual ammunition.

Point 8: National data on graduates by discipline has been extremely useful to us in adding realism to the debates on recruiting and clarifying the need for addressing pipeline issues. Funding of undergraduates on research grants has been a powerful tool here and I hope such funding increases. In addition to special programs, special needs should be funded heavily with add-ons to regular grants. This reduces overhead and ties activities to your best people.

Sincerely,

E. J. McCullough, Jr.
Dean, Faculty of Science

EJM:j\t\j\pcast

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9202108
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: HUGHES, KENT: COUNCIL ON COMPETITIVENESS

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/13/92

SUBJECT: ENCLOSED REPORT REGARDING THE "CAPITAL CHOICES: CHANGING THE WAY AMERICA INVESTS IN INDUSTRY."

****

DIRECTORATE ASSIGNED:

STAFF ASSIGNED:

ACTION REQUIRED:

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE:

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: INDUSTRIAL
D. Allan Bromley

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 07/27/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

2108

CHAIRMAN
George M. C. Fisher
Motorola, Inc.
VICE CHAIRMEN
Thomas E. Everhart
California Institute of Technology
Howard D. Samuel
Industrial Union Department, AFL-CIO
Henry B. Schacht
Cummins Engine Company, Inc.
EXECUTIVE COMMITTEE
John F. Akers
International Business Machines Corporation
Paul Allaire
Xerox Corporation
John L. Clendenin
BellSouth Corporation
Joseph Duffey
American University
Earl Graves
Black Enterprise Magazine
Jerry Jasinowski
National Association of Manufacturers
Peter Likins
Lehigh University
Thomas J. Murrin
Duquesne University
Michael Porter
School of Business Administration, Harvard University
Carl E. Reichardt
Wells Fargo & Co.
James J. Renier
Honeywell, Inc.
Ian Ross
AT&T Bell Laboratories
Roland W. Schmitt
Rensselaer Polytechnic Institute
Albert Shanker
American Federation of Teachers, AFL-CIO
Jack Sheinkman
Amalgamated Clothing and Textile Workers Union, AFL-CIO, CLC
Ray Stata
Analog Devices, Inc.
Charles M. Vest
Massachusetts Institute of Technology
Arnold Weber
Northwestern University
A.D. Welliver
The Boeing Company
Lynn R. Williams
United Steel Workers of America, AFL-CIO, CLC
John A. Young
Hewlett-Packard Company
PRESIDENT
Kent H. Hughes
EXECUTIVE VICE PRESIDENT
Daniel F. Burton, Jr.
DISTINGUISHED FELLOW
Erich Bloch
SENIOR ADVISOR
B. R. Inman
NATIONAL AFFILIATES
American Assembly of Collegiate Schools of Business
American Association for the Advancement of Science
American Business Conference
American Council for Capital Formation
American Council on Education
American Electronics Association
American Enterprise Institute
American Management Association
American Productivity and Quality Center
American Society for Training and Development
Association of American Universities
Business - Higher Education Forum
Center for Strategic and International Studies
Committee for Economic Development
Council on Research and Technology
Economic Policy Institute
Health Industry Manufacturers Association
IC² Institute
Industrial Research Institute, Inc.
Labor-Industry Coalition for International Trade
National Alliance of Business
National Association of Manufacturers
National Association of State Universities & Land-Grant Colleges
National Association of Wholesaler-Distributors
National Center for Manufacturing Sciences
National Planning Association
Pharmaceutical Manufacturers Association
Semiconductor Industry Association
The Aspen Institute
The Association for Manufacturing Technology
The Brookings Institution
The Conference Board
The Institute of Electrical and Electronics Engineers - U.S. Activities

Council on Competitiveness

July 13, 1992

Dr. D. Allan Bromley
Assistant to the President and Director of the
Office of Science and Technology Policy
Old Executive Office Building
Washington, DC 20506

Dear Allan:

Please find enclosed a final printed copy of the report *Capital Choices: Changing the Way America Invests in Industry*. As you may know, the report enjoyed a successful release at our press conference on Thursday, June 25th and was the subject of a full committee Senate Banking Hearing on Friday, June 26th.

RECEIVED

The enclosed report is the culmination of a two-year, large-scale research project on U.S. corporate investment that the Council on Competitiveness and the Harvard Business School commissioned. *Capital Choices* was written by Professor Michael Porter, who directed the project's research. The report is both a synthesis of the project and also includes extensive additional research and analysis by Michael Porter. The Council's Executive Committee has expressed strong support of the research contained in this project and is urging that both the public and private sector carefully study the recommendations contained within the synthesis report.

The Council will be following the debate produced by the report and will be working to develop a consensus on the report's policy recommendations. The Council itself will be pursuing a number of activities related to the project, including a series of conferences in the Fall and Winter of this year.

I can be reached at (202) 785-3990, should you or your staff have any questions or comments about the report.

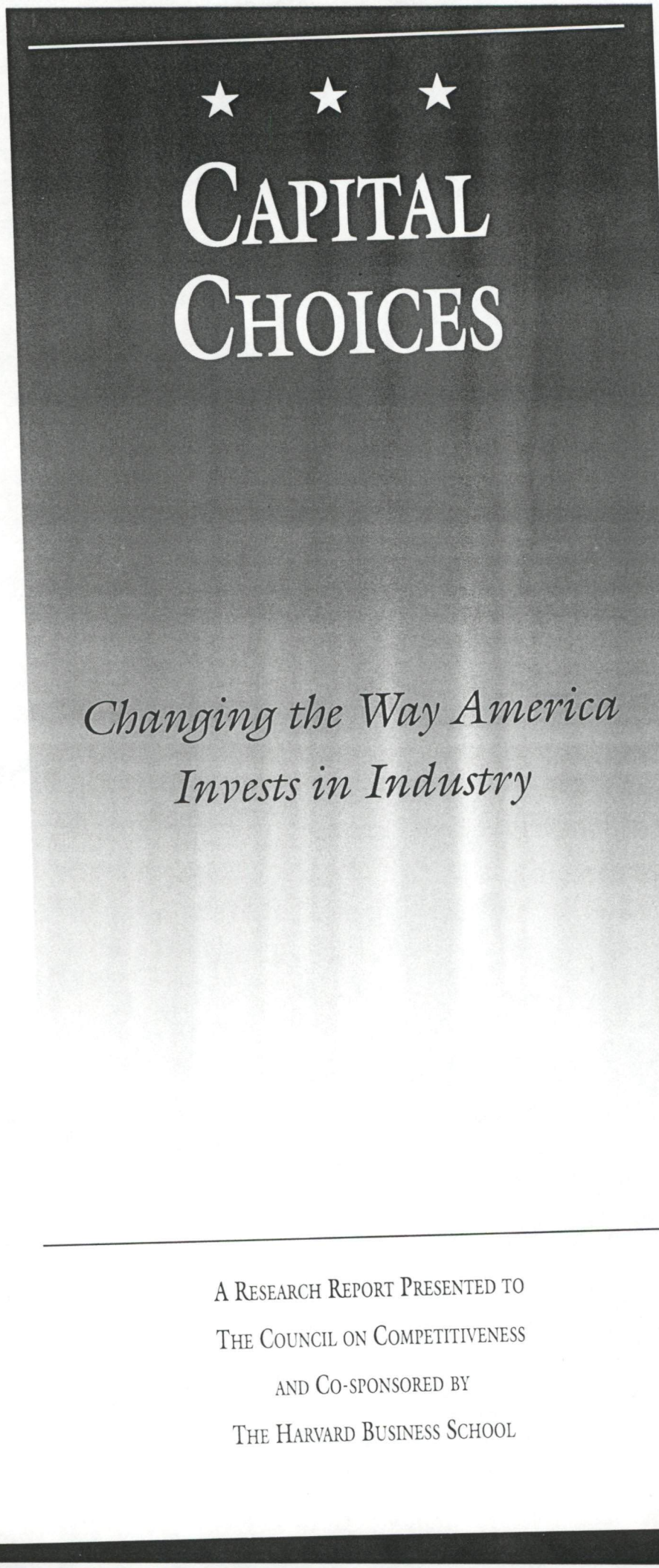
I date-lined your hand in National Presidents Technology awards remarks

Sincerely,

Kent H. Hughes

Enclosure: *Capital Choices: Changing the Way America Invests in Industry*

900 17TH Street, NW • Suite 1050 • Washington, DC 20006
(202) 785-3990 • FAX (202) 785-3998



CAPITAL CHOICES

Changing the Way America Invests in Industry

A RESEARCH REPORT PRESENTED TO

THE COUNCIL ON COMPETITIVENESS

AND CO-SPONSORED BY

THE HARVARD BUSINESS SCHOOL

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9207881
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: ROSS, Ian M.: AT&T

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 06/30/92

SUBJECT: HE IS FORWARDING AN ADVANCE COPY OF HIS PAPER, "A NATIONAL TECHNOLOGY AGENDA".

****

DIRECTORATE ASSIGNED: STAFF ASSIGNED:

ACTION REQUIRED: STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
INDUSTRIAL
NATIONAL SECURITY

****

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:

REMARKS:

OSTP RECEIVED: 07/16/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

7881

AT&T Bell Laboratories

Ian M. Ross
President Emeritus

101 Crawfords Corner Road
P.O. Box 3030
Holmdel, NJ 07733-3030
TEL: 908 949-3242
FAX: 908 949-7183

June 30, 1992

Dr. D. Allan Bromley
Assistant to the President for
Science and Technology
Executive Office of the President
Room 360, Old Executive Office building
Washington, DC 20506

Dear Allan:

Attached is a preprint of the paper, *"A National Technology Agenda,"* which you saw in draft form. The paper will appear next month in the National Academy of Engineering's publication, The Bridge. I am pleased to share with you a preview copy of the article. In courtesy to its formal publication, please use discretion in passing it on for the next few weeks.

Sincerely,

Ian

Attachment

Info:

cc: Nat'l Security
DAB
Industrial

Ian M. Ross

A National Technology Agenda

America's future is being foreclosed in part because we are experiencing the erosion of our high-tech industry

America's future is being foreclosed. The promise of prosperity is being broken. Foreboding reports are numerous: The United States has gone from the world's leading creditor to the world's leading debtor; real wages for the majority of Americans have fallen; the nation has faced a persistent trade deficit; our students have consistently shown comparatively low academic achievement; we have been frustrated by our inability to solve problems of poverty at home, or to help the economically disadvantaged abroad; we have been vexed by the deterioration of our cities, roads, and bridges, along with the transfer of our choicest assets and properties to foreign ownership; and we have endured an ominous recession, a recession from which jobs did not return, consumer confidence did not rebuild, and business did not rebound, as we would have liked. All these reports suggest a single question: Will our standard of living survive?

A country's standard of living has many dependencies. A major one, well recognized as a driver of productivity, prosperity, and economic growth in advanced nations, is such high-technology industries as electronics, aerospace, chemicals, and biotechnology. Consider the ubiquitous role of high tech: Our national security depends on state-of-the-art technology for weapons and intelligence. Our health care depends on sophisticated instruments for diagnosis and treatment, as well as on advanced pharmaceuticals. We eat well because America has been "greened" by agricultural science. We have commerce and personal mobility because of the myriad technologies embodied in cars, planes, boats, and trains. We communicate and stay informed thanks to

This paper is meant to provoke thought and discussion on one major driver of America's economic future: high-technology industry. There is ample evidence that important sectors of this industry are eroding. There is, however, no consensus as to whether this is a temporary aberration or, without intervention, an irreversible trend. This paper presents arguments that suggest we are indeed on a long-term, downward trend that could have widespread impact on our economic well-being. It is frequently suggested that our only recourse is to resort to a strong protectionist policy. The paper discusses the drawbacks to such an approach. Finally, an agenda is proposed that would use acceptable "American" concepts to maintain the nation at the leading edge in high-technology industry. The style of the paper can be described as a logical ordering of propositions, any one of which could bear its own paragraph of elaboration, or its own dressing in rhetorical flair. With the objective of assembling the facts and arguments in a reasonably short space, I have preferred this concise approach.

Ian M. Ross is president emeritus, AT&T Bell Laboratories, Holmdel, N.J.

complex telecommunications networks. Service and manufacturing jobs are everywhere dependent on computers and automation. Even the quality of our leisure time is based on consumer electronics and the technological wizardry of the entertainment industry. The things we need, need technology, and the providers of the things we need are those who possess the best technologies, the high technologies. In the world of today, and increasingly in the world of the future, the technology rich are the "haves," and the technology poor are the "have-nots."

We Have a Problem with High-Technology Industry

America's future is being foreclosed in part because we are experiencing the erosion of our high-tech industry. Thus, the underpinnings of our national security and quality of life are weakening. Our steel industry, once the largest and most advanced in the world, suffered a decade of decline and has been forced to fight for its return. Our auto industry is under siege. Our aircraft industry is fighting for market share with Europe while seeking financial support from Asia. Our consumer electronics manufacturing industry is lost; indeed, most of the high-volume electronics industry is gone. Our computer industry is under attack, and our semiconductor industry is steadily losing world market share. The erosion is even spreading to the service sector, where three-quarters of Americans work. The erosion that stopped the growth in service jobs seen in the 1980s is predicted to bring stagnation to the sector in the 1990s, and could precipitate decline by the next century.

Overall, the electronics industry perhaps best illustrates the nature and the seriousness of the high-tech erosion. Electronics is the lifeblood of high-technology industry. Today, almost every high-tech sector is electronics-based, or dependent on electronics for its manufacture or operation. Yet, overall, the U.S. electronics industry has been losing about 3 percent of world market share per year since the mid-1980s, a market that today is about three-quarters of a trillion dollars, and is expected to be $2 trillion by the beginning of the next century. The impact on American jobs, balance of trade, investment in R&D and plant, and the national store of knowledge and skills has been significant. The United States entered the 1980s with a $20-billion trade deficit. By 1990 it had multiplied by 500 percent to about $100 billion, with the deficit in manufactured goods equal to almost the entire amount, and electronic goods directly contributing at least 20 percent of the total. Today's weakness in the electronics sector is more than America bargained for. As J. Richard Iverson, president and chief executive officer of the American Electronics Association, put it: "We're declining far more sharply than any of us really thought. It is obvious that American high technology is at risk. This shrinking of the United States' market share must be reversed."

How did this situation in electronics come about? The problems started with the loss of onshore manufacturing of consumer electronics products, and spread to most high-volume electronics industries, which include consumer electronics and broadly cover lower-cost electronic equipment such as FAX machines, printers, and copiers, all of which are used in large numbers in the office and home.

The technology rich are the "haves," and the technology poor are the "have-nots."

The demise of the U.S. consumer electronics manufacturing industry had many causes. We turned to cheap foreign labor and components as a method of reducing costs. We made business decisions to exit the difficult areas of commodity-type, low-margin products, characteristic of consumer electronics. We made strategic decisions not to invest substantially in plant and leading-edge technology. We underestimated the foreign potential to take advantage of these actions, especially of foreign governments' willingness to support their industries with policies that ranged from tax breaks to low-cost capital, from trade restrictions to dumping practices. But, most critically, we lacked an appreciation of the value of consumer electronics to the entire electronics industry.

As consumer electronics manufacturing moved offshore, locally made components were substituted for U.S. products. In consequence, the U.S. semiconductor industry lost major customers. High-volume electronics products require high volumes of chips, and

this type of mass market is essential because of the large economies of scale inherent in semiconductor manufacturing. In contrast, Japan's market for high-volume electronics products supported nearly all of its growth in integrated circuits. Japan now has about 50 percent share of the world semiconductor market; the United States, going from virtually 100 percent market share, is now around 40 percent.

The problem has spread more recently to other parts of the electronics industry. Although computer manufacturing may seem like a strong domestic industry, closer scrutiny shows that an increasing portion of the lower-cost products are manufactured in the Far East, and for those still made in America, an increasing amount of the value added is in components and subsystems from abroad. Our lower-cost telecommunications terminal products have largely followed the overseas route of consumer electronics.

As the U.S. manufacturing market share fell from almost 100 percent to zero in product after product, we were giving up much more than large and growing markets. We were also losing leading-edge technology drivers. Twenty years ago, the defense industry pushed state-of-the-art technology. Later, computers and telecommunications systems became the leaders. Now, high-volume electronics is increasingly becoming the dominant technology driver, and thereby exercising control over large portions of an underlying technology base, a base still needed for national security and our remaining high-tech industries. To give some examples: miniature TV has been a driving force in display technology; digital audio tape is a leader in storage technology; compact discs are driving laser technology, digital signal processor design, and optical storage techniques; camcorders are at the frontier of image processing power and miniaturization technologies. As a nation, we are facing lost skills in precision mechanics, storage media technologies, some branches of optics, copier-printer subsystems, ferromagnetics (i.e., audio and video heads), and display technology. And, of significant consequence, we have also lost high-volume manufacturing skills.

With high tech gone, America could be forced to live on its natural resources

The history of electronics illustrates the process by which a major high-tech industry has been weakened. There is reason to fear that if we stay on our present course the erosion will continue. We could lose nearly all domestic manufacture of semiconductors and electronics, then automobiles and other high-tech industries, and eventually see the demise of our technology-based service industries. With high-tech industry gone, America could ultimately be forced to live on its natural resources, on the harvest of its land, and on the low-wage service labor of its people. This is not the tomorrow we want. The reasons for this gloomy forecast can be better understood by looking closely at the nature of high-tech industry.

The Nine Attributes

High-technology industry has at least nine key attributes that, to different degrees in different sectors of the industry, define its requirements and dynamics. The drive of corporations and nations to cultivate these attributes helps explain the past and predict the future; it also provides a basis for developing a national technology agenda.

The first attribute is the *large knowledge base* needed by high-tech industry. Basic technology generation needs research, often over long periods. The development of such new technologies as genetic engineering or nuclear power can take decades. There is a need to acquire a deep experience base; characteristically, one finds a broad buildup of intellectual property in high technology. This translates into heavy investment in R&D. To cite some examples, it can take $1 billion to bring to market an advanced electronic switching system for a telecommunications network, or a new jet engine for commercial airliners. In the semiconductor field, it takes about $200 million to develop a new-generation product, such as a memory chip, and the needed investment is not diminishing: by the end of the decade, we expect this number to triple. On average, it takes about 12 years and over $200 million for a pharmaceutical firm to develop a new drug.

The second attribute of high-tech industry is the need for *large capital investment*. The advanced manufacturing equipment and complex process manage-

ment required for production drive large capital demands across most high-tech industries. In the semiconductor industry, for example, a fabrication line can today cost about half a billion dollars; by the start of the next century, it is expected to cost about $2 billion. In the mid-1980s, the chemical industry had to capitalize at over $90,000 per worker, compared with an average of $43,000 for all manufacturing.

High-tech production and service jobs will increasingly require technical literacy and strong basic skills.

The third attribute is the need for a *highly skilled work force.* It is not always possible to apply the classical trade-offs of labor for capital; advanced equipment and automation are essential. Mechanization has always been a path to productivity, but the use of advanced manufacturing machinery is today often the only path to a high-tech product. Thus, high-tech production and service jobs will increasingly require technical literacy and strong basic skills. As a corollary, the labor market itself has split into the higher-wage, highly skilled jobs that revolve around the core intellectual content of the product, and the low-wage, "tail-end" assembly jobs.

The fourth attribute concerns the *large economies of scale* inherent in many high-tech areas. Capital intensive manufacture and heavy investment in R&D tend to economies of scale, since large fixed costs must be amortized.[1] Even a "big ticket" item such as a new commercial aircraft requires production of 400 to 500 units to break even.

The fifth attribute is *accelerated time cycles.* In some high-tech sectors, the rapid pace of technological progress has compressed product life cycles to years and shortened the life span of factories, thus amplifying the effects of economies of scale. Semiconductors and optical communications products—the underpinning technologies of the Information Age—double their capacity per unit cost every 12 to 18 months, a spectacular pace for any human endeavor. Technical progress is not new, but such speed and magnitude of progress have been experienced only in high technologies during the last few decades.

The sixth attribute follows from the prior attributes: it is the need for *large market share.* In an effort to maximize market size, high-tech businesses must seek global markets and become fewer in number. To the economist this latter trend is called "fewness," and it reflects the simple fact that large market share cannot be held by many. High-tech sectors are increasingly ruled by a global business oligopoly. For example, about 12 major corporations supply more than 80 percent of the world's telecommunications network products. Similarly, the world's automobiles and commercial aircraft are produced by a small number of giant corporations. Looking at the high-tech segments of the textile industry, we see that about 90 percent of all U.S. synthetic fiber is produced by 10 companies.

The seventh attribute is that there are *strong linkages,* both horizontal and vertical, in high-tech industries. There is a web of customer and supplier relationships that knit high-tech businesses closely together. Horizontal linkages are seen in the dependency of financial services on computers and communications, or of aircraft and automobile production on hundreds of subcontracted industries. A premier example of horizontal linkages is provided by electronic systems, which, as already pointed out, are at the core of almost every high-tech industry, from aerospace to manufacturing, from medicine to entertainment. And these linkages continue to grow: in the past decade, the cost of electronic systems in some American cars has tripled as a percentage of the total cost; at least one European car manufacturer already claims electronics accounts for 20 percent of its auto costs. By the mid-1990s, it is projected that 30 to 35 percent of auto costs will be in electronic components and systems. Electronic systems are vertically dependent on advanced semiconductors and vice versa. Both are dependent on materials and manufacturing equipment and skills, and all are dependent on basic research, which in turn relies on the education system for its talent, and on the prosperity of our society for its funding. These are important linkages; weakness in any link affects the strength of the whole.

[1]This implies the need for high-volume manufacture, where "high-volume" encompasses flexible manufacture of different products from common platforms, and is not synonymous with "mass production."

The eighth attribute is the *importance of commodity, low-margin products.* There is temptation to exit low-margin,[2] high-volume, commodity-type areas, a temptation the United States yielded to in consumer electronics. We would prefer to work in higher-margin, but usually lower-volume, areas such as computers. But this, as already noted, is a dangerous strategy because high-volume, commodity production has many values: it generates large revenues needed to support investment, it advances our skills in high-volume manufacturing, and it increasingly drives leading-edge technology. Furthermore, there is growing evidence that high-volume commodities form a base for expansion into the higher-margin areas, as demonstrated in the current challenge to the computer industry coming from high-volume electronics. Another example is found in the Japanese auto industry's progression from economy cars to luxury-class autos, or the advances made by Japan in multiple video and image areas (including film) arising from competencies in precision optics or micromechanics gained from a base position in cameras. Indeed, it may not be possible to sustain a position in the higher-margin products without a strong position in that base.

The ninth attribute is concerned with the *barriers to entering or reentering high-tech businesses.* If we were to talk to a classical economist, we might hear the following logic: if a country that is currently manufacturing an item finds it can be obtained cheaper elsewhere, it is in the best interest of the consumer to buy the product from the foreign supplier. Later, if the supplying country were to corner the market and raise the price, the buying country should simply go back into production. This logic encounters difficulties when the high-tech attributes are considered. In trying to reenter a high-tech field, a manufacturer would lack the knowledge base, and would have to absorb large losses while building the market volume needed to compete. In modern economics, these are recognized barriers to entry into industries with large economies of scale. In particular, where technology moves very rapidly, those who drop out of the race—or even fall behind for only a short period—find it very difficult to catch those who have continued to run. This pace affects business plans in major ways: long-term commitment and staying power are often essential to success in a high-tech enterprise.

From these nine attributes, we can make two observations relevant to a technology agenda. Regardless of a country's natural wealth, there is an opportunity for a poor or emerging country to increase productivity, create wealth, and raise its standard of living by creating comparative economic advantage through high-tech industry. This opportunity becomes an imperative in most nations that care about their people. Facing established industry in advanced countries, the barriers to entry are high and can be surmounted only by a national initiative. Technical knowledge may be acquired by purchase (as in patent licensing), by negotiation (as perhaps a condition of doing business in the country), or even by ignoring intellectual property rights (which amounts to theft). Large investments must be made in R&D and in plant facilities. Operating losses must be sustained over a period of years while the emerging industries acquire markets and gain economies of scale. Markets must be made available by protecting home markets and subsidizing entry to overseas markets, even to the point of dumping. In the recent past, we have seen all of these tactics successfully employed to break down barriers to entry. These are the actions that characterize how the "have-nots" become the "haves" in the high-tech game.

Where technology moves very rapidly, those who drop out of the race find it very difficult to catch those who have continued to run.

It is interesting to note that, according to this analysis, the emerging nations do not abide by the principles of free trade, despite the benefits that are supposed to accrue. Under the theory of free trade, all nations benefit by increased specialization in their areas of natural comparative advantage. Thus, under free trade, one might expect an emerging nation to improve its standard of living by more effective provi-

[2]Commodities are not always low-margin; for example, there is often opportunity to establish good profit margins in the introductory phases of a commodity product.

sion of agricultural products, handicrafts, and available raw materials. However, the standard of living would also increase in the advanced nation it traded with, and the standard of living gap would not be closed. Importantly, under free trade there is no way for the emerging nation to surmount the barriers to building high-tech industries, industries that offer a preferred route to economic equality. Thus, managed trade rather than free trade is in the emerging nation's best interests. As long as we have prosperity gaps between nations, and recognizing that populations are not generally free or able to migrate, we will not see free trade adopted worldwide. We should not criticize a nation for taking actions that are in the best interests of its people; we should, however, recognize what is happening and, if it is detrimental to our interests, take action on our own behalf.

The second observation relates to a threat to established high-tech industry in advanced nations. In effect, industries in these nations often find themselves competing against foreign governments. Given the tactics discussed above, they can find their overseas markets foreclosed and their domestic markets eroded. In consequence, the advanced nation's industry may be less able to afford investment. Thus, the industry falls behind, further eroding its position, and the process starts feeding on itself, potentially moving at a very rapid pace. Even though only a few industry sectors may be targeted by foreign competitors, the "linkage" and "commodity base" attributes can undermine strength in nontargeted sectors. Finally, once an industry is lost, the advanced nation is then itself faced with barriers to reentry. This is how the "haves" become the "have-nots," and this is the course we are on!

Regardless of natural wealth, a poor or emerging country can raise its standard of living through high-tech industry.

The Course We Are On—The Current Agenda

What will be the outcome if we stay on our present course? Based on the nine attributes, our high-tech industry could follow, in all or in part, the following extreme (but plausible) scenario:

- The erosion in the electronics industry continues to spread into higher-margin products.
- As a consequence, our semiconductor industry continues to lose market share.
- In the face of a decline in its market share, the semiconductor materials and equipment industry, a critical supplier to the semiconductor industry, cannot afford the escalating investment required to stay at the high-tech frontier.
- Hence, the semiconductor materials and equipment industry goes totally overseas.
- The combined effect of foreign dependency and diminishing market share for materials and manufacturing equipment finally destroys the broad-based U.S. semiconductor industry. This will leave the United States with few, if any, critical electronic components manufactured onshore.
- The remainder of the electronics industry—computers, network communications equipment, medical instrumentation—erode at an accelerated rate because they are now "hollowed out" of domestic content (i.e., chips and value-added subsystems). All that survives on American soil are low-wage assembly jobs.
- The auto industry, already weak, becomes dependent on overseas suppliers for electronic systems, which constitute 30 percent or more of the vehicle's value. The auto industry can no longer compete.
- Other high-tech manufacturing industries, linked to electronics, fail over time.
- With high-tech manufacturing gone, our service industries, deprived of support linkages, will be targets for foreign takeover. (Foreign enterprises already display expertise in running railroads, airlines, hotels, and financial institutions.)
- Software eventually collapses as a strong domestic business. (Sony bought Columbia because they wanted the software to run on their hardware. Why wouldn't this thinking continue? It is a natural line of expansion and a logical aspect of linkages. We should also observe the aggressive plans in Japan and elsewhere to build software capabilities.)
- We cease to use U.S. taxpayers' money to fund

basic research because the benefits accrue mainly to overseas industry.

- Our agriculture, which presumably will remain government-supported, continues to be strong. We thus export our agricultural products (produced by less than 3 percent of our population) to pay for our imports of fuel and high-tech products.
- Economic theory tells us that, in the long run, the balance of trade must tend to zero. In the case of a declining high-tech industry, this will be accomplished by exporting lower value, lower skill-content products to pay for the import of high-value, high-tech products. *The net result will be a decline in America's relative standard of living—a process that already appears to be under way.*

If permitted to continue, the effects of our present course will eventually become intolerable.

I admit this is an extreme scenario. But even if it is partially fulfilled, the future prospects for our standard of living appear gloomy. The risk of even partial fulfillment of this scenario is unacceptable—yet on the present course, this is the type of scenario we will inevitably face. And it will come not because of the malice of any group or institution, but because the dynamics of industry and world trade have changed significantly for high-tech products.

Drastic Action—The Protectionist Agenda

If permitted to continue, the effects of our present course will eventually become so intolerable that the public will demand a change. By that point, the erosion could be so advanced that our only option will be to take drastic action. Foreign nations and current ideologies will be labeled the culprit. Too late for moderate measures, extreme positions will be seen as solutions. The protectionists, many of whom are already agitating, will take over.

We will look to the successful measures adopted by Japan, Korea, and Taiwan in entering and developing high-tech industries. Indeed, we would be irresistibly inclined to emulate them. Thus, in a time of reaction and crisis, the nation would have little choice but to resort to actions of the following kind:

- Target specific strategic and "hard hit" industries for support.
- Use national influence and coercion to obtain know-how from overseas.
- Restrict the flow of intellectual property abroad.
- Mandate specific R&D and manufacturing consortia.
- Protect fledgling industries with subsidies and tariffs as they gain market share.
- Erect barriers to imports of unwelcomed products.
- Raise taxes substantially as part of an effort to curb the budget deficit.
- Intervene dramatically in our education system as part of an effort to put a long-term solution in place.

These are not things we do well. We do not have the government infrastructure suited for such action, nor do we have the appropriately skilled government employees qualified to exercise such responsibility. Some nations, with different cultural and political roots, do. To learn from the experience of others is wise; but blindly to apply foreign approaches—assuming that what works in Japan or Korea will work here—is an error. Nevertheless, if we persist on the current course, these erroneous measures will be the very ones demanded by a nation feeling desperate. In the short term, some problems may be ameliorated, but the true problems of the nation will ultimately be compounded. These actions would suppress our greatest asset, our free enterprise system. Excessive interference with freedoms that have been at the core of America's strength through its history is not the way. In the long run, a drastic solution creates a drastic problem.

Neither the current course nor the drastic alternative is acceptable. While there is ample evidence that the present approach is not working, we also recognize that massive government intervention and a protectionist retreat from the global marketplace are a mistake of major proportion. We are not the only advanced nation that has faced challenges to its high-tech industries. The U.K. and Europe have lost a number of high-tech industries, and Japan will face increasing challenge from the present and emerging Asian "tigers." But we are the nation that can seize an oppor-

tunity: the opportunity of arriving at an early understanding of the solution to the "have and have-not" problem. Therefore, we must find a better way.

The Better Way—A National Technology Agenda

The starting point for a national technology agenda is to declare that leadership in high-technology industries is a national objective. This must be a bipartisan objective, led by the President, supported by Congress, endorsed by business, and recognized as vital by the American people. The connection between leadership in high-tech industry and an increased standard of living must be understood and supported by all. The resultant benefits to all Americans must be proclaimed, perhaps debated, but ultimately accepted by the nation as a whole. This is not "picking winners and losers"; rather, it is choosing to be a winner instead of a loser!

The Elements of a National Technology Agenda

First, we must establish a level playing field for our high-tech industry, a field at least as favorable as that in other advanced nations:

- We need to *facilitate investment in R&D, plant, and worker training.* For more than a decade, the real cost of capital to business—not just the interest on debt—has been higher, by a factor of two or more, for U.S. firms than for many foreign competitors. In consequence, our competitors are out-investing America in R&D and plant, and are investing for a longer-term payoff. We must employ a range of tactics aimed at making capital available at lower cost. Balancing the national budget and creating incentives for Americans to save will serve this objective. New tax and fiscal policies, such as investment tax credits, R&D tax credits, and accelerated depreciation schedules, are needed. This will, of course, require difficult trade-offs—trade-offs of short- versus long-term gain, of consumption versus savings—in order to create the proper environment for capital formation if our high-tech industry is to flourish.
- We need to *establish fair trade* in our global markets. Our persistent trade deficits cannot be totally blamed on the quality or inappropriateness of American products for foreign markets; a lack of reciprocal market openness has been a major factor. Washington's concern, in GATT and elsewhere, for America's business interest must match the concern of foreign capitals. Free trade is a commendable long-term objective, but fair trade is an immediate imperative.[3]
- We need to *strengthen our national education system* as a means to create a globally competitive work force. High-tech jobs are knowledge intensive, not just in the research laboratory, but also on the factory floor or at the business workstation. National technical literacy is a clear priority. However, we cannot wait for improvement in our school systems to produce results in the workplace, since this can take decades. We need to seek short-term remedies together with permanent, long-term cures.

The starting point is to declare that leadership in high-technology industries is a national objective.

Second, we must stimulate, and in some cases repatriate, our high-volume electronics industries. While high-volume electronics is not the only industry that we may want to bring back onshore, it is a critical one, and exemplifies strategies that can be used for high-tech repatriation. Reentering manufacture of mature products in the face of large, established foreign competitors is a tough, uphill fight. There are opportunities, however, where the technology or the marketplace is going through major changes or discontinuities.

In these cases the barriers to entry are somewhat equalized for all players, providing openings for those with ingenuity and determination. Examples of technology discontinuities that may be expected include broadband communications, intelligent vehicle and highway systems, advanced displays, speech and image processing, and high-definition television.

There is the possibility, however, that relying on technology discontinuities will not be enough in some areas. With effectively zero United States manufactur-

[3]And we should not neglect the importance of a large and strong home market, where "home" can extend beyond our political borders, as such organizations as the North American Free Trade Area demonstrate.

ing market share, and recognizing the large size and rapid growth of our foreign competitors, the barriers in consumer electronics may be too high to be surmounted, at least in a timely way, by relying only on emerging markets. We may need our government to ensure technology transfer from Asia for consumer electronics, and we may need to arrange import and export agreements on specific products while our manufacturing capability matures. Were we to decide on this type of action, proposals must be embraced cautiously, with full understanding of the hazards, and with strict limitations on duration and scope.

Third, we must make changes to our culture to support the coordination of precompetitive technology development, and to encourage the formation of consortia, alliances, and collaborations. Other nations have benefited from the economies of cooperating in the early phases of technology development, even extending the benefits to the development and manufacturing phases; yet they have retained the ability to compete fiercely in the marketplace. We in the United States have been late to recognize this opportunity and to learn how to cooperate and compete at the same time. We have, however, made some progress in this direction. The administration has concluded that it is proper for government to encourage and fund generic, precompetitive technology. The task of identifying strategic technologies that are candidates for such treatment has already been accomplished: the White House, the Department of Defense, the Department of Commerce, and the Council on Competitiveness have, with remarkable consensus, published lists of strategic technologies. And not only is there domestic agreement in these lists, but America's view is essentially the same as the Japanese and European Community views. So again there is no issue of picking winners and losers. What remains is to select areas that are appropriate for cooperative programs between government, industry, and academia—and to make then work. In this too we have already made some progress, although there is still much to be learned from our successes and failures. Sematech has provided a model by demonstrating that U.S. institutions can cooperate in developing generic technology for the semiconductor industry. But we lack a process for selecting specific areas for cooperation. We need at least a forum in which enthusiastic, knowledgeable, and influential members of government and business can meet and recommend suitable action. It is important to note that forums without enthusiastic membership are doomed to fail.

We must not too narrowly interpret this agenda item. It does not imply that the United States should not continue to build international partnerships. Some of the high-tech industries of the future will be the property of large, worldwide consortia. But in any worldwide consortium, the United States must have a strong and equitable position. This agenda item *does* say that America must maximize its domestic strength through cooperation, and thus be a strong, not a weak, player in global high-tech activities.

We may need our government to ensure technology transfer from Asia for consumer electronics.

Fourth, we need a renewed commitment to a total quality program, including high-quality manufacturing skills. We have erred in the past by not insisting on product quality as essential to customer satisfaction, corporate profitability, and international competitiveness. In some cases, we have lost sight of customer needs in designing and delivering products. The Malcolm Baldrige Award is an example of an instrument that can build quality awareness in U.S. business. We know today what has to be done, and we have an increasing number of examples of success. What we need is total commitment.

This agenda is not foreign to the American Way. We have long benefited from encouraging such broad classes of industry as aerospace and agriculture. What is proposed here is the encouragement of the very broadest class of industry, one that leads to improved living standards for all our people. This can be achieved by providing an environment that nurtures the basic attributes of the industry. No special targeting is needed.

How practical is this technology agenda? I believe we have the resources to carry out this program. Our basic science and technology are the envy of much of

the world. Our research universities are the first choice for aspiring scientists and engineers from around the globe. Our North American market is large enough to provide a powerful competitive base. Our best factories meet world-class quality standards, and our best workers and managers can compete with anybody. Our productivity is still unmatched in many areas. Our country is rich in natural resources, and our agriculture is without equal. With these assets, what can get in the way? What must we do?

We need a renewed commitment to a total quality program, including high-quality manufacturing skills.

Clearly, our national priorities must be reordered, and a number of tough decisions must be made. To begin, the leaders of government, industry, and academia must embrace the concept of leadership in high-tech industry as a national goal. This concept must be discussed and understood widely so that the electorate can support the administration, the Congress, and business in the actions that must be taken. We must decide to save and to invest adequately for the future of our industry, albeit at the expense of some short-term benefits. Economic advantage must be given proper weight relative to military advantage. We must, as a people, value wealth creation over consumption, and demand industry promotion as our ultimate goal. We must build a degree of understanding and trust between government and industry so they can work effectively together in the national interest. We must make the tough decisions, country by country, to establish conditions of fair trade that serve U.S. interests. With the support of government, industries must learn to cooperate in the precompetitive phases of their activities while competing vigorously in the world marketplace. We must identify and implement short-term and long-term measures to improve our education and training. And all this must be done promptly, while we still have an asset base strong enough on which to build.

Acknowledgments

Few of the ideas in this paper are original. Most have been expressed by others too numerous to mention, who are concerned about competitiveness issues. If there is value here, it is mainly from bringing these ideas together in one place. I specifically wish to acknowledge the benefits from sharing ideas over the past three years with my colleagues on the National Advisory Committee on Semiconductors. Indeed, part of the stimulus for writing this paper came from the observation that its strategy for the semiconductor industry was more widely applicable. I have borrowed liberally from that strategy in developing thoughts on high-tech industry. I am particularly indebted to those who have read early drafts of this paper and provided valuable commentary. I am also indebted to Christopher G. Harrington of AT&T Bell Laboratories for his ideas and assistance in preparing and organizing the paper.

TYPE: ACTION DOCUMENT NUMBER: 9202571 Don
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

****

FROM: FORDICE, Kirk: GOVERNOR OF THE STATE OF MISSISSIPPI

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/16/92

SUBJECT: HE IS WRITING TO ENDORSE THE NOMINATION OF DR. JOE THOMPSON FOR THE HIGH PERFORMANCE COMPUTING ADVISORY BOARD.

****

DIRECTORATE ASSIGNED: INDUSTRIAL

STAFF ASSIGNED:

ACTION REQUIRED: AS NECESSARY

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: 08/07/92

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 07/24/92 DEPT RECEIVED:

FILE: P-INDUSTRIAL

CENTRAL FILES:

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

August 6, 1992

Dear Governor Fordice:

Thank you for your letter endorsing the nomination of Dr. Joe F. Thompson for membership on the High Performance Computing Advisory Committee. According to the authorizing legislation, members of this Committee are to be appointed by the President. This process is administered by the Office of Presidential Personnel. I have provided my own recommendations for membership on the Committee and I will forward your letter to that office.

Sincerely,

D. Allan Bromley
Director

The Honorable Kirk Fordice
Governor, State of Mississippi
P.O. Box 139
Jackson, Mississippi 39205

OFFICE OF SCIENCE AND TECHNOLOGY POLICY

STAFFING SHEET

SUBJECT: Ack. of nomination of Dr. Thompson for HPCAC

ORIGINATOR: E. Wong **PHONE:** 3902

DATE ORIGINATED: 8/4/92 **DATE DUE:** 8/7/92 **CORR TRACKING NO:** 9202571

EXTERNAL COORDINATION: none

	COMMENTS	DATE
DIRECTOR		
GENERAL COUNSEL		
EXEC. ASST.		

ACTION REQUESTED: DAB signature

COORDINATION		COMMENTS	DATE
Henderson, D. A.	Concur: Non Concur:		
Erb, K.	Concur: Non Concur:		
Ratchford, J. T.	Concur: Non Concur:		
Wong, E.	Concur: XX Non Concur:	Wong approved Pryor draft ltr. Pls return to Sherman for dispatch	8/6
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		
	Concur: Non Concur:		

2571

STATE OF MISSISSIPPI
OFFICE OF THE GOVERNOR
KIRK FORDICE
GOVERNOR

RECEIVED
92 JUL 24 AM : 06
OSTP
MAIL ROOM

July 16, 1992

Dr. Allen Bromley, Director
White House Office of Science and Technology
Old Executive Office Building
Suite 358
Washington, D.C. 20506

Dear Dr. Bromley:

It is my understanding that Dr. Joe F. Thompson, Director of the National Science Foundation Engineering Research Center at Mississippi State University, has been nominated for the new High Performance Computing Advisory Board.

I would greatly appreciate every consideration being given to Dr. Thompson, as I feel that his expertise in the field of high performance computing and aerodynamics would be very beneficial to your Advisory Board. Dr. Thompson is well-rounded educationally and professionally and could certainly do justice to this most distinguished board.

Please feel free to call upon me if I can be of further assistance in this regard. I look forward to hearing back from you.

Sincerely,

Kirk Fordice

KIRK FORDICE
Governor

KF:bb

cc: Dr. Donald Zacharias

POST OFFICE BOX 139, JACKSON, MISSISSIPPI 39205, 601-359-3100
FAX 601-359-2917

"Document Control"

TYPE: ACTION DOCUMENT NUMBER: 9202523
ORIGINATOR: 02 STATUS I DIRECTORATE STATUS

****

FROM: GLATZEL, Richard E.

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 07/08/92

SUBJECT: HE IS WRITING REGARDING THE NUMBER OF UNEMPLOYED ENGINEERS.

****

DIRECTORATE ASSIGNED: INDUSTRIAL

STAFF ASSIGNED:

ACTION REQUIRED: AS APPROPRIATE

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE: 08/04/92 STAFF DUE DATE
DATE COMPLETED: DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley

****

WHITE HOUSE TRACKING #: CONTACT PERSON:
PHONE: EXT:

REMARKS:

OSTP RECEIVED: 07/21/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON, D.C. 20506

August 12, 1992

Dear Mr. Glatzel:

Dr. Bromley has asked me to acknowledge with thanks your letter to him of July 8, 1992.

Personally, I very much appreciate the thoughtful nature of your letter, and agree with much of the substance. Serious efforts should be made to develop ways of using the underutilized pool of already trained technical personnel that exists.

Thank you again for your letter.

Sincerely yours,

Eugene Wong
Associate Director
for Industrial Technology

Mr. Richard E. Glatzel
152-17 12th Road
Whitestone, New York 11357

2523

RECEIVED
JUL 21 AM
OSTP
MAIL ROOM

152-17 12th Road
Whitestone, NY 11357
July 8, 1992

Honorable D. Allan Bromley
Director, White House Office of
Science and Technology Policy
The White House
Washington, D.C. 20500

Dear Dr. Bromley:

I am an electrical engineer whose education includes a Bachelors Degree in Electrical Engineering, a Master of Science Degree in Electrical Engineering, and a Master of Science Degree in Computer Science. I also have a Professional Engineering License in New York State and have 27 years of experience in the design and development of advanced electronic equipment.

For the past six months I have been unemployed and unable to find work. There are tens of thousands of technically trained engineers like myself who are unable to find a job. I want the White House to think of these highly educated people when American industry complains about the lack of technically competent people in the workforce. I also want you to think of these unemployed engineers, scientists, and mathematicians when the educational establishment asks for billions of tax dollars to train more people in the fields of science, mathematics, and engineering.

American industry should be encouraged, through legislation if possible, to make use of the technically trained human resources which are already plentiful and immediately avaiable to them. Unless this can be done there is no reason to spend tax dollars to educate more people in areas of science or technology when there will be no place for them to work.

Sincerely,

Richard E Glatzel

Richard E. Glatzel

Withdrawal/Redaction Sheet
(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01a. Cover sheet	Re: Letter to Allan Bromley (1 pp.)	7/1/92	(b)(1)	

Collection:

Record Group: Bush Presidential Records
Office: Science and Technology Policy, Office of (OSTP)
Series: Bromley, D. Allan, Files
Subseries: General Science Files
WHORM Cat.:
File Location: Industrial: General [3 of 6] [1992]

Date Closed:	3/10/2010	**OA/ID Number:**	62035-003
FOIA/SYS Case #:	2005-0336-F	**Appeal Case #:**	
Re-review Case #:		**Appeal Disposition:**	
P-2/P-5 Review Case #:		**Disposition Date:**	
AR Case #:		**MR Case #:**	
AR Disposition:		**MR Disposition:**	
AR Disposition Date:		**MR Disposition Date:**	

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Removed as a personal record misfile.

Freedom of Information Act - [5 U.S.C. 552(b)]

(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

Withdrawal/Redaction Sheet
(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01b. Letter	To: Allan Bromley From: B.G. Saltykov Re: Superconducting Supercollider (1 pp.)	7/1/92	(b)(1)	

Collection:

Record Group: Bush Presidential Records
Office: Science and Technology Policy, Office of (OSTP)
Series: Bromley, D. Allan, Files
Subseries: General Science Files
WHORM Cat.:
File Location: Industrial: General [3 of 6] [1992]

Date Closed:	3/10/2010	**OA/ID Number:**	62035-003
FOIA/SYS Case #:	2005-0336-F	**Appeal Case #:**	
Re-review Case #:		**Appeal Disposition:**	
P-2/P-5 Review Case #:		**Disposition Date:**	
AR Case #:		**MR Case #:**	
AR Disposition:		**MR Disposition:**	
AR Disposition Date:		**MR Disposition Date:**	

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Removed as a personal record misfile.

Freedom of Information Act - [5 U.S.C. 552(b)]

(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

Withdrawal/Redaction Sheet
(George Bush Library)

Document No. and Type	Subject/Title of Document	Date	Restriction	Class.
01c. Letter	To: Boris Saltykov From: Allan Bromley Re: Superconducting Supercollider (1 pp.)	7/15/92	(b)(1)	

Collection:

Record Group: Bush Presidential Records
Office: Science and Technology Policy, Office of (OSTP)
Series: Bromley, D. Allan, Files
Subseries: General Science Files
WHORM Cat.:
File Location: Industrial: General [3 of 6] [1992]

Date Closed:	3/10/2010	**OA/ID Number:**	62035-003
FOIA/SYS Case #:	2005-0336-F	**Appeal Case #:**	
Re-review Case #:		**Appeal Disposition:**	
P-2/P-5 Review Case #:		**Disposition Date:**	
AR Case #:		**MR Case #:**	
AR Disposition:		**MR Disposition:**	
AR Disposition Date:		**MR Disposition Date:**	

RESTRICTION CODES

Presidential Records Act - [44 U.S.C. 2204(a)]

P-1 National Security Classified Information [(a)(1) of the PRA]
P-2 Relating to the appointment to Federal office [(a)(2) of the PRA]
P-3 Release would violate a Federal statute [(a)(3) of the PRA]
P-4 Release would disclose trade secrets or confidential commercial or financial information [(a)(4) of the PRA]
P-5 Release would disclose confidential advice between the President and his advisors, or between such advisors [a)(5) of the PRA]
P-6 Release would constitute a clearly unwarranted invasion of personal privacy [(a)(6) of the PRA]

C. Closed in accordance with restrictions contained in donor's deed of gift.

PRM. Removed as a personal record misfile.

Freedom of Information Act - [5 U.S.C. 552(b)]

(b)(1) National security classified information [(b)(1) of the FOIA]
(b)(2) Release would disclose internal personnel rules and practices of an agency [(b)(2) of the FOIA]
(b)(3) Release would violate a Federal statute [(b)(3) of the FOIA]
(b)(4) Release would disclose trade secrets or confidential or financial information [(b)(4) of the FOIA]
(b)(6) Release would constitute a clearly unwarranted invasion of personal privacy [(b)(6) of the FOIA]
(b)(7) Release would disclose information compiled for law enforcement purposes [(b)(7) of the FOIA]
(b)(8) Release would disclose information concerning the regulation of financial institutions [(b)(8) of the FOIA]
(b)(9) Release would disclose geological or geophysical information

"Document Control"

TYPE: INFORMATION DOCUMENT NUMBER: 9207879
ORIGINATOR: 02 STATUS C DIRECTORATE STATUS

****

FROM: MASSEY, Walter E.: NATIONAL SCIENCE FOUNDATION

TO: DR. D.A. BROMLEY

DATE OF
CORRESPONDENCE: 06/30/92

SUBJECT: HE IS FORWARDING THE SMALL BUSINESS INNOVATION RESEARCH PROGRAM ANNUAL REPORT FOR FY 1991.

****

DIRECTORATE ASSIGNED:

STAFF ASSIGNED:

ACTION REQUIRED:

STAFF ACTION:

****

SENDER'S DUE DATE:

OSTP DUE DATE:

STAFF DUE DATE

DATE COMPLETED:

DATE COMPLETED/DEPT:

****

COPIES TO: D. Allan Bromley
INDUSTRIAL

****

WHITE HOUSE TRACKING #:

CONTACT PERSON:

PHONE: EXT:

REMARKS:

OSTP RECEIVED: 06/03/92 DEPT RECEIVED:
FILE: P-INDUSTRIAL

CENTRAL FILES:

7879

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

OFFICE OF THE DIRECTOR

RECEIVED
92 JUL 5 A10:59
OSTP
MAIL ROOM

June 30, 1992

Honorable D. Allan Bromley
Assistant to the President for
Science and Technology
Office of Science and Technology Policy
Old Executive Office Building
Room 358
Washington, D.C. 20506

Dear Dr. Bromley:

Pursuant to Section 4(g)(7) of Public Law 97-219, as amended, I am pleased to transmit the National Science Foundation's Small Business Innovation Research (SBIR) Program Annual Report for Fiscal Year 1991.

The SBIR report and the non-SBIR goals and accomplishments data for Fiscal Year 1991 have been submitted to the SBA.

Sincerely,

Walter E. Massey
Director

Enclosure
SBIR Annual Report, FY 1991

Info.

CC: DAB

U. S. Small Business Administration
Office of Innovation, Research and Technology

SMALL BUSINESS RESEARCH & R & D (R&R&D) GOALING PROGRAM

Annual Report Format
FY 91

Date: May 22, 1992

Reporting Agency: National Science Foundation

FY 1990

I. a.	Previous Fiscal Year (FY) Total R&R&D Obligations	$ 1,689.5	
b. 1.	Previous FY Total Prime R&R&D Dollars Awarded to Small Business Concerns (less SBIR Awards)	$ 19.07	1/
2.	Previous FY Total Prime R&R&D Dollars Awarded to Minority and Disadvantaged-owned Small Business Concerns (less SBIR Awards)	$ 7.89	2/
c. 1.	Percent of Previous FY R&R&D Obligations Awarded to Small Business Concerns (I.b1 % Ia)	1.13 %	
2.	Percent of Previous FY R&R&D Obligations Awarded to Minority and Disadvantaged-owned Small Business Concerns (I. b2 % Ia)	0.47 %	
II. a.	Total R&R&D Obligations for Reported FY 1991	$ 1,706.6	3/
b. 1.	Total R&R&D Small Business Percent Goal for Reported FY. (This goal may not be less than the percent awarded to small business concerns in the previous FY and may not include SBIR awards.)	1.13 %	
2.	R&R&D Small Business Goal in Dollars (IIa x IIb 1)	$ 19.29	
c. 1.	Total R&R&D Dollars Awarded to Small Business Concerns for reported FY (Less SBIR Awards)	$ 19.474	1/
2.	Total R&R&D Dollars Awarded to Minority and Disadvantaged Small Business Concerns (Less SBIR Awards)	$ 6.47	2/
d. 1.	Percent of Total R&R&D Obligations Awarded to Small Business Concerns for Reported FY (IIc 1 % IIa)	1.14 %	
2.	Percent of Total R&R&D Obligations Awarded to Minority and Disadvantaged Small Business Concerns (IIc 2 % IIa)	0.38 %	
e.	Percent of Goal Achieved for Reported FY (IIc 1 % IIb2)	100.9 %	

U. S. Small Business Administration
Office of Innovation, Research and Technology
SMALL BUSINESS RESEARCH & R & D (R&R&D) GOALING PROGRAM
Annual Report Format
(continued)

III. a. Total number and total dollar value of Prime R&R&D Funding Agreements with Small Business Concerns in the following categories for the reported FY. (This data should include SBIR and all other Awards over $10,000.)

	FY 1991 Total Number	Total Dollar
1. Contracts (Excludes GSA/FSS & Purchase Orders)	127	$10.93
2. Grants	337	$26.97
3. Cooperative Agreements	Data not collected	

b. Total number and total dollar value of R&R&D Funding Agreements with Other Than Small Business for the following categories for the reported FY.

	Total Number	Total Dollar
1. Contracts (Excludes GSA/FSS & Purchase Orders)	121	$ 140.8
2. Grants, Co-op Agreements and other actions	15,289	$1,624.8
3. Cooperative Agreements	Data not collected	

NOTES:

1. **Other Than Small Business** includes any and all obligations provided to an organization that is not a small business concern as defined in 13 CFR, Part 121, Federal Register, Vol. 54, No. 244, page 52634, et seq (December 21, 1989).

2. **R&R&D Obligations** include extramural plus intramural funds.

3. **Reporting** includes all contracts, grants and cooperative agreements less SBIR awards.

1/ Excludes SBIR Awards, Purchase Orders, GSA/FSS Awards, Interagency Agreements, primes under other agencies' contracts.
2/ Information Available on contracts only.
3/ Total Conduct of R&D, FY 91 Actual Data reported by Office of Budget, Finance and Award Management, NSF.

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

ANNUAL REPORT TO THE U. S. SMALL BUSINESS ADMINISTRATION

Reporting Fiscal Year: 1991

Agency:	**Reporting Unit:**
National Science Foundation	Office of Small Business R&D
Submitted by (please print or type) Name:	**Date:**
Carolyn J. Smith	May 22, 1992
Signature: Carolyn J. Smith	**Phone Number:** (202) 653-5202

1. **Agency Total Extramural R&R&D Budget** $ 1,697.4

2. **Agency Total SBIR Budget** $ 21.22

3. **Solicitation Data**

3a. Total Number of Phase I SBIR Solicitations Released	1
3b. Identification Number of the Solicitation	NSF 91-20
3c. Date of Solicitation Released	April 1, 1991
3d. Solicitation Proposal Due Date	June 17, 1991
3e. Number of Topics in Solicitation	26
3f. Number of Subtopics in Solicitation	N/A
3g. Number of Solicitations Distributed	45,000

(Agencies that released more than one solicitation should attach a separate sheet for each solicitation detailing all information required in Section 3 above.)

1/ Calculated using actual FY 91 data as provided from NSF's Office of Budget, Finance and Award Management, minus intramural research estimate from NSF's latest available FY 91 data: NSF conduct of R&D -- $1,706.5 mil., minus $9.1 mil. x 1.25% = $21.2175.

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

ANNUAL REPORT TO THE U. S. SMALL BUSINESS ADMINISTRATION

4. **Phase I Data**

4a. Number of Phase I Proposals Received	1492	
4b. Number of Phase I Awards for Reported FY	184	
4c. Phase I Dollars Obligated for Reported FY		$ 9,161,533
4d. Number of Minority and Disadvantaged Phase I Awards for Reported FY	18	
4e. Minority and Disadvantaged Phase I Dollars Obligated for Reported FY		$ 894,621

5. **Phase II Data**

5a. Number of Phase II Proposals Received	131	
5b. Number of New Phase II Awards for Reported FY	56	
5c. Total Funding Agreement (Face) Amount of new Phase II Awards		$ 13,218,312 2/
5d. Number of New Phase II Minority and Disadvantaged Awards for Reported FY	4	
5e. Total Funding Agreement (Face) Amount of Minority and Disadvantaged New Phase II's		$ 959,602

6. **Agency Phase II Obligations**

6a. Number of New Phase II Awards Funded with Initial Obligations for Reported FY	56	
6b. Dollar Amount of Obligations for New Phase II Awards for Reported FY		$ 12,369,159
6c. Number of Previously Reported Phase II Awards with Dollars Obligated during Reported FY	5	
6d. Dollar Amount of Second and Subsequent FY's Obligations of Previously Reported Awards		$ 442,806

2/ Includes $849,153 proposed funding for continuing grants in FY 92 contingent upon availability of funds and scientific progress of the project.

SMALL BUSINESS INNOVATION RESEARCH (SBIR) PROGRAM

ANNUAL REPORT TO THE U. S. SMALL BUSINESS ADMINISTRATION

7. Agency Total SBIR Obligations

7a. Number of Funding Agreements with Dollar Modifications During Reported FY: 5

7b. Net Dollar Amount of Modifications for Reported FY: $ 44,517

7c. Total Agency Obligations for Reported FY (This amount is the sum of # 4c + 6b + 6d + (-) 7b.): $ 22,018,015

8. Awardee Information

Please attach a list of all new Phase I and Phase II SBIR awards made during the reporting year. The list should include the following information:

(a) Awardee Name and Complete Address. Please indicate if name of firm receiving Phase II award changed since it received Phase I award.

(b) Solicitation Number, Topic Number, and Subtopic Number

(c) Project Title

(d) Total Funding Agreement (FACE) Amount

(e) Dollars Obligated this Fiscal Year

(f) Identify Minority and Disadvantaged Owned Small Businesses

(g) Identify Women-Owned Small Business Concerns

(h) Period of Performance (in months)

(i) Identify Phase II Winners that Obtained a Follow-on Funding Commitment.

9. Name and address of small business concerns for whom process exceeded (6) month period from the closing date of agency SBIR Solicitation to date of SBIR award.

List attached.

10. If known, the name and address of small business concerns for which there has been a name change from the time of the Phase I award to the award of Phase II.

None known.

FY 1991 SBIR PHASE I AWARDS

FIRM	ADDRESS		PRINCIPAL INVESTIGATOR		TITLE	AWARD AMOUNT	M	W*	Topic No.
Adaptive Solutions Inc	1400 NW Compton Drive Suite 340	Beaverton	OR 97006	Skinner Toby E	Feasibility of Spoken Letter Recognition on a VLSI Neurocomputer	48,870.00	N	N	20
Adelphi Technology Inc	285 Hamilton Ave Suite 430	Palo Alto	CA 94301	Boyers David G	High Efficiency Ozone Generation	49,987.00	N	N	25
Adelphi Technology Inc	285 Hamilton Ave Suite 430	Palo Alto	CA 94301	Piestrup Melvin A	Superlattice Channeling Radiation as an Intense, Quasi-Monochromatic X-Ray Source	49,996.00	N	N	3
Advanced CounterMeasure Systems	9838 Old Placerville Rd	Sacramento	CA 95827	Reed Jeffrey H	An Optimal Time-Dependent Receiver for Interference Rejection	49,979.00	N	N	21
Advanced Environmental Research Group Inc	Rt 2 Box 2948	Davis	CA 95616	Thornton Donald K	Electrically-Activated, Liquid-Crystal Filled, Holographic Diffractive Structure for Wavelength Control	49,464.00	N	N	1
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT 061080 343	Serio Michael A	Reprocessing of Used Tires into Activated Carbon and Other Carbon Materials	49,947.00	N	N	25
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT 061080 343	Serio Michael A	Non-Intrusive Diagnostics to Study Soot Formation	49,924.00	N	N	23
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT 061080 343	Morrison Philip W	In Situ Measurement of Submicron Particles During Synthesis from Gaseous Precursors	49,941.00	N	N	23
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT 061080 343	Solomon Peter R	A New Method of Time-Temperature Modeling of Sedimentary Basins	49,689.00	N	N	7
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT 061080 343	Solomon Peter R	Improved Time Resolution Infrared Spectroscopy	49,862.00	N	N	2
Advanced Technology Materials Inc	520-B Danbury Road	New Milford	CT 067764 318	Kirlin Peter S	Plasma Enhanced Chemial Vapor Deposition of Bati03	50,000.00	N	N	3

M = Minority and Disadvantaged Owned

W = Woman Owned

Advanced Technology Materials Inc	520-B Danbury Road	New Milford	CT	067764 318	Hamaguchi Norihito		Weak Link Formation in Thallium Borium Calcium Copper Oxide	50,000.00	N	N	3
AeroChem Research Laboratories Inc	P. O. Box 12	Princeton	NJ	08542	Calcote Hartwell	F	Combustion Synthesis of Powders for Advanced Ceramic Materials	49,967.00	N	N	23
Aerodyne Research Inc	45 Manning Road	Billerica	MA	018213 976	Kebabian Paul	L	Investigation of a Zeeman Split Neutral Xenon Laser for Infrared Monitoring of Atmospheric Carbon Monoxide	49,980.00	N	N	6
AeroHydro Inc	P O Box 684/Main Street	Southwest Harbor	ME	04679	Letcher John	S	Lofting and Fabrication of Compound-Curved Plates	43,198.00	N	N	22
Aerosol Dynamics	2811 Wilshire Blvd Suite 790	Santa Monica	CA	90403	Hering Susanne	V	On-Line Determination of Single Particle Size and Density inthe 5 - 100 nm Diameter Range	49,852.00	N	Y	23
American Research Corporation of Virginia	P.O. Box 3406	Radford	VA	241433 406	Sarrafzadeh Adel		Fracture Toughness Testing of Engineering Materials Using Hybrid Quantitative Nondestructive Techniques	50,000.00	N	N	24
Ansoft Corporation	4 Station Square Suite 660	Pittsburgh	PA	15219	Ashtiani Cyrus	N	Separation of Large DNA Molecules by Gel Electrophoresis Using a Sweeping Electric Field	49,781.00	N	N	15
Apeldyn Corporation	520 S W Yamhill	Portland	OR	97204	Rumbaugh Scott	H	Investigation of Liquid Crystal Polarization Controller for Coherent Fiber-Optic Communication System	46,325.00	N	N	21
Applied Research Associates Inc Albuquerque	4300 San Mateo Blvd NE Ste A220	Albuquerque	NM	87110	Sues Robert	H	Research and Development of an Optimum Device to Reduce Seismic Structural Pounding Damage	49,929.00	N	N	25
Applied Research Laboratory (ARL) Inc	1745 Jefferson Davis Hwy Ste 306	Arlington	VA	22202	Morel Donald	E	Injection Molding of Metal Matrix Composites	46,465.00	N	N	22
Applied Science and Technology Inc	35 Cabot Road	Woburn	MA	01801	Post Richard	S	Microwave Plasma Diamond Deposition at High Growth Rates	50,000.00	N	N	24
Applied Science and Technology Inc	35 Cabot Road	Woburn	MA	01801	Post Richard	S	Plasma and Ultra Violet Damage in Oxygen Photoresist Stripping with a Downstream Microwave Plasma Source	50,000.00	N	N	21

Aprend Technology	2369 Laura Lane	Mountain View	CA	94043	Alvarez Robert	E	Optical Force Trap Micromanipulator	49,655.00	Y	N	15
Arctic Energies Ltd	511 Heavitree Lane	Severna Park	MD	21146	Kumm William	H	Engineering Research on Fuel Cells for Antarctic Energy Production and Conservation As Well As Potable Water Treatment and Delivery	49,979.00	N	N	9
Arete Technologies	15 Withington Lane	Harvard	MA	01451	Matson Stephen	L	A Membrane-Stabilized Preferential Crystallization Process	49,850.00	N	N	23
Arizona Instrument Corporation	PO Box 1930 1100 E University DR	Tempe	AZ	85281	Chelvayohan Mahesan		Activated Thin Film Noble Metal Combustible Gas Sensors	49,562.00	N	N	2
AstroPower Inc	30 Lovett Avenue	Newark	DE	19711	Mauk Michael	G	Conformal Heteroepitaxy of GaAs and InP on Silicon and Sapphire Substrates	50,000.00	N	N	21
AstroPower Inc	30 Lovett Avenue	Newark	DE	19711	Negley Gerald	H	Large-Scale Liquid Phase Epitaxy of Multiple Layer III-V Semiconductor Compounds	50,000.00	N	N	21
Atom Sciences Inc	114 Ridgeway Center	Oak Ridge	TN	37830	Willis Robert	D	New Concepts in Ultrasensitive Noble Gas Detection for OceanScience Applications	50,000.00	N	N	8
Aurora Flight Sciences Corporation	P O Box 11998	Alexandria	VA	22312	Langford John	S	Lightweight Autonomous Dropwindsonde System for Unmanned Aircraft	50,000.00	N	N	6
Bend Research Inc	64550 Research Road	Bend	OR	977018 599	Herbig Scott	M	A New Class of Photo-Responsive Polymers	49,993.00	N	N	3
Bend Research Inc	64550 Research Road	Bend	OR	977018 599	Kelley Stephen	S	Development of Novel Organic/Inorganic Hybrid Materials	49,981.00	N	N	3
Bend Research Inc	64550 Research Road	Bend	OR	977018 599	van Eikeren Paul		Novel Membrane-Based Process for the Production of Substituted Benzyl Alcohols	49,965.00	N	N	25
Bio-Metric Systems Inc	9924 West Seventy Fourth Street	Eden Prairie	MN	55344	Swanson Melvin	J	Receptor Immobilization for Affinity Separations	50,000.00	N	N	23

Bio-Metric Systems Inc	9924 West Seventy Fourth Street	Eden Prairie	MN 55344	Guire Patrick	E	Semiconductor Surface Chemistry for Biosensors	50,000.00	N	N	10
Biological Monitoring Inc	PO Box 184	Blacksburg	VA 24063	Diamond Jerome	M	Automated Fish Ventilatory Monitoring for Distinguishing Different Toxicants	47,190.00	N	N	25
Bonneville Scientific Inc	918 East 900 South	Salt Lake City	UT 84105	Grahn Allen	R	Ultrasonic Separation of Fine Particulates	50,000.00	N	Y	23
Brewer Science Incorporated	2401 High Tech Dr PO Box GG	Rolla	MO 65401	Brewer Terry		Intrinsically Absorbing Polymers for Antireflective Coating Applications	50,000.00	N	N	21
Brewer Science Incorporated	2401 High Tech Dr PO Box GG	Rolla	MO 65401	Moss Mary	G	Electrical Devices Based on Spin-Coatable Polyanilines	50,000.00	N	N	21
California Bio-Marine Products	1001 Capri Road	Leucadia	CA 92024	Mendola Dominick		Aquaculture of Tropical Marine Sponges to Yield Research andCommercial Quantities of Bio-Active Secondary Metabolites	50,000.00	N	N	8
Cambridge Acoustical Associates Inc	80 Sherman Street	Cambridge	MA 02140	Cole John	E	Actively Controlled Hood for Machinery Noise	48,594.00	N	N	24
Candela Laser Corporation	530 Boston Post Road	Wayland	MA 01778	Treacy Brian		Optical Tweezers	50,000.00	Y	N	1
Cape Cod Research Incorporated	PO Box 600 (95 Main Street)	Buzzards Bay	MA 02532	Deans John	R	A Novel Rhizobium Delivery System for Legumes	50,000.00	N	N	10
Cape Cod Research Incorporated	PO Box 600 (95 Main Street)	Buzzards Bay	MA 02532	Dixon Brian	G	A High Performance Marine Timber Protection System	50,000.00	N	N	25
Catalytica Inc	430 Ferguson Drive Bldg 3	Mountain View	CA 94043	Evitt Eric		Efficient Approaches to New Organic Compounds by Metathesis of Functional Olefins	49,500.00	N	N	2
ChemLogic	67 Blackstone Str	Bellingham	MA 02019	Aurian-Blajeni Benedict		Dielectric Materials for Capacitors for Ultralow Temperatures	50,000.00	N	N	3
CHROMEX INCORPORATED	15000-B Central Avenue S E	Albuquerque	NM 87123	Gobeli Garth	W	A Multiple Input 90 Millimeter Spectrograph	49,986.00	N	N	2

Coleman Research Corporation	5950 Lakehurst Dr	Orlando	FL	32819	Gibbs Bruce	P	Application of Model-Based Predictive Control to Fossil Power Plants	49,950.00	N	N	21
COMTEK	702 East Woodland Road	Grafton	VA	23692	Abrahamson Louis	A.	Pedagogical Techniques for Classroom Communication Systems	49,841.00	N	N	26
Continuum Dynamics Inc	P O Box 3073	Princeton	NJ	08543	Bilanin Alan	J	An Acoustic Air Conditioner	49,332.00	N	N	23
Creare Incorporated	Etna Road P O Box 71	Hanover	NH	03755	Valenzuela Javier	A	Advanced Microdrilling Process	48,924.00	N	N	22
Creare Incorporated	Etna Road P O Box 71	Hanover	NH	03755	Rothe Paul	H	Two-Phase Computational Fluid Dynamics	49,890.00	N	N	4
Daniel H Wagner Associates Hampton	2 Eaton St Suite 500	Hampton	VA	23669	Hulbert Douglas	S	Numerical Solutions for Aircraft Tracking and Position Prediction	49,785.00	N	N	4
DCS Corporation	954 East Hennepin Avenue	Minneapolis	MN	554141 314	Sandborgh Raymond	E	Estimating Software Effort Completion	49,998.00	Y	N	17
Dean Technology Inc	P O Box A-56	Hanover	NH	03755	Dean Robert	C	High-Speed Biphase Microdrops	49,453.00	N	N	22
Dinsmore Instrument Company	1814 Remell	Flint	MI	48503	Dinsmore Robert	C	Phase-shift Effect Magnotometer	49,930.00	N	N	7
Displaytech Incorporated	2200 Central Avenue	Boulder	CO	80301	Arnett Kenneth	E	Nonlinear Optics and Integrated Optical Switching with Ferroelectric Liquid Crystal Waveguides	49,628.00	N	N	21
Displaytech Incorporated	2200 Central Avenue	Boulder	CO	80301	Thurmes William		Synthesis of Ferroelectric Liquid Crystals for Infrared Modulators	49,999.00	N	N	2
DNA Plant Technologies Inc Oakland	6701 San Pablo Avenue	Oakland	CA	94608	Dooner Hugo	K	Isolation of Fatty Acid Biosynthetic Genes from Arabidopsis - A First Step in Plant Oil Content Modification	49,692.00	N	N	11
DULY Research Inc	1912 MacArthur Street	Rancho Palos Verdes	CA	90732	Yu David U.	L	A Compact Electron Injector for an X-Ray Lithography Ring	49,994.00	Y	N	21
ECC Incorporated	4400 Fair Lakes Court	Fairfax	VA	220333 899	Avramovic Bozidar		Artificial Intelligence in Power System Voltage Control	50,000.00	N	N	21

Ecodynamics Research Associates Inc	PO Box 8172	Albuquerque	NM	87198	Knupp Patrick	M	Robust and Fast Numerical Grid Generation	49,783.00	N	N	4
ElectroChem Inc	400 W Cummings Park	Woburn	MA	01801	Jalan Vinod		Anion Exchange Membrane Based Fuel Cell for Transportation Applications	50,000.00	N	N	23
Electrostatic Applications	16525 Jackson Oaks Dr	Morgan Hill	CA	95037	Crowley Joseph	M	A Software Tool for Analytical Solutions of Laplace's Equation	49,886.00	N	N	26
Electrosynthesis Company Inc	P O Box 430	East Amherst	NY	14051	Genders David		New Technology for the Production of Sodium Hydroxide	50,000.00	N	Y	2
Elliot Geophysical Co Inc	3865 E 34th Street Suite 106	Tucson	AZ	85713	Elliot Charles	L	A Small Integrated Geophysical Instrument for the Field Measurement of the Magnetic and Electrical Properties of Rock Samples	48,705.00	N	N	7
Eltron Research Inc	4260 Westbrook Drive	Aurora	IL	60504	Sammells Anthony	F	Mixed Conducting Membranes for NOx Decomposition in Automobile Exhausts	50,000.00	N	N	23
Energy International Inc	127 Bellevue Way SE Suite 200	Bellevue	WA	980046 229	Bernstein Samuel		Parallel Process Simulation Technique for Combustion Analysis	49,943.00	N	N	23
Engineering Software Research and Development Inc	48 Crestwood Drive	Clayton	MO	63105	Myers Kent	W	Software Architecture for Advanced Finite Element Analysis Methods on Parallel and Distributed Computational Systems	49,980.00	N	N	16
Essex Corporation Florida	1040 Woodcock Rd Suite 227	Orlando	FL	32803	Kennedy Robert	S	Improving Productivity by Dose Equivalency Modeling	48,518.00	N	N	13
Excel Technology Inc	140-20 Keyland Court	Bohemia	NY	11716	Rao Rama		High Temperature BCSCO Superconducting Films on Si Substrate at Low Processing Temperature for Possible Applications in Hybrid Opto-Electronic Devices	50,000.00	Y	Y	3
Exfluor Research Corporation	P. O. Box 7807	Austin	TX	78713	Kawa Hajimu		The Synthesis of Perfluoropolyether Di-Basic Carboxylic Acids by Direct Fluorination	50,000.00	N	N	3

Fastman Inc	1414 Millard Street	Bethlehem	PA	18018	Tucker Michael		Absolute Interferometry for the Machine Tool Industry	50,000.00	N	N	22
Fore Systems Inc	116 Greyfriar Drive	Pittsburgh	PA	15215	Bitz Francois		Topology and Routing for Multiple-Switch ATM-Based Local Area Networks	47,473.00	N	N	18
Giner Inc	14 Spring Street	Waltham	MA	022549 147	Sarangapani	S	Proton Exchange Membrane Electrochemical Ultracapacitor	50,000.00	Y	N	23
Giner Inc	14 Spring Street	Waltham	MA	022549 147	Kackley Nancy	D	Treatment of Reinforcing Bars During Construction of Concrete Structures to Prevent Corrosion	50,000.00	Y	N	24
Hydrogenesis Incorporated	14814 18th Court SE	Mill Creek	WA	98012	Vila Jose	M	Aerial Wells: Water from the Air	50,000.00	N	N	23
Hypermedia Systems Inc	6754 North Whipple Street	Chicago	IL	606454 123	Rokach Abraham	J	The Interactive Structural Analysis Instructor and Helper	49,996.00	N	N	26
IGC/Advanced Superconductors Inc	1875 Thomaston Avenue	Waterbury	CT	06704	Motowidlo Leszek	R	Niobium Titanium Superconductors with Improved Current Density Through the Use of Artificial Pinning Centers	49,887.00	N	N	3
ImmunoGen Incorporated	148 Sidney St	Cambridge	MA	02139	Guild Braydon	C	Genetic Engineering of a Ricin Immunotoxin	50,000.00	N	N	11
Implant Sciences Corporation	35 Cherry Hill Drive	Danvers	MA	01923	Bunker Stephen	N	Arbitrary Concentration Surface Alloys Using Ion Implantation	49,586.00	N	N	3
InfoLogic Software Inc	1223 Peoples Avenue Suite 5405	Troy	NY	12180	Kass David		Methods to Test a Large, Complex Very Large Scale Integration Computer Aided Design oftware System	49,991.00	N	N	19
INRAD Inc	181 Legrand Avenue	Northvale	NJ	07647	Zhang Zhenyu		Synthesis of Zeolite Membranes on Polymer Films	49,186.00	N	N	23
Intelligent Text Processing Inc	1310 Montana Avenue	Santa Monica	CA	90403	Dahlgren Kathleen	G	Wide Coverage Syntactic Processing	50,000.00	N	Y	13
INTERMET Technology	166 Long Road	Georgetown	PA	15043	Krepski Richard	P	Pre-College Education Modules in Materials Science	35,774.00	N	N	26
Intersonics Inc	3453 Commercial Ave	Northbrook	IL	600621 818	Weber K. Richard		Liquid Phase Processing and Synthesis at Very High Temperatures	49,517.00	N	N	3

KSE Inc	P O Box 368	Amherst	MA	01004	Kittrell James	R	Novel Diesel Particulate Catalytic Oxidation Trap	49,878.00	N	N	23
KSE Inc	P O Box 368	Amherst	MA	01004	Singh Rajindar		A Novel Chemically Modified Ultrafiltration Membrane Process	49,765.00	N	N	25
Laser Technology Inc	10131 Colonial Industrial Drive	South Lyon	MI	48178	Niedzielski Peter		Pulsed Laser Spot Cleaning	48,775.00	N	N	22
LaserGenics Corporation	P O Box 611330	San Jose	CA	951611 330	Schlecht Richard	G	Single Crystal Fibers of Cerium Doped Gadolinium Silicate for Scintillation Detectors	49,801.00	N	N	1
LaserGenics Corporation	P O Box 611330	San Jose	CA	951611 330	Schlecht Richard	G	Very High Temperature Fibers of Vanadium Carbide and Niobium Carbide	49,963.00	N	N	24
LaserGenics Corporation	P O Box 611330	San Jose	CA	951611 330	Schlecht Richard	G	Tunable Fiber Laser Materials	49,963.00	N	N	21
Lynntech Inc	111 East 27th Street Suite 204	Bryan	TX	77803	Hitchens Duncan		Enzyme Electrodes Based on Photoactivated Conducting Organic Polymers	50,000.00	N	N	25
Lynntech Inc	111 East 27th Street Suite 204	Bryan	TX	77803	Murphy Oliver	J	Paired Electrochemical Synthesis of Ozone and Hydrogen Peroxide for Waste Water Treatment	50,000.00	N	N	25
Lynntech Inc	111 East 27th Street Suite 204	Bryan	TX	77803	Murphy Oliver	J	Conducting Polymers for Iontophoretic Self-Administration Drug Delivery Devices	50,000.00	N	N	25
MacConnell Research	11408 Sorrento Valley Road #202	San Diego	CA	92121	MacConnell William	P	Method of Ordering Chromosome-Specific Overlapping Clones	49,708.00	N	N	11
Marko Materials Inc	19-1 Sterling Road	North Billerica	MA	01862	Ray Ranjan		Molybdenum Silicide (MoSi2) Based High Temperature Materialswith Enhanced Ductility and Toughness	49,887.00	Y	N	3
Massachusetts Technological Laboratory Inc	312 Austin Street	West Newton	MA	02165	Fang Ta-Ming		Design of "SMART" Phased Arrays Utilizing Massively Parallel Computer Architectures	48,826.00	Y	N	17

Ion Physics Corporation	11 Industrial Way	Atkinson	NH 03811	Milde Helmut	I	Apparatus for Water Treatment by Simultaneous Application ofHigh Potential Gradients and Ozone	50,000.00	N	N	9
Ionics Research Inc	10655 Richmond Ave Suite 170	Houston	TX 77042	Schwartz Robert	D	Purification of Macromolecules by Precessing Continous Counter-Current Distribution	50,000.00	N	N	15
Ionwerks	2215 Addison	Houston	TX 77030	Schultz Albert	J	Mass Spectroscopy of Recoiled Ions (MSRI) for U-Pb Geochronology	50,000.00	N	N	7
Iowa Laser Technology Inc	6122 Nordic Drive	Cedar Falls	IA 50613	Baldwin Mark	W	A Laser Manufacturing Process for Stripping of Paint Coatings	50,000.00	N	N	22
J and D Scientific Inc	1815 West 1st Avenue Suite 102	Mesa	AZ 85202	Yaniv Daphna	R	Glucose Microbiosensor Utilizing Scanning Tunneling Microscopy	49,931.00	N	N	25
John R Bayless Co	20325 Seaboard Road	Malibu	CA 90265	Bayless John	R	Advanced Concept for Waste Gas Pollution Control	50,000.00	N	N	25
John R Bayless Co	20325 Seaboard Road	Malibu	CA 90265	Bayless John	R	Feasibility Experiments for the Induction Synchrotron Accelerator Concept	50,000.00	N	N	21
Jupiter Technologies	187 Langmuir Lab Brown Road	Ithaca	NY 14850	Panda Prakash	C	Glass Ceramic-Diamond Composites for Electronic Packaging Applications	50,000.00	Y	N	3
K C Research Corporation	11231 Main Range Trail	Littleton	CO 80127	Cerni Todd	A	A New High Sensitivity Laser Hygrometer	49,964.00	N	N	6
KAB Laboratories Inc	3116 Mercer Lane	San Diego	CA 92122	Konotchick John		Improvements to Magnetic Induction Nerve Stimulation	50,000.00	N	N	25
Key Curriculum Press	2512 M L King Jr Way PO Box 2304	Berkeley	CA 94702	Rasmussen Steven		Researching Support Materials for Geometry Education Software	49,850.00	N	N	26
Knowledge Based Systems Inc	2746 Longmire Drive	College Station	TX 778415 424	Mayer Paula S.	D	Intelligent Assistant for Simulation Model Generation from IDEF3 Process Descriptions	49,550.00	N	N	22
Knowledge Based Systems Inc	2746 Longmire Drive	College Station	TX 778415 424	Mayer Paula S.	D	Knowledge Based Information Model Integration	49,686.00	N	N	22

Materials and Electrochemical Research Corporation	7960 South Kolb Road	Tucson	AZ	85706	Withers James	C	The Synthesis of Titanium Aluminide with Carbon Addition as a High Coefficient of Thermal Expansion Fiber Utilizing Plasma-Assisted Chemical Vapor Deposition	50,000.00	N	N	3
Materials and Electrochemical Research Corporation	7960 South Kolb Road	Tucson	AZ	85706	Loutfy Raouf	O	Metal Coated Nanoparticles for Nonlinear Optics	50,000.00	N	N	3
Materials Modification In	P O Box 4817	Falls Church	VA	22044	Malshe Ajay		Ultrafine Structures by Evaporation from Liquid Sources	50,000.00	Y	N	21
Mathematical Technologies Inc	One Richmond Square	Providence	RI	02906	Manbeck Kevin		Mathematical Methods for Emission Computed Tomography	49,963.00	N	N	4
McLean Media	19 Locke Lane	Mill Valley	CA	94941	McLean Lois	M	Women in Science: A CD-ROM Multimedia Database	46,931.00	N	N	26
MEI Research	40975 Chiltern Drive	Fremont	CA	94539	Mogri Juzer	S	A 4 GHZ Multi-Chip System for High Resolution Analog-to-Digital Converters	50,000.00	Y	N	19
Membrane Technology & Research Inc	1360 Willow Road Suite 103	Menlo Park	CA	94025	Baker Richard	W	Surface Chemical Reaction Techniques for Ultrathin CompositeMembranes	50,000.00	N	O	23
Mickley & Associates	752 Gapter Rd	Boulder	CO	80303	Mickley Michael	C	A Novel Approach to Make Low-Fouling Polymeric Membranes	49,997.00	N	N	23
MicroFab Technologies Inc	1104 Summit Avenue Suite 110	Plano	TX	75074	Wallace David	B	Picoliter Solder Droplet Dispensing for Electronics Manufacturing	50,000.00	N	N	22
Microgravity Research Associates	PO Box 10505	Midland	TX	79702	Mazuruk Konstanty		GaAs by Liquid Phase Electroepitaxy in Gllium Bismuth Solution	49,182.00	N	N	3
Moltech Corporation	Chemistry Bldg SUNY Stony Brook	Stony Brook	NY	117943 400	Skotheim Terje	A	Electroluminescent Devices Based on Organometallic Membranes	49,811.00	N	N	21
Norian Corporation	1025 Terra Bella Avenue	Mountain View	CA	94043	Constantz Brent	R	Evaluation of New Cementing Technique for Implants	49,985.00	N	N	25
North American Geotechnical Co	3658 Lake St	Houston	TX	77098	Davies B		A Real Time Scour Measurement Instrument	49,655.00	N	N	25

North Star Research Corporation	5555 Zuni Road S E Suite 345	Albuquerque	NM 87108	Adler Richard	J	RF Accelerator Technology for Very High Powers	47,185.00	N	N	21
Nova Technology Inc	1206 Lanier Blvd NE	Atlanta	GA 30306	Lao Kenneth	Q	Laser Speckle Interferometric Microscope	47,669.00	Y	N	3
O C A Applied Optics Inc	7421 Orangewood Avenue	Garden Grove	CA 92641	Joseph Michael	P	Durable Silver-Based High-Reflectance Coating	49,599.00	N	N	5
Optivision Inc	744 San Antonio Road	Palo Alto	CA 94303	Farrelle Paul	M	Intelligent Bus Extender Crossbar Network	50,000.00	N	N	18
Optivision Inc	744 San Antonio Road	Palo Alto	CA 94303	Farrelle Paul	M	Methods for Reducing the Blocking Artifact Observed in Images Which Have Been Compressed Using Transform Coding andVector Quantization	50,000.00	N	N	18
Optron Systems Inc	3 Preston Court	Bedford	MA 01730	Fuleihan Camille	F	Thin Film Optical Frequency Converter	49,992.00	Y	N	21
Oregon Laser Consultants	455 Hillside Avenue	Klamath Falls	OR 97601	Deutschman William	A	Modeling Laser and Optical Phenomena for Technology Students	45,831.00	N	N	26
Paradigm Development Group Ltd	3701 Sumter Court	Fairfax	VA 22033	Buede Dennis	M	Examination of Automated Problem Structuring Techniques	49,988.00	N	N	14
Paradigm Development Group Ltd	3701 Sumter Court	Fairfax	VA 22033	Buede Dennis	M	Decision Analysis Convergence Techniques	49,959.00	N	N	14
PCP Consulting and Research Inc	P.O. Box 5943	Lawrenceville	NJ 08648	Ramaprasad R		A Photochemical Method for the Production of Semiconductor Grade Silicon for Use in Energy Conversion Devices	50,000.00	Y	N	23
Peptides International Inc	10101 Linn Station Road	Louisville	KY 40223	Benovitz Deanne	E	Membrane Based Peptide Synthesis	46,500.00	N	N	25
Permacharge Corporation	5930 Midway Park Blvd NE	Albuquerque	NM 87109	Bragg Lewis	E	Microcellular Electret Foam Filtration Media Fabrication	50,000.00	N	Y	23
Physical Optics Corporation	20600 Gramercy Place Suite 103	Torrance	CA 90501	Chen T		Electro-Optic and All-Optic Collinear Asymmetrical Directional Coupler	49,972.00	N	N	21

Physical Optics Corporation	20600 Gramercy Place Suite 103	Torrance	CA	90501	Moslehi Behzad		High Speed Fiber Optic Modulator Based on Surface Plasmon Wave Resonant Coupling	49,974.00	N	N	21
Physical Optics Corporation	20600 Gramercy Place Suite 103	Torrance	CA	90501	Sadovnik		A Real-Time Holographic Printer for Computer-Assisted Three-Dimensional Modeling of Macromolecules	49,991.00	N	N	15
Physical Sciences Inc	20 New England Business Center	Andover	MA	01810	Parker Terence	E	Transient NOx/Soot Monitor	49,949.00	N	N	23
Phyton Catalytic Inc	225 Langmuir Lab Box 1027	Ithaca	NY	148501 257	Bringi Venkataraman	N	Engineering and Biological Considerations for Immobilized Plant Cell Systems	49,896.00	N	N	25
Plasma Dynamics	60 Hurd Road	Belmont	MA	02178	Lane Barton	G	A Novel Large Area Microwave Source for Diamond Thin Film Deposition	50,000.00	N	Y	21
Polytronix Inc	805 Alpha Drive	Richardson	TX	75081	Lin Jacob	W	Improved Bonding of Indium-Tin-Oxide (ITO) to Plastic Substrates	50,000.00	N	N	3
Preservation by Pressurization Partners	287 Pyle Road	Fillmore	CA	93015	Keller G		Effects of Positive Pressures on Biological Reactions in Post-Harvest Products	47,000.00	N	N	10
Princeton X-Ray Laser Inc	1-H Deerpark Drive	Monmouth Junction	NJ	08852	Blanc Joseph		Three-Dimensional Displays for Cell Microscopy from a Number of Two-Dimensional Displays: Transforming Depth into Time	50,000.00	N	Y	15
Princeton X-Ray Laser Inc	1-H Deerpark Drive	Monmouth Junction	NJ	08852	Blanc Joseph		Optically Driven and Controlled X-Ray Source	49,998.00	N	Y	1
PSI Technology Company	20 New England Business Center	Andover	MA	01810	Taylor Jennings		On-Site Electrochemical Peroxide Generator	50,000.00	N	N	23
Quantex Corporation	2 Research Court	Rockville	MD	20850	Storti George	M	New Detector Screen Media for Autoradiography	49,822.00	N	N	15
Radiation Monitoring Devices Inc	44 Hunt Street	Watertown	MA	02172	Entine Gerald		Additive to Improve the Plasticity and Drying of Large Ceramics	50,000.00	N	N	3
Radiation Monitoring Devices Inc	44 Hunt Street	Watertown	MA	02172	Squillante Michael	R	Large Area, Position Sensitive X-Ray Detector	50,000.00	N	N	3

Radiation Monitoring Devices Inc	44 Hunt Street	Watertown	MA	02172	McGann William	J	A Large Area Real-Time Imaging System for Screening DNA Libraries	50,000.00	N	N	15
Radiation Monitoring Devices Inc	44 Hunt Street	Watertown	MA	02172	Squillante Michael	R	A New Variable Bandgap Semiconductor System	50,000.00	N	N	3
Radiation Monitoring Devices Inc	44 Hunt Street	Watertown	MA	02172	Lund James	C	Novel Photodetector for Scintillation Spectroscopy	50,000.00	N	N	1
Rainbow Analysis Systems Group	PO Box 9775	Austin	TX	78766	Johnson Allen	M	A New Simulation Method for System Dependability Analysis	49,324.00	Y	N	17
Real-Time Intelligent Systems Corporation	16 Summerhill Ave	Worcester	MA	01606	Green Peter	E	Artificial Intelligence Support for Statistical Process Control of Discrete Manufacturing Processes	49,953.00	N	N	22
Rocky Mountain Instrument Company	1501 S Sunset Street	Longmont	CO	80501	Aminou A		Low Cost, Light Weight Optics for Application to Infrared Detection	49,325.00	Y	N	5
Saphikon Inc	51 Powers Street	Milford	NH	03055	Bates Herbert	E	Oxide Eutectic Filaments for High Temperature Composites	49,764.00	N	N	3
Science Research Laboratory Inc	15 Ward Street	Somerville	MA	02143	Flusberg Allen		Coherent Laser Remote Structural Analysis	49,980.00	Y	N	24
Scientific Research Associates Inc	50 Nye Road P O Box 1058	Glastonbury	CT	06033	Kreskovsky John	P	Educational Software for Demonstrating Two-Dimensional Semiconductor Device Physics	49,779.00	N	N	26
Scientific Research Associates Inc	50 Nye Road P O Box 1058	Glastonbury	CT	06033	Fernandez Salvador	M	Tunable Time-Resolved Fluorescence Microscopy	49,947.00	N	N	15
SEASUN Power Systems	124 East Rosemont Ave	Alexandria	VA	22301	Hagerman George	M	Hydrodynamic Modeling and Feasibility Study of a Wave-Powered Pump	43,665.00	N	N	25
Signal Analytics Corporation	374 Maple Ave East Suite 200	Vienna	VA	221804 718	Mort Michael	S	Automatic Classification of Nanoplankton Using a Neural Network on Color Fluorescence Microscope Images	49,125.00	N	N	8

Silicon Engines Inc	955 Commercial Street	Palo Alto	CA	94303	Lozano Raul		Protocol to Support Real-Time Video Teleconferencing on Integrated Services Digital Network	46,975.00	N	N	18
Smart Software Inc	392 Concord Avenue	Belmont	MA	02178	Smart Charles	N	Forecasting Fluctuating Demand in Manufacturing	49,989.00	N	N	14
Spire Corporation	Patriots Park	Bedford	MA	01730	Namavar Fereydoon		SIMOX Structures for Optical Waveguides and Electro- Optic Devices in Silicon	49,861.00	N	N	21
Spire Corporation	Patriots Park	Bedford	MA	01730	Halverson Ward	D	Radiation-Tolerant Membranes for X-Ray Lithography Masks	49,877.00	N	N	21
Spire Corporation	Patriots Park	Bedford	MA	01730	Johnson Edward	A	Growth of Epithelial Cells on Textured Surfaces	49,711.00	N	N	25
Spire Corporation	Patriots Park	Bedford	MA	01730	Daly James	T	Combination Effluent Scrubber/Heat Recovery System for Semiconductor Processes	49,997.00	N	N	23
Spire Corporation	Patriots Park	Bedford	MA	01730	Blatchley Charles	C	Microchannel Plate Amplifiers by Accelerator Bombardment and Particle Track Etching	49,999.00	N	N	1
Stylometrics Inc	19 Briggs Street	Quincy	MA	02170	Willett Shirley		A Computational Model of 3D/2D Apparel Pattern Design and Expert System	50,000.00	N	Y	22
Superconductor Technologies Inc	460 Ward Drive Suite F	Santa Barbara	CA	931112 310	Robinson McDonald		Chemical Vapor Deposition Epitaxial Buffer Layers for Superconductors	49,995.00	N	N	3
Sutter Instrument Corporation	40 Leveroni Court	Novato	CA	94949	Flaming Dale	G	A Laser Based Quartz Micropipette Puller	49,648.00	N	N	13
Tanner Research Inc	444 N Altadena Drive	Pasadena	CA	91107	Tanner John		Analog CMOS Neural Circuits for Speech Recognition	49,994.00	N	N	21
TCI Software Research Inc	1190 Foster Road	Las Cruces	NM	88001	Hunter Roger	H	Mathematical Objects for Display and Manipulation	50,000.00	N	N	4
TDA Research Inc	12421 West 49th Avenue, #6	Wheat Ridge	CO	80033	Copeland Robert	J	A Novel Cooling Device	50,000.00	N	N	23
Terra Tek Inc	400 Wakara Way	Salt Lake City	UT	84108	Zheng Ziqionq		Self-Stabilizing Underground Excavation Cross Section	50,000.00	N	N	24

Top Level Inc	196 North Pleasant Street	Amherst	MA	01002	Murray Kelly	E	Scalable Supercomputing: Integrating Distributed Processingin a General Purpose Parallel Programming Language	48,800.00	N	N	17
TPL Inc	100 Via Florence	Newport Beach	CA	92663	Harrah Larry	A	A New Hermetic Sealing Ceramic Material Derived at Low Temperature from a Sol Gel	50,000.00	N	N	24
Transducer Research Inc	1228 Olympus Drive	Naperville	IL	60540	Stetter Joseph	R	Real-Time, Long-Term Monitoring of Volcanic Emissions	49,585.00	N	N	7
Transitions Research Corporation	15 Great Pasture Road	Danbury	CT	06810	Weiman Carl F.	R	Robot Vision System Based on Log-Polar Image Plane Coordinates	49,842.00	N	N	20
Ultramet	12173 Montague Street	Pacoima	CA	91331	Sherman Andrew	J	Forced Flow Thermal Gradient Pulse Silicon Carbide Infiltration for Improved Ceramic Composites	49,999.00	N	N	22
Universal Energy Systems Inc	4401 Dayton-Xenia Road	Dayton	OH	454321 894	Bhattacharya Rabi	S	Modifications of Solid Lubricating Coatings by MeV Ion Beams	49,971.00	Y	N	3
Weidlinger Associates	4410 El Camino Real Suite 110	Los Altos	CA	94022	Wojcik Gregory	L	An Application-Specific Computer for Laplace's Equation	49,998.00	N	N	19
Zeger-Abrams Incorporated	1112 Clark Road	Wyndmoor	PA	191181 504	Abrams Burton	S	Investigation of a Novel Direct Sequence, Code Division Multiple Access Receiver with Near/Far Immunity	49,982.00	N	N	18

NATIONAL SCIENCE FOUNDATION

FY 1991 NEW SBIR PHASE II AWARDS

DURATION: 24 MONTHS

FOLLOW-ON FUNDING AGREEMENT OBTAINED FROM ALL PHASE II WINNERS EXCEPT 1, AS NOTED ON PAGE 3 ATTACHED.

FY 1991 SBIR PHASE II AWARDS

FIRM	ADDRESS			PI		PROJECT TITLE	SOL. NO. TOPIC NO.	AWARD AMOUNT
Adelphi Technology Inc	285 Hamilton Ave Suite 430	Palo Alto	CA 94301	Piestrup Melvin	A	A Multilayer Mirror/Monochromator for Dual-Energy Digital Subtraction Angiography	89-30 1	$268,607.00
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT 061080343	Solomon Peter	R	Temperature Modulation Method for In-situ Measurement of Surface Temperature & Emissivity	89-30 23	$236,244.00
Advanced Refractory Technologies Inc	699 Hertel Avenue	Buffalo	NY 14207	Shaffer Peter T. B.		Scale-up Studies in Silicon Nitride and Tantalum Synthesis by Flame Technology	88-8 3	$229,656.00
Advanced Research and Applications Corporation	425 Lakeside Drive	Sunnyvale	CA 94086	Dusaussoy Nicolas	J	Three Dimensional Reconstruction of Images of Interior Objects Using X-rays and Large Area Detectors	89-30 24	$250,000.00
Advanced Surface Technology Inc	85 Rangeway Road Bldg #1	North Billerica	MA 01862	Loh Ih-Houng		Coating For Implantable Biosensors	89-30 25	$250,000.00
American Research Corporation of Virginia	P.O. Box 3406	Radford	VA 241433406	Varshney Usha	V	Laser-Driven Directional Solidification in High Tc Superconducting Polycrystalline Fibers	89-30 22	$225,000.00

MD = Minority and Disadvantaged Owned Small Businesses
WO = Woman Owned Small Business

Atmospheric and Environmental Research Inc	840 Memorial Drive	Cambridge	MA 02139	Louis Jean-Francois	Optimizing a Local Weather Forecast System	89-30 6	$224,945.00
Aurora Flight Sciences Corporation	P O Box 11998	Alexandria	VA 22312	McGeer Tad	THESEUS: A High-altitude Aircraft for Atmospheric Science	89-30 6	$220,000.00
Bio-Imaging Research Inc	425 Barclay Boulevard	Lincolnshire	IL 60069	Sivers E. Anne	Subsurface Inspection with X-ray Generated Positrons	88-8 24	$249,588.00
Biosym Technologies Inc	10065-A Barnes Canyon Road	San Diego	CA 92121	Lee Richard H	Algorithms for the Building of Model Proteins Using Structural Homology	89-30 11	$250,000.00
Brewer Science Incorporated	2401 High Tech Dr PO Box GG	Rolla	MO 65401	Brewer Terry	Polyimide Sacrificial Layer Materials for Micromachining Applications	89-30 21	$223,200.00
Cambridge Scientific Inc	195 Common Street	Belmont	MA 02178	Trantolo Debra J	Enzymatically-Based Sulfate Modification on Sea-Weed Derived Polysaacharides	89-30 25	$250,000.00
Charles Evans & Associates	301 Chesapeake Drive	Redwood City	CA 94063	Fleming Ronald H	Imaging Neutron Activation Analysis	89-30 2	$224,945.00
Continuum Dynamics Inc	P O Box 3073	Princeton	NJ 08543	Bilanin Alan J	Improved Means of Trailer Base Drag Reduction	89-30 23	$224,762.00

Convolve Inc	132 Nassau St	New York	NY 10038	Singer Neil	C	Improving the Dynamic Performance of Manufacturing Systems and High Speed Products 22	89-30	$250,000.00
Covalent Associates Inc.	52 Dragon Court	Woburn	MA 01801	Langmuir Margaret	E	A Fiber Optic Fluorescence Detector for the Lithium Ion 23	89-30	$249,647.00
Daniel H Wagner Associates Inc (Hampton Office)	2 Eaton St Suite 500	Hampton	VA 23669	Overton Robert	H	Automated Container Ship Loading 21	88-8	$249,426.00
Data Parallel Systems Inc	P O Box 954	Bloomington	IN 47402	Bridges Timothy		Single Instruction Stream Multiple Data Stream (SIMD) Parallel Algorithms for Nested Relational Database Implementation 20	88-8	$250,000.00
Digital Video Processing Inc	2401 Research Blvd Suite 200	Rockville	MD 20850	Girson Andrew	D	An American-Sign-Language-To-English Recognition and Translation System 20	89-30	$249,691.00 *
DNA Plant Technologies Inc Oakland	6701 San Pablo Avenue	Oakland	CA 94608	Dunsmuir Pamela		Genetic Engineering of Plants with Antifreeze Proteins to Enhance the Quality of Frozen Plant Products 11	89-30	$224,339.00 WO
ECC Incorporated	4400 Fair Lakes Court	Fairfax	VA 220333899	Avramovic Bozidar		Relief of Energy Transfer Limitations 21	89-30	$224,878.00
Energy and Environmental Research Corporation	18 Mason	Irvine	CA 92718	Lyon Richard	K	Removal of Submicron Particles and Sulfur and Nitrogen Oxides 23	89-30	$246,218.00

* No Follow-on Funding Commitment for this project.

ENIG Associates Inc	11120 New Hampshire Ave Ste 500	Silver Spring	MD 209042633	Krispin Jacob		High-Resolution Calculations in Gas Dynamics	89-30 24	$231,583.00	
Excel Technology Inc	101-2 Colin Drive	Holbrook	NY 11741	Rao Rama		Extremely Sensitive and High Speed Quantum Detector in 1-10 Micron Region Fabricated with High Tc BCSCO Superconductor	88-8 5	$225,000.00	
EXPORTech Company Inc	P.O. Box 588	New Kensington	PA 150680588	Oder Robin	R	Magnetostatic Coalescence	88-8 23	$250,913.00	
Giner Inc	14 Spring Street	Waltham	MA 022549147	Sarangapani S.		Advanced Corrosion Resistant Materials For Electrochemical Applications	89-30 3	$259,661.00	MD
INRAD Inc	181 Legrand Avenue	Northvale	NJ 07647	Landmann Wolf		Nondestructive Instrumentation for Measureing Thermal Conductivity and Interface Thermal Resistance of Thin Films	89-30 23	$224,993.00	
Interphases Research Co	722 Rushing Creek Place	Thousand Oaks	CA 91360	Menezes Shalini		A New n-CuInSe Based Photovoltaic Cell With an Electrochemically Formed p-(CuIn2S3I)-CuISe3 Window	89-30 21	$224,983.00	MD
Intersonics Inc	3453 Commercial Ave	Northbrook	IL 600621818	Krishnan Shankar		Polarimetric Emission Pyrometer for Temperature Measurement	89-30 3	$249,968.00	

John R Bayless Co	20325 Seaboard Road	Malibu	CA 90265	Bayless John	R	Plasma Electron Gun Feasibility Experiments	89-30 21	$243,637.00	
John R Bayless Co	20325 Seaboard Road	Malibu	CA 90265	Bayless John	R	Advanced Density Logging Tool	89-30 7	$242,927.00	
Maurer Engineering Inc	2916 West T.C. Jester	Houston	TX 77018	Maurer William	C	Deep Earth Sampling System	89-30 7	$224,107.00	
MicroMed Systems Inc	120 South Whitfield	Pittsburgh	PA 15206	Copper Jack	M	Design and Prototype of an Acoustic Analysis Workstation	88-8 25	$240,397.00	
Moltech Corporation	Chemistry Bldg SUNY Stony Brook	Stony Brook	NY 117943400	Hale Paul	D	Advanced Amperometric Biosensors	89-30 25	$224,999.00	
Newport Electro Optics Systems Inc	4451-B Enterprise Court	Melbourne	FL 32935	Young Eddie		A New Efficient Acousto-Optic Resonator For GHz Laser Mode Locking	89-30 21	$224,958.00	MD
Nonvolatile Electronics Inc	12800 Industrial Park Blvd	Plymouth	MN 55441	Daughton James	M	Highly Magnetoresistive Thin Film Multilayers	89-30 3	$215,851.00	
Peninsu-Lab	5795 NE Minder Road	Poulsbo	WA 983708814	Ames Robert	N	Biological Control of Soilborne Plant Pathogens in Containerized Growing Media	88-8 12	$186,908.00	
Perinatronics Medical Systems Inc	2411 Crofton Lane Suite 14B	Crofton	MD 21114	Frank Thomas	H	The Feasibility of an Adaptive Canceller for Real-Time Signal Extraction	88-8 19	$250,000.00	

Physical Optics Corporation	20600 Gramercy Place Suite 103	Torrance	CA 90501	Lin Freddie		Multiplexed Holographic Fabry-Perot Resonators for Optical Communications and Processing Applications	89-30 21	$249,993.00
Physical Optics Corporation	20600 Gramercy Place Suite 103	Torrance	CA 90501	Chen Ray	T	Polymer Gelatin Waveguide Modulator	89-30 1	$249,982.00
Physical Sciences Inc	20 New England Business Center	Andover	MA 01810	Frish Michael	B	Non-Intrusive Furnace Exhaust Gas Temperature Monitor	89-30 23	$221,647.00
Quantex Corporation	2 Research Court	Rockville	MD 20850	Soltani Peter	K	A High Resolution Cathode Ray Tube Employing a New Thin Film Phosphor	89-30 21	$225,585.00
Queues Enforth Development	432 Columbia Street	Cambridge	MA 02141	Cahn Michael	F	The Queue Inference Engine: A New Technology for Monitoring & Managing Waiting Lines	88-8 14	$224,137.00
Rangen Aquaculture Research Center	Route 1 Box 264	Hagerman	ID 83332	Grant Blake	F	Nutritionally-Balanced Microcapsules For Penaeid Shrimp Larvae	89-30 8	$236,660.00
Rose Plastics & Machinery Inc	12247 W Fairview Avenue	Milwaukee	WI 53226	Rose Douglas	R	A Prototype System for Molding Virgin and Recycled Discontinuous Long-Fiber Reinforced Plastic Composites into Commericial Products	89-30 22	$249,400.00

Saltire Software Inc	2535 SW 211th Court	Aloha	OR 97006	Todd Philip		Hypergraph Methods for Variational Geometry	89-30 22	$223,940.00	
Software Design & Analysis Inc	PO Box 3521	Boulder	CO 80303	Dowson Mark		Ada Quality Toolset	89-30 17	$238,346.00	
Tanner Research Inc	444 N Altadena Drive	Pasadena	CA 91107	Tanner John		The Use of Ultra Violet Radiation to Improve Chips Used in Neural Synapses	89-30 19	$224,553.00	
TDA Research Inc	12421 West 49th Avenue, #6	Wheat Ridge	CO 80033	Wright John	D	Mechanisms of Ignition Enhancement in Methanol-Dimethyl Ether Diesels	89-30 23	$249,623.00	
Terrapin Diagnostics Inc	165 Eighth Street, Suite 306	San Francisco	CA 94103	Kauvar Lawrence	M	Protein Affinity Chromatograpy	89-30 11	$250,000.00	
TiNi Alloy Company	1144 65th Street	Oakland	CA 94608	Johnson A. David		High Force Micro-Actuator Using TiNi Shape Memory Alloy	89-30 21	$249,334.00	
Top-Vu Technology Inc	2650 14th Street NW	New Brighton	MN 55112	Vu Tho	T	Gallium Arsenide Readout and Preprocessing Electronics for Linear One-Dimensional and Z-Dimensional Infrared Focal Plane Array Sensors	89-30 19	$250,000.00	MD
Vatell Corporation	PO Box 66	Christiansburg	VA 24073	Langley Lawrence	W	Thermal Conductivity, Diffusivity Instrument	89-30 23	$207,334.00	

WYKO Corporation	2650 East Elvira Rd	Tucson	AZ 85706	Wyant James		High Resolution Interferometric Profiler for Submicron Linewidth Measurements	89-30 21	$266,676.00
Yellowstone Environmental Science	320 S Willson Avenue	Bozeman	MT 59715	Hunter Robert	M	System for In Situ Rehabilitation of Pipelines	89-30 24	$229,071.00
Zytron Ltd	85 N Cretin	Saint Paul	MN 55104	Sweeny Mark	F	Magnetic Gradiometer Using High Critical Temperature Superconductors and a Fluxgate Sensor	89-30 21	$180,000.00

National Science Foundation

FY 1991 SBIR Annual Report Data

Names and addresses of small firms for whom the SBIR Phase I Award Date exceeded December 18, 1991

NSF SBIR SOLICITATION NO. NSF 90-31, CLOSING DATE: June 18, 1990

FY91

NATIONAL SCIENCE FOUNDATION
PROPOSALS EXCEEDING 6 MONTH PERIOD

FIRM	STREET	CITY	STATE
Adaptive Solutions Inc	1400 NW Compton Drive Suite 340	Beaverton	OR
Adelphi Technology Inc	285 Hamilton Ave Suite 430	Palo Alto	CA
Advanced Environmental Research Group Inc	Rt 2 Box 2948	Davis	CA
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT
Advanced Fuel Research Inc	P O Box 380343 87 Church Street	East Hartford	CT
Advanced Technology Materials Inc	520-B Danbury Road	New Milford	CT
AeroChem Research Laboratories Inc	P. O. Box 12	Princeton	NJ
Aerosol Dynamics	2811 Wilshire Blvd Suite 790	Santa Monica	CA
Ansoft Corporation	4 Station Square Suite 660	Pittsburgh	PA
Applied Research Associates Inc Albuquerque	4300 San Mateo Blvd NE Ste A220	Albuquerque	NM
Applied Science and Technology Inc	35 Cabot Road	Woburn	MA
Aprend Technology	2369 Laura Lane	Mountain View	CA
Arizona Instrument Corporation	PO Box 1930 1100 E University DR	Tempe	AZ
Atom Sciences Inc	114 Ridgeway Center	Oak Ridge	TN
Biological Monitoring Inc	PO Box 184	Blacksburg	VA
Brewer Science Incorporated	2401 High Tech Dr PO Box GG	Rolla	MO
Brewer Science Incorporated	2401 High Tech Dr PO Box GG	Rolla	MO
California Bio-Marine Products	1001 Capri Road	Leucadia	CA
Cape Cod Research Incorporated	PO Box 600 (95 Main Street)	Buzzards Bay	MA
Catalytica Inc	430 Ferguson Drive Bldg 3	Mountain View	CA
CHROMEX INCORPORATED	15000-B Central Avenue S E	Albuquerque	NM
Dinsmore Instrument Company	1814 Remell	Flint	MI
Displaytech Incorporated	2200 Central Avenue	Boulder	CO
DNA Plant Technologies Inc Oakland	6701 San Pablo Avenue	Oakland	CA
ElectroChem Inc	400 W Cummings Park	Woburn	MA
Electrosynthesis Company Inc	P O Box 430	East Amherst	NY
Elliot Geophysical Co Inc	3865 E 34th Street Suite 106	Tucson	AZ
Essex Corporation Florida	1040 Woodcock Rd Suite 227	Orlando	FL
Giner Inc	14 Spring Street	Waltham	MA
Giner Inc	14 Spring Street	Waltham	MA

NSF Proposals Exceeding 6 Month Period (con'd.)

Hydrogenesis Incorporated	14814 18th Court SE	Mill Creek	WA
Intelligent Text Processing Inc	1310 Montana Avenue	Santa Monica	CA
John R Bayless Co	20325 Seaboard Road	Malibu	CA
K C Research Corporation	11231 Main Range Trail	Littleton	CO
KAB Laboratories Inc	3116 Mercer Lane	San Diego	CA
KSE Inc	P O Box 368	Amherst	MA
LaserGenics Corporation	P O Box 611330	San Jose	CA
Lynntech Inc	111 East 27th Street Suite 204	Bryan	TX
MacConnell Research	11408 Sorrento Valley Road #202	San Diego	CA
MEI Research	40975 Chiltern Drive	Fremont	CA
Membrane Technology & Research Inc	1360 Willow Road Suite 103	Menlo Park	CA
Norian Corporation	1025 Terra Bella Avenue	Mountain View	CA
Nova Technology Inc	1206 Lanier Blvd NE	Atlanta	GA
O C A Applied Optics Inc	7421 Orangewood Avenue	Garden Grove	CA
Optivision Inc	744 San Antonio Road	Palo Alto	CA
Paradigm Development Group Ltd	3701 Sumter Court	Fairfax	VA
Paradigm Development Group Ltd	3701 Sumter Court	Fairfax	VA
Permacharge Corporation	5930 Midway Park Blvd NE	Albuquerque	NM
Physical Sciences Inc	20 New England Business Center	Andover	MA
Phyton Catalytic Inc	225 Langmuir Lab Box 1027	Ithaca	NY
Princeton X-Ray Laser Inc	1-H Deerpark Drive	Monmouth Junction	NJ
Quantex Corporation	2 Research Court	Rockville	MD
Radiation Monitoring Devices Inc	44 Hunt Street	Watertown	MA
Radiation Monitoring Devices Inc	44 Hunt Street	Watertown	MA
Science Research Laboratory Inc	15 Ward Street	Somerville	MA
Scientific Research Associates Inc	50 Nye Road P O Box 1058	Glastonbury	CT
Silicon Engines Inc	955 Commercial Street	Palo Alto	CA
Smart Software Inc	392 Concord Avenue	Belmont	MA
Spire Corporation	Patriots Park	Bedford	MA
Transducer Research Inc	1228 Olympus Drive	Naperville	IL
Ultramet	12173 Montague Street	Pacoima	CA
Weidlinger Associates	4410 El Camino Real Suite 110	Los Altos	CA