Table II-2

21

Share of Federally Funded Industrial 1/ R&D Directed to Basic Research

iscal Years 1970 - 78

aniero anoru	<u>9</u> 4	(250) 10	State			
	scal Year	<u> <u>A</u></u>	Per	cent fo	r Basid	Research
公 选 9. 会议 第二	1970	:22	-860-		2.4%	azaa
1. B. A.	1971	20	- 51		2.2	A027
E A	1972	184	5)		2.0	600
ço -	1973	8			2.5	181
08÷	1974	3 8 yr.	3		1.6	SENCO
	1975				1.5	I
centers (FFRDC	1976	reserict 3 or.	tebeut of Stis soct	Federral Valibera	1.5	ni <u>Ni</u> Isa
	1977(est)			· · ·	1.6	
	1978(est)	· · · · · · ·		the second second	1.8	
1						

S MINES: FORST FULLY STRUCK, 451

1/ Includes federally funded research & development centers (FFRDC's) administered by this sector.

Source: Federal Funds surveys. NSF 1/25/78

as ibau?

- (a)

Table II-4: " Basic Research in Industry by Source of Funds

(Dollars in millions) 1970 - 1978

		Total Basic R.	Federal	Company	Company as a % of total
	1970	\$602	\$158 3782	\$444	74%
	1971	58Í	125 STOL	456	79
· · · · · · · · · · · · · · · · · · ·	1972	582	127 A. O.	455	78
· ·	1973	620	129	491	79
	1974	688 ²⁵	160 BREE	528	77
	1975	717 . S	1573ab)(Sel	560	78
	1976	786	172 2 an 19782	614	78
	1977(est)	835	185	650	78
	1978(est)	905	205	700	77
Avge an of chan 1970-1		тана Соластана 5.2%	an-128 (septre) 3.3% 8€\4}\1	5.9%	

Source: National Science Foundation 1/25/78

	<u>Table II-6:</u>	Basic Research by	Performing Sect	or, 1970 - 78	2 ² 2 6 ²
. •		Federal Govt.	NERS STERVERSE STATION STATE	niversities & Colleges	Nonprofit
J NA.	1970	\$541	\$602	\$2,065	\$305
	1971 (cr.	491	581	2,174	322
	1972	538 ⁻⁸⁷⁵	582	2,272	345
	1973	537 ⁼⁰	620	2,352	357 ³⁶ 7 ³⁶ 7
	1974	611	688	2,447	396
	1975	682	717	2,713	407
	1976	719	786	2,890	439
	1977(est)	790	835	3,155	479
	1978(est)	850	905 abides	n 3,580 ,	<
	ಸೇಸಕರ ಕಾರ್ಯಗಳ್ಳಗ ಸ್ಥಾ	sia sai percent i	Distribution	ີ່ເສຍແຜນ ກາສາເປີດຊື່ ຫຼືກັບສະຫລັດເຫັນ ແຜ	n Briggerför 1987 av Annahman
	1970	15.4%	17.1%	58.8%	8.7%
	1971	13.8	16.3	60.9	9.0
	1972	14.4	15.6	60.8	9.2
	1973	13.9	16.0	60.8	9.2
	1974 .	14.8	16.5	59.1	9.6
	1975	15.1	15.9	60.0	9.0
	1976		16.3	59.8	9.1
·	1977(est)	15.0	15.9	60.0	9.1
	1978(est)	14.5	15.5	61.1	8.9

Source: National Science Foundation 1/25/78

813

Table II-8: Funds for Industrial Basic Research by Field of Science: (Includes Company and Federal Funds) 1971 and 1976

	100110	1.2.146.0	in it in on sy	19 - CARE -		· .
Repres Sector Color Total Physical Sciences	<u>19442</u> •8672 578	<u>1971</u> \$581 281	% of Tota1 100%	<u>1976(</u> Pre] \$786 350	<u>100%</u>	Percent Change 35.% 25
Chemistry		180	31.	249	} 32 }∂11.00 ∛	2 38 :
0ther	ý.t	101	17	101	- 13.3533 en 65:305324	
Mathematics		14	2	13	2	-7 Teoblaci
Environmental Sciences		8	î	15	2 21 Med april 50	88
Atmospheric Sciences	de T	3	.5%	6	-1995-1996 1 ∙8% are tetra	100.0
Geological Sciences		8	. 5%	6	.8%	3 100 €0Å.
Oceanography	. S	2	.3%	3	.4%	50.0
Engineering	951	159	27.	175	ar 22 :toobs/	563 10 FCA
Life Sciences		94	. 16	134	17	43
Biological Sciences	•	57	10	101	13	77
Clinical Medical Sciences		37	6	33	4	_11 * *
Other Sciences	-	24	4	99	13 13	313

(Dollarsein millions)

Source: National Science Foundation 1/15/78

815

Table II-10: Funds for Basic Research by Selected Industry

and Source of Funds: 1971 and 1976

100

(Dollars in Millions)

	Federal	% Total	1971 Company	% Total	Federal	<u>1976 (Preliminary)</u> % Total Company %% Total		
Total	\$125	100%	\$456	100%	\$172	700%	\$614	
Chemicals & Allied Products	30	24%	······································	41	63	37	259 42	
Electrical Equipment & Communication	35	28%	108	24	21	12	127 21	
Aircraft & Missiles	17	14	36	8	20	12	32 5	
Nonmanufacturing	24	19	2 7 5 110	2	15	9	14 2 2	
All other industries Source: National Science 1/25/78	19 - Property and the second s	Guptin Lotanton en la vi Suern caneta Constanton electro electrostantes Constantes electrostationes Lestrostationes activitationes	encompany former encompany, and source former encompany, and source former encompany.	 Sound and a first of the second s	 53 Absolve Sedart Sampon (2001) A	31 t.	30 182 17 17 18 19 10 10 10 10 10 10 10 10 10 10 10 10 10	
		AND AN D D				C .	ere in suid the instantial state of the	

Scientists and Engineers Population and Funding

Comparison of certain of the data on the population of scientists and engineers working in basic research and employed by industry with the data on funding patterns for basic research support in industry shows the following:

Rank Ordered by Percent of Total, By Field

Doctoral S&E Basic Resear Industry by of Science	ch in	Funds for Industrial Basic Research by Field of Science, 1976	
Total	100%	Tota]	100%
Physical scientists Life scientists Engineers Environmental sci-	14.4%	Engineering Elsenant coestific sciences Other sciences	45% 22% 17% 13%
entists Psychologists Math & Stat scientists	4.4% 2.2% 2.0%	Versient of 2005-A	2% 2%
Computer scientists Social scientists	1.7%	TTOP CALVY FRANCES	

In both lists physical science, life science, and engineering are the top three in proportions of people and funding and in each list they include well over 80% of the totals. These not surprising parallels suggest a high likelihood of both interests and capabilities from the industrial basic research sector in these three fields if opportunities for funding relatively unstructured basic research were available. The dominance of these three fields should not suggest a lack of capabilities or interest in industry in other fields of science that have smaller resources. In the nature of basic research, it would be fallacious to assume that size or quantity are necessarily dependable indicators of ingenuity or creativity. The good record in technological innovation of small firms compared to larger firms illustrates this point.

Experience in other agencies, summarized in Part IV of this report, does not suggest the likelihood of extremely heavy proposal pressure or interest from private firms as measured by sheer volume of proposals when support is equally accessible to all proposers. Yet NSF has encountered very keen interest by a small business r and d sector that appears relatively limited in number but whose actual dimensions currently are not known in any systematic way.

-NSF-Proposal-Pressure-from-Industry-and-Awards-to-Industry-

The flow of proposals for research support from private firms to NSF programs is affected significantly by the views of the science community on the likelihood of proposal approval. This is true both for NSF directorates, and for individual fields of science or program areas within directorates. The observation is based on several dozen conversations with representatives of private firms coming to the Office of Small Business R&D for information and guidance, and the observation is confirmed to some degree by NSF data.

NSF's basic research supporting directorates adhere to the policy that awards to private industrial firms are made only under special criteria that are additional to the criteria of scientific merit applicable to all proposals. This is discussed in more detail in a later section.

The Directorate for Scientific, Technological and International Affairs and the Directorate for Science Education issue a number of program announcements each year. These announcements indicate who is eligible to apply for support. In a number of areas such as program evaluation, policy research and analysis, data processing and analysis, and program design and recommendations, commercial firms are eligible to submit proposals.

The Directorate for Research Applications (now succeeded by the Directorate for Applied Science and Research Applications), has from its establishment funded proposals from industrial concerns, including small business. Beginning in fiscal year 1976, the Congress directed a special emphasis toward the support of proposals from small, firms capable of quality research and development.

NSF DIRECTORATES, EXCLUDING RESEARCH APPLICATIONS

In total, NSF directorates and offices (excluding RA) received 137 proposals from private firms for grant and contract support in fiscal year 1977. Seventy-nine such awards were made to private firms, 35 of them to small businesses.

The highest number, as well as proportion of FY 1977 total directorate obligations to commercial firms, is in the Directorate for Scientific; Technological and International Affairs. This is true also for awards to small business firms. Awards to private firms by STIA divisions support such work as policy studies and analyses and provision of assistance for international travel arrangements. The STIA small business awards range from processing of survey data for the Division of Science Resources Studies to research primarily by software firms on use of scientific information for the Division of Science Information.

Science Education awards to business firms supported such work as program evaluation, experimental science programs for television, and data processing.

fears dood and yotfou sid!

RESOLUTION ON BASIC RESEARCH IN INDUSTRY APPROVED BY THE NATIONAL SCIENCE BOARD <u>tseat</u> AT ITS 195th MEETING ON JANUARY 19-20, 1978 网络紫色树 小叶 2 ri bevi⊷arr ງສະວິດເພີ່ອຸດສຸມ, ສະວິດສະຊິດຄະ HELESIA STROQUENTS STEW LIDGE-RODSHID laange latt GeoThe National Science Board unanimously seed but emerging attendeCIDED. that the Foundation's policy on there is any good the support of basic research by private to the set and profit organizations should be modified garantias sindicated by the following language; see the second of (a insewhich should be substantially reflected in (1913) and) Frinklage National Science Foundation policy searches fearpoland bes a sit a si**documents** and sea to bee well and be retrie yespecto uniper, escu The National Science Foundation welcomes in Jacob La unsolicited proposals from commercial crush is firms. But it also wants to avoid substituting Federal support for normal commercial investment in normal commercial investment in research or compromising the vitality of research in educational institutions, 白い花花の where research makes a special added contribution to science education. Thus, unsolicited proposals for the second secon from commercial firms may be funded (a) the project is of special where: concern from a national point of view; TAGE POR appoint (b) special resources are available in industry for the work; or (c) the project proposed is especially meritorious. and motions thinks work of working for our shadet. beau eru: The National Science Foundation is also particularly interested in supporting research projects that couple the research resources and perspectives of industry with the research resources and perspectives of universities. It a histoph therefore especially welcomes proposals for cooperative research projects in-10.1551141月106 volving both universities and industry. 28 Set 20 C the sense of the tradition of the contract of the sense o nedian trucks managed to this velocitiened to see as seen at a company of the ຊີຊີຊີເປັນ ຕໍ່ໄດ້ເຊັ່ມຂຶ້ນຜູ້ແມ່ການອີກລະນີ່ມີເອົ້າແມ່ນມີກລັບເຊັ່ງເມື່ອເມື່ອງດີ ເອັນການການອີນສະຊີ ຊີປະການເຊັ່ງຜ ການກາງການເປັນການອີນສະຊີແຕ່ເປັນມີກວ່າຍົມຂະຫາການແຮກເຮັບສາກອຸດແອກເຫຼີ່ ແໜກນີ້ເອົາ ກາງແຜນແຮງ ແລະແໜກຊີ ແລະແໜນນີ້

si populi napata di dalaying di dalah kata kata dalah s

823

General RA Program Area

·····································	
Productivity WIRDERS READER AND	agr 171 5 (134) esc
Environment (1994, 108, 168, 36	134 (94)
Resources	92 (87)
Technology Assessment	25 (14)

25

143250

3.32

In fiscal year 1976, 247 proposals were received by RA from private films, compared to the total of 431 in FY 1977. The FY 27 solicitation appeared to stimulate a substantial increase in proposals. Strong interest in the solicitation led to 8000 requests for the announcement in addition to 4000 in the initial mailing.

In the FY 1977 proposals from industry, some relatively small number of the proposals submitted in response to the solicitation would have been submitted without it, according to comments received at the Office of Small Business R&D. There were several advantages to submitting a proposal in response to the solicitation: the prospect of qualifying for Phase II support; no cost-sharing requirement and a fee allowed since the proposals were solicited; winning such an NSF competition could be commercially prestigious and advantageous to a firm; the tie-in to venture capital; and patent rights.

1.16.10

91.1.29

thin work a second

37.

JATON

Other (Contractional Office) of Prainter's Polymers (Contraction (2014 - 10 Contraction) (Contraction)

entresseries and the second and a contraction of the second second second second second second second second se

Table III-2

FY 77--Proposals Received by NSF from Industry--By Directorate--& Amount Requested

		•
	RC 07 - 17	ana - 19 .0 2010.00
Directorate	<u>No</u>	ed over the table of Amount
Mathematical, Physical & Engineering Sciences	22	\$ 2,481,701
Scientific, Technological & International Affairs	45	4 ,975,938
Astronomical, Atmospheric, Earth & Ocean Sciences	29	9,865,225
Research Applications	431	23,829,799
Biological & Behavioral & Social Sciences	11	1,524,600
Science Education	17	2,256,902
Administration	5	634,445
Office of Planning & Re- sources Management	7	311,563
Office of Government & Public Programs	_1	e or en <u>trans5,000</u> eers of entranses fak
TOTAL:	568	\$45,885,173 How Harlow Details How To Have How To Have Have Harlow Details
		andre and a standard and a standard An an
n na serie de la composición de la comp	n and Yerren Arrightson Arrightson	anna an the the second s
90 - 1871 년 1976 년 1 1월 17 월 1		Biorectic Constant (1997) - Sociel Constant - Roman Statements
n en de la Réferir de la composition de	1) i	
and the second	a traditional	n - 17 2 Na 1916 - Brill State Baser, lein - 1918 - A Milliander (* 19
1997 - 1997 -		n 1995 - Martin Start, and Start and Albertan 1995 - Martin Start, and Albertan 1995 - Andrew Start, and Albertan
1997 (1997) 1997 - 1997 - 1997 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -		

827

$A \le 1$

1946780. 42- Netherster

1.1 keV

No.

Directorate/Field

Research Applications		en avan i ti	\$ 3,235,800
Resources Environment Productivity Communications	tital (91 134 170 2	\$ 3,235,800 11,871,300 7,197,827 265,400
Industrial Technology Assessment Other	oti sis	8 25 1	142,819 1,115,675 978
	TOTAL:	431	53, 5 523, 829, 799
Science Education	化合成化 花儿		997,430
Science & Society Science Education Develo Science Education Resear	CN	11 1	1,248,984. <u>10,488</u> 2,256,902
- 	TOTAL:	17	
Planning & Resources Manage	ment		al and the Constant Strate Arrest of
Other Studies	EN NY CENT	.a 7	311,563
Administration	11. AN 11	12	
Training Data Processing & Equipm	ent Rentals TOTAL:	2 3 15	43,350 <u>591,095</u> 634,445

Government & Public Programs

remment a navne negoties. 55,000 AudioeVisual no 28 com negoties fear bar bar a sonta avappination 1993 28 com providente companyation. 15 com providente as newsparts polis. Born and to be also

as in the offensions of the second - And Althe Applemented only relaxed and depty admentation and the second s

Augusta Andreas (1997) autoria (1997)

41.

Amount

a tar a comencia		Table III-5	i _{je s} e s			
	FY 1977 A	WARDS TO IN	DUSTRY	95 .1 67193 3	le de la composition La XX - Internet	
·	BY DIRECTORATE	AND FIELD O	F SCIENCE	OR	pissonat ac	1997 - 19 1
	PROGRAM AREA	WITHIN DIR	ECTORATE ¹	n an leistr	ont i anach Crùd courr	3.1
		. 5057	: (A41)	ann 1921 3	za 63 last va L	d.
Directorate/Field/	Program Area	-	<u>No.</u>		Amount	5) 51.4K
Mathematical & Phys	sical Sciences &	Engineerin	g h Repret	est a gr	unit 6 he d	
Mathematical Sc Engineering Materials Reseau Chemistry Other		TOTAL:	4 5 1 1 12	9-5-445C 	3,000 231,300 399,500 60,000 24,535 \$718,335	ya (155) 1
Scientific, Technol	logical & Interna	ational Affa	irs			
Policy Research International So Science Informat Science Resource	ience a average	e Gooden a Total :	5 2 8 <u>6</u> 21	tos () (). periorens	217,847 524,915 694,979 534,269 \$1,972,010	profile States
Astronomical, Atmos	pheric, Earth &	Ocean Scier	nces			
Atmospheric Scie Polar Programs	ences	TOTAL	9 10 19		694,000 7,443,372 \$8,137,372	,
Biological, Behavio	oral & Neural Sci	ences		:		
Biological Scier Social Sciences	ices	TOTAL:	4 2 6	····	245,356 <u>95,200</u> \$340,556	
Research Applicatio	ns					
Technology Asses Environment Productivity Industrial Resources Exploratory Rese Communications Research Evaluat RA Other	arch	TOTAL :	10 25 43 6 13 2 8 2 1 110	· · . ·	781,935 3,664,079 2,713,752 385,578 1,179,637 138,115 468,887 120,607 <u>261,480</u> \$9,714,070	

and the last

Table III-6

FY 1977 GRANT AND CONTRACT AWARDS1/

TO SMALL BUSINESS2/

<u>Directorate</u>	No. Awards	Amount	% of FY 77 Obligations	FY 77 Obligations
Mathematical & Physical Sciences & Engineering	5	258,635		224.4
Scientific, Technological & International Affairs	16	1,754,163	9.0	19.4 ^{<u>3</u>/}
Astronomical, Atmospheric, Earth & Ocean Sciences	3	209,800	.09	233.5 <u>4</u> /
Research Applications	95	7,594,435	11.9	63.7 ^{3/}
Science Education	5	91, 4, 4, 4, 5, 60, 60, 60, 60, 60, 60, 60, 60, 60, 60	.94	59.0 <u>5</u> /
Biological, Behavioral & Social Sciences		82,700	.07	126.6
Planning & Resources Management	3	125,664	• <u>-</u>	
Office of Government & Public Programs	2		, . .	
TOTAL:	130	\$10,609,046	1,46	\$ 726.6 <u>-6/</u>

 $\underline{1}$ /Appendix <u>C</u> is an itemized list of NSF Awards to Small Business

2/Excludes purchase orders

<u>3</u>/These figures shown without \$1.3 million transfer from RA to STIA for technology assessment as shown for FY 77 for consistency in the FY 1979 Budget request.

4/Includes U.S. Antarctic Program.

5/Science Education total obligations less Fellowships and Traineeships (\$15.3m).

6/FY 1977 Total NSF obligations (\$791.8) less Special Foreign Currency (\$4.4m), PD&M (\$45.5m), and Fellowships and Traineeships (\$15.3m).

33

Support of Basic Research in Industry by Five Other Federal Agencies

We inquired of five other science-supporting agencies about their experiences with proposal pressure and the likely subject areas of research contributions from industrial performers of basic research. Discussions were held with staff of the Office of Naval Research, Department of Energy, National Institutes of Health, National Aeronautics and Space Administration, and the Air Force Office of Scientific Research. Findings are summarized belowing the second state of th

the second se

DEPARTMENT OF ENERGY

The department's policies do not favor one sector of basic research performers over others. In practice, the preponderance of basic research award funds go to universities or to federally funded research and development centers (FFRDC's) administered by universities.

Proposal interest or pressure from industry is at a fairly low level, is about 5% or less of total, and is fairly constant. Awards to industry amount to about 2 to 4% of the total number of awards. These figures exclude FFRDC's. 에는 가장 이 것 같아요. 이 가 가 가 있는 것 같아요. 이 것 같아요. 이 가 있는 것 같아요 이 같아요. 이 가 있는 것 같아요. 이 가 있는

About \$90 million in basic research awards to universities is estimated for FY 1978; slightly over \$1 million is estimated for basic research awards to industry and the second Sec. 1

At DoE the fields of basic science in which research is supported are heavily dominated by physical sciences, involving probably 80% or so of total dollars. Research support is primarily in the fields of nuclear physics, chemical sciences, high energy physics, metallurgy and materials sciences.

The agency has been so recently organized in its present form that some aspects of its experience must be drawn from its predecessor agencies, the Atomic Energy Commission and the Energy Research and Development Agency. The new Department of Energy has been taking initiatives to increase the participation of small business in its programs.

liner, the sectored with constant states and

OFFICE OF NAVAL RESEARCH, which has a set of the state 3.6.3

Research support to outside performers is almost entirely through contracts. The basic research contracts tend to go to universities as a consequence of both industry interest and ONR's assessment of the capabilities of the proposers seeking basic research support for individual projects. About 15% of the dollars for "Defense Research Sciences" (that include some funds 15% of the dollars for "Defense Research Sciences" (that include some funds for applied research, though most are for basic) go to industry, 71% to universities, 3% to nonprofits (FY 1977 data). These proportions have been relatively stable in recent years. In FY 77, 19.4% went for energy conversion, 16.4% for materials, 10.9% for mechanics, 10.8% for math sciences, 8.9% for general physics, 7.1% for terrestrial, 7% for behavioral/social science, and 6.1% for oceanography. n an an an an Arrent an an an Arrent an A An Arrent a

Most basic research is carried out inhouse or by NASA's own personnel (about 45 - 50% of total). Industry represents the second major performing sector accounting for about 30 percent of the total in FY 1978. Universities and FFRDC's administered by universities accounted for almost all of the remaining NASA performance. In 1978, about two-thirds of NASA's basic research is in the physical sciences (astronomy and physics), one-fifth in the environmental sciences and one-tenth in engineering.

In space science the research interests of the NASA centers vary and they have much autonomy in choice of research performers. In the diffe sciences, it is a pattern that research tending toward general theory or research in biomedical areas is performed mostly at universities; research that is more technology oriented is more likely to be carried out by industrial performers.

NASA accepts unsolicited proposals for basic research but staff report that relatively few are received from industry. Most unsolicited proposals received come from universities. Those from industry are more likely to result from a program announcement. Requests for proposals stimulate proposals from both universities and industry; in the basic research areas, industry submits relatively few proposals. The more technological the area the more likely industry is to propose and the more likely such proposals are to be funded on competitive merit.

In engineering basic research, approximately 15% is reported as performed by industry; in biomedical involving mainly biology and medicine around 5%, but for the bioengineering and technology aspects 70 to 75% of the basic research is performed by industry; in space and terrestrial sciences, there is great variation by field. In magnetospheric research and astronomy, most extramurally performed basic research is done by universities. In remote sensing, industry interest and participation increases though the activity is described as mostly government. In the materials science area there is currently a growing interest in such areas a alloys of different purities, vacuum molding and casting, and composite materials. In such areas it is probable that there is good research capability in industry. The space and terrestrial sciences areas, as in the others, seem to involve industry more at the high technology end; for example, when expensive instrumentation is with such capabilities.

Small businesses were said to be involved mainly in the support services area, except in the advanced technology aspects of the life sciences area. There the research capabilities of high technology small firms were mentioned specifically.

1.11 Pro 1.12

Most of NASA's support of basic research in industry appears to be supported a per through contracts rather than grants. As with NSF, NASA is required by the day appropriations legislation to require cost-sharing by grantees or contractors when such awards result from unsolicited proposals. This can be a problem for some small business firms.

Publication of basic research findings in the open literature is encouraged and in many cases is regarded by AFOSR as the appropriate way to report on the research to AFOSR; the policy appears very similar to that of NSF.

Cost-sharing is encouraged by AFOSR but is not required.

CONCLUSIONS

Industry participation in basic research programs of the five agencies varied substantially. Industry participation seemed to occur more often in those programs most clearly defined by mission areas and at the technology end of the spectrum; at the theoretical or abstract research end there seemed less industry interest and participation.

The missions of the agencies, the titles of their program areas and agencies' use of requests for proposals all serve to focus more identifiable research targets. This seems to facilitate industrial participation through submission of proposals or expressions of interest that link their skills and interests to problems for research.

The effects that flow from the known characteristics of agency missions and program areas tends to structure the basic research environment toward greater specificity than is the case with the National Science Foundation in most of its basic research areas.

									· ·
	FY 77Proposals Recvd. by NSF from	In	dustry	yt	by NSF F	Program	Element	i cont cont	- 69 - 1
Ċ	ter an anna 1997. Karna an taoinn			÷.,	ang da p		111110 11112	ren ne ne en rectore est	
	MPE	, i		No.		10.10		Amount	х. С. С.
	HILL REAL REAL REAL REAL REAL REAL REAL RE	44		110.	<u>.</u>		endande.	Allount	5.3
	Other Math Sciences	S (7			de tracé qu	ំ \$ ំ3;0	00
	Atomic & Molecular Physics	έĽ		1				95,80	00
	Nuclear Physics	·		-]			भिन्दी गई छड़ते । इ.स. १९३४ -	116,7	00 00
	Engineering-Fluid Mechanics			2	,		Si testa da la c	708.20)D
	Devices & Waves].	aloretta v	9813 Ory	here ei 124		00
	Solid State Physics	 		1			· .	2,0	00
	Metallurgy			3 3			Servezer -	237,50 511,90	10
۰.	Ceramics DMR	1		1		s five	n albent i	175,2	10 10:
	Chemical Analysis	1	÷.,	3	i engel on	1997. P		508,8	
	Software Engineering	1		ĭ	1.1.1.1	waren e	Prine and state		
Ĵ	International Travel		1.8	3	(1996) e t	49 B	nggi ya wa	50,0 3,0	56
	MPE			1	-			10,5	35
1	TOTAL:	3		22		1.1		\$2,481,70	<u>)</u>
		2					Antonia di	ga en el la m ración a la m	
	STI ^{20, h}	i i					an atawa un a lia	n den ingden en Frei Romania	and - Null
	<u>311</u>	7					ac des		
	Policy Research & Analysis	÷		8	seast or	 < < 	en bai de	701.0	39
÷	Cooperative Science Program	<u>.</u>		2	drave e	nel 🔅	han na sh	1,500,0	э́о́
	Cooperative Science Program (Japan)			1	100	(anala)	i te hizut	21.5	DO 🦾
	Cooperative Science Program (U.S.S.			1			3,000	27,10	00
	Scientific Organization & Resources	Pri	og.	2	DAT	2	(edulation)	75,00	
	Economics of Information	12.24		3	1.11	17.3		197,9	
	Access Improvement			8 13				805,93	
	User Requirement Studies of Science Resources			7				1,158,84 488,6	
	TOTAL:			45	-			\$4,975,9	12
	Alter Adv.						200	54,57,5,5	
							250 C. S	1.172	5 C
	AEO	2					261.87		6. <u>(</u>
		1	· .•				6.000		1
• •	Galactic & Extragalactic Astronomy	1	1.1.1	- 2		an a		324,70	
	Astronomical Instrumen. & Developme	int		3	×.	a para na la	1 - To - E - F	74,0	
	Aeronomy Meteorology (Atmospheric)	1		2		1.1		255,30	
	Solar-Terrestrial	1		3		stan Au	No. 21	150,00 397,00	
	Solar-Terrestrial Physics	1		2	1			64,7	
	Research Ship Support			5				1,862,4	
	Contract Support (DPP)			4				5,467,12	
	Oceanography			2	•			103,40	
	Meteorology (DPP)			1				181,50	
	Environmental Forecasting			1				40,70	
	Climate Dynamics		•	3	-			944,30	
	TOTAL:			29				\$9,865,22	25

841

APPENDIX A

843

8	ų,	1	194	j.	

ingend. No. 200 No. 201 Building Street The DSE Amount Public Understanding of Science 7 \$ 500,500 Alternatives in Higher Education 5 778,320³ Continuing Education 1 15,132 ಂ : ನಕ್ಷಮಿಕೆ .**1.17,245** ಸಿ Special Studies & Experimental Projects 1 486,037 Research in Education 5 asianassa? Systems Approach 1 10,488 496,930 Ethical & Human Value Implications 4 18 \$2,404,652 TOTAL: $E_{\rm e}(\lambda)$ 18474 contoesplicteffmod 1.585 na sang Nganggangganggan 365,83 ol sectora ADA real \$2 :6100 581,095 2 Equipment Rentals 43,350 10,000 2 Training Contracts ì Data Processing Contracts 634,445 TOTAL: 5 ŝ 0/D and the second of the second of the 21 JAN authatefte ar **311,563** M OPRM--Other:Studies 7 OGPP--Feature Film 1 8-11 DP-TOTAL: 8 encrucial contact to the tot 147.97 818,887 (1911,94 (1911,94 19000000 a maria 1938: A Herena Level 4046: A Corol Clark (2019) [1930: A Antoloxy)[21] A Antoloxy i - construction (construction) Construction Stepping (USAR) Of the Style Structure (construction) Street, a lot of Artistan tio T 312 33 (27) 030 703 2017 (17 quated a generation. unan pulsa ang . Harmodi . 198. 3 367.7 Ase of 1. 19522.0 $\{ i \in \mathcal{I} \}$

FY 77 AWARDS TO INDUSTRY--BY NSF PROGRAM ELEMENT

845

RA		No.	Amount
Technology Assessment		10	\$ 781,935
Environment		25	3,664,079
Productivity		43	2,713,752
Industrial Program		6	385,578
Resources		13	1,179,637
Communications	. · · ·.	8	468,887
Exploratory Research		2	138,115
Research Evaluation	1	2	120,607
RA-Other		· 1 ·	261,480
	TOTAL :	110*	9,714,070*

Public Understanding of Science 1	203,100
Continuing Education 1	15,132
Special Studies & Experimental Proj.	124,854
Special Studies & Experimental Proj.	19,890
	344,662
Technological Innovations in Educ. 2	707.638*

TACHER STATE OF STREAM AND

AD/A

SE

Training Data Processing/Equipment	alianti in ang <u>bag a si sa</u> a ang sagar ang sagar ang ang sagar ang sagar ang sagar sagar ang sagar ang sagar ang sagar sagar ang sagar ang sagar ang sagar ang sagar sagar ang sagar ang sagar ang sagar ang sagar ang sagar ang sagar sagar ang sagar ang s sagar ang sagar ang sa sagar ang sagar ang s sagar ang sagar	17,100 1,098,644 1,115,744
OPRM	i.	

Evaluations/Studies				
· · · · · · · · · · · · · · · · · · ·				295,999*

2

OGPP

Films/Other

28,055

* Totals do not include Purchase Orders

MATHEMATICAL AND PHYSICAL SCIENCES, AND ENGINEERING DIRECTORATE

DATE OF AWARD	FIRM NAME	Antonio de Roberto de Calendario (N. 1999) en 1999 Recipio (N. 1996) (N. 1997) en 1998 Recipio (N. <mark>PROJECT, TITLE</mark> , de tante (N. 1997)	AWARD NUMBER	PROGRAM	AMOUNT
8/77 3\\\\	Institute for Scientific Informa- tion of constant the second	Data Extraction from the Science	, istra-da S	MPE to the second s	
2/77	Aerochem Research Labs Princeton, N.J.	Studies of the Thermodynamics of Coal Impurity Combustion Products	7615609	Engineering	\$ 27,700
6/77	Manlabs Inc. Cambridge, Ma.	Calculation of Ternary Phase Diagrams by Computer Methods	7713861	Materials Research	\$ 75,300
9/77	Manlabs Inc. Cambridge, Ma	Evaluation of Advanced Cutting Tool Systems	7715577	Materials: Research	\$ 64,600
4/77	Bend Research Bend, Ore.	Fundamentals of Membrane Permeation	7617291	Engineering	
·	an a	in general and the service of the se	an a	н 1944 г. 1	
		Neg. Will prove the second second	: · · ·		
<u>HAN</u>	na an a	gal ga bhan a <u>s</u> a' an an an àr an	1900	11 - 11 - 11 - 11 - 11 - 11 - 11 - 11	1. 2000 200
िल्लान्स इन्हें	章·唐·楚			i servita na	
	Contactif of the	s 1995 - State St 1995 - State St	1.017-12 1	.1	59.

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS DIRECTORATE

	DATE OF AWARD	FIRM NAME		PROJECT TITLE	Award Number	PROGRAM AREA	AMOUNT
	9/77	Capital Systems Group Inc Rockville, Md.		Research on the Use of Scientific and Technical Information and Its Im- pact on the Effectiveness of Scientists and Engineers	7718073	Science	\$ 86,369
and agreed of a first of the second second	4/77	Moshman Associates Inc. Washington, D.C.	e Li	Data Processing and Other Related Ser- vices in Support of the Survey of Federa Funds for Research, Development, and Other Scientific Activities, Vol. XXVI		Science Resources	\$ 33,274
dente forte bete	12/76	Moshman Associates Inc. Washington, D.C.		Data Processing of Three University Survey Systems, FY 1977	7684638	Science Resources	\$ 92,426
la treva di Alternativo da una	9/77	Computer Horizons Inc. Cherry Hill, N.J.	14. f	and the second	7722770	Science Resources	\$ 30,559 C 11,647000
Stangene Linkeren	9/77	Moshman Associates Inc. Washington, D.C.		Analysis of Distribution of Federal Funds for Research and Development	7720867	Science Resources	\$ 28,900
and the former of the	9/77	Moshman Associates Inc. Washington, D.C.		Survey of Graduate Science Student Support and Postdoctorals, Fall 1977	7724140	Science Resources	\$151 ,91 0
na state in the South Court	9/77 545 1	Westat Inc. Wester Brit Rockville, Md.		New Entrants Surveys of Recent College Graduates (1972 and 1974 Classes) In	7727560	Science Resources	\$197,200
March 1	The second	bark aware a		Science and Engineering		1.4.9	¥1
and a standard and a standard and a standard a	9/77	King Research, Inc. Rockville, Md.		An In-Depth Study of the Interactions Between Scientists & the Publishing of Scientific Journals	7717943	Science In-	\$ 49,800

energia de la composition de

849

2.

RESEARCH APPLICATIONS DIRECTORATE

FY 1977 SMALL BUSINESS AWARDS

 $\{ (1,1) \}$ DATE OF

7/77

8/77

6/77

7/77

12/76

7/77

6/77

6/77

9/77

1.1.1

	FY 1977 SMALL BUSINESS AWARDS	(13)		
a ang align terta ang sa	an a	1971753.2×	$2^{2NA}/2^{2N}$	n an the Car
FIRM NAME	PROJECT TITLE	AWARD NUMBER	PROGRAM AREA	AMOUNT
	in the state manager of the second states of the second states of the second states of the second states of the	- 신 (211)	State and the	213-1395
Cambridge Systematics, Inc. Cambridge, MA	Personal Transportation Modes: An Assessment of Use, Choice, and Future Preferences		Tech. Assess.	\$243,072
Gellman Research Associates Jenkintown, PA	Large Air Transport Technology Assessment	76-80328	Tech. Assess.	
Jenkincown, FA	建碱化物 动物性刺激动物	- 1		
International Research and Technology Corporation	Materials Process - Product Model Andrews	71-01663 A06	Tech, Assess.	4,275
Washington, D.C.	 Compare of Apple Apple (Compare Compare) (Apple) Compare Compare (Compare) 	12. A.A.B.M.	gan jan badag	t prograder
Kalba Bowen Associates, Inc. Cambridge, MA	A Framework for Analysis of Technologically- Induced Social Effects	76-24067	Tech. Assess.	~ *
Scientific Analysis Corp. San Francisco, CA	Evaluation Systems for Technology Assessments: A Planning Study		Tech. Assess.	29,700
Scientific Analysis Corp. San Francisco, CA	Institutional Variables that Impact the Performance and Use of Technology Assessment Studies	77-15503	Tech. Assess.	153,100
The Futures Group Glastonbury, CT	Technology Assessment of Life Extending Technologies	75-10708 A02	Tech. Assess.	16,728
J. H. Wiggins Co.	Risk to Structures from Natural Hazards: A Technology Assessment	75-09998 A01	Tech. Assess.	
algar v Contribuird	化合理性性的 蒙古电影 化甘油酸盐 化磷酸盐 网络马尔斯 化磷酸盐		$\mathbb{P}^{n} = \{ X_{0}, X_{0} \} = \{ X_{0}, X_{0} \}$	2 (c. 1918)
Aerochem Research	Aerosol Characterization in Real Time	77-11252	Environment	113,800
Laboratories, Inc. Princeton, NJ		2100 G V 1996 G		ka akir Vi

Å.

DATE OF AVIARD	FIRM NAME		AWARD NUMBER	PROGRAM AREA	AMOUNT
9/77	Meteorology Research, Inc. Altadena, CA	Application of Computer Graphics to Air Quality Data Analysis	77-12487	Environment	133,100
9/77	North American Weather Consultants Goleta, CA	Workshop on Extended Area Effects of Weather Modification	77–15028	Environment	30,800
3 /77 , 100	Panametrics, Inc. Waltham, MA	The Role of Solar Ultraviolet Radiation in the Formation of Hydroxyl Radicals in the Troposphere	76-23902	Environment	37,200
9/77	Perceptronics, Inc. Eugene, OR	Identifying, Evaluating, and Managing and Environmental Risks - Part II	77 -1 5332	Environment	208,300
9/77 <u>* *</u> *	William Spangle & Associates Portola Valley, CA	Post-Earthquake Land Use Planning	76-82756	Environment	213,200
9/77	Sterling Hobe Corporation Washington, D.C.	Development and Testing of Risk-Benefit- Cost Analysis for Policy Formulation	77-15501	Environment	154,000
9/77	Teknekron, Inc. Berkeley, CA	An Analysis of Urban Drought: A Case Study of the San Francisco Bay Area	77-16283	Environment	341,200
2/77	Weidlinger Associates New York, NY	Underground Lifelines in a Seismic Environment	76-09838 A01	$\textbf{Environment}_{1, \mathbb{C}^{2}}$	42,170
5/77	Westgate Research Corp. Los Angeles, CA: growing water	An Investigation into the Chemistry of the UV-Ozone Water Purification Process of the average	76-24652	Environment gevenseeee	93,600
9/77	J. H. Wiggins, Co. Redondo Beach, CA	Cost-Benefit Risk Analysis of Research Budgeted for Hazard Mitigation	77-08435	Environment	40,900
5/77	William & Works, Inc. Grand Rapids, MI	Use of Wetlands for Management of Pond- Stabilized Domestic Wastewater	76-20812 A01	Environment	6,400 ගු

- 3 -

.

ATE OF AVARD	ELECTRONIC STREET	on environmente astronomicante environmente environmente environmente environmente environmente environmente e Secondatione environmente environmente environmente environmente environmente environmente environmente environm	AWARD NUMBER	PROGRAM	AMOUNT
9/77 AB	Harmony Blue Granite Co. Elberton, GA	Studies of Improved Granite Cutting	77-03288 \\\\\\\	Productivity	60,800
8/77	Holosonics, Inc. Richland, MA	Scanned Acoustical Holography for Geologic Prediction	् 77-20075 ∆र∸⊜->े8	Productivity	131,600
9/77 \\\\	Holosonics, Inc. Richland, WA	Scanned Acoustical Holography for Geologic Prediction (Compared Compared Compared	77-20075 A01	Productivity	107,353
2/76	Holosonics, Inc. Richland, WA	Scanned Acoustical Holography for Geologic Prediction	73-03200 A03	Productivity	49,900
9/77	Holosonics, Inc. Richland, MA	Scanned Acoustical Holography for Geologic Prediction	73-03200 A04	Productivity	51,617
9/77	IRT Corporation San Diego, CA	In Vitro Detection of Allergy Using Human Head Hair	*77-19721	Productivity	24,646
3/77	Innocept, Inc. Dallas, TX	Federal Assistance Delivery System Productivity - Small Business	76-20856 A01	Productivity	55,900
9/77	Integrated Sciences Corp. Santa Monica, CA	Visual Feedback Speech Training System for the Deaf	*77-19883	Productivity	24,474
9/77	International Diagnostic Technology Santa Claras CA	Improved Methods for the Rapid Detection of Microbial Contaminants	*77- 19701	Productivity	25,000
9/77	Kellogg Corporation Littleton, CO	Resource Allocation System for Construction Industry Managers	*77-19782	Productivity	24,953
8/77	Koba Associates, Inc. Washington, D.C.	Condition Forecast: Economic Welfare Among Retirement Aged Blacks in the Year 2000	76-83410	Productivity	173,200

- 5

		-7-			
DATE OF	aseon midal (gronti erec solor participation (<u>FIRM NAME</u>	er gebruchten volgense gebruchten volgense gebrucht <u>project title</u>	AWARD NUMBER	PROGRAM AREA	AMOUNT
	the LAN H.				
9/77	Stearns, Conrad, & Schmidt Consulting Engineers	Decision-Related Research on Technology Utilized by Local Government: Refuse	77-17354		
87.11	Long Beach, CA	Collection, Phase II	NA 4 15	218-12-12-14 - 1	18 9 19
8/77 (133)	Technical Assistance Research Programs, Inc. Washington, D.C.	1 Identification of the Nature and Frequency of the Product/Service Problems of the Consumer	76-84200	Productivity	50,300
9/77	Terraspace, Inc. Rockville, MD	Hydraulic Bursting of Concrete and Rock	*77-19804	Productivity	
9/77	Terra Tek, Inc. Salt Lake City, UT	Hydro-Mechanical Sensing of Deep Hole Drilling Deviations	*77-19526	Productivity	(1063) ad .24,970 100 (ad ant
9/77	Terra Tek, Inc. Salt Lake City, UT	Research on the Simplification of Methods for Measuring Fracture Toughness	*77-19461	Productivity	24,993
⁹ 12/76	The Futures Group Glastonbury, CT	A Study of the Consequences and Policy Implications of Increased Unionization of Court Personnel	76-84021	Productivity	160,900
18 cupt	The state of the s	y hypersonal cycle teatra a gin dag ceithe ceith can a constant a constant a constant a constant a constant a An an	1977년 1978년		
12/76	Workers' Disability Income	An Evaluation of State Level Human Resource	75-01067	Productivity	23,200
$\omega_{\rm e} M$	Systems, Inc. Washington, D.C.	Delivery Programs: Disability Compensation Programs	A03	forense ogs	15 da.
5/77	Manalytics, Inc. San Francisco, CA	Study of Government-Industry Cost-Sharing as an Incentive to Technological Innovation		y Industa Prog.	4,720
8/77	Mar-Jac Corporation Gainesville, GA	Studying the Feasibility of Automated Handling and Transfer Techniques for the Poultry Processing Industry	77-09749 Million	Indus. Prog.	49,900
, se a presa de la ferencia de la composición de la composición de la composición de la composición de la compo		· · ·			1

8.0

_

857

DATE OF	FIRM NAME	PROJECT TITLE		PROGRAM	AMOUNT
9/77	Experienced Resource Group, Inc. Baton Rouge, LA	Alternative Food Delivery Systems - Cost A An Exploratory Assessment	77-07184 A01	Resources	7,700
6/77	Capital Systems Group Rockville, MD	Support Operations for the RANN Technical Information Program	75-22472 A05	Communications	260,377
11/76	Courtesy Travel Washington, D.C.	Travel Support for RANN Symposium Speakers	77-01320	Communications	
5/77	Courtesy Travel Washington, D.C.	BiLateral Research Coordination Meetings	77-01320 A01	Communications	1,500
n Westerland an Earlin	ck Young Productions York, NY	Preparation of Treatment/Concepts for Four RANN Films	77-04862	Communications	
 Mail door successful contractions 	pa Systems pa Systems Alangton, VA Starson Data	RFP 76-120 - Provide Expert and Technical Advice and Services for the Production and Staging of a RANN Symposium	76-23498	Communications	38,600
1/77	Media Four Productions Hollywood, CA	Preparation of Treatment/Concepts for Four RANN Films	77-04861	Communications	5,000
8/77	Media Four Productions Hollywood, CA	RFP 7F-102: Production of Four RANN Films	77-17353	Communications	113,410
1/77	Vision Associates New York, NY	Preparation of Treatment/Concepts for Four RANN Films	77-04863	(TOSUS) Communications	5,000
7/77	Design Alternatives, Inc. Washington, D.C.	Workshop to Identify Appropriate Techno- logical Responses to Resource, Environmental, and Social Challenges to the Economy	77-21824	Exploratory Research	84,515

q

ATE OF Aviard	FIRM NAME	PROJECT TITLE	AWARD <u>NUMBER</u>	PROGRAM	AMOUNT
5/77	Impact Assessment Institute Bethesda, MD	Revised Bibliography of NSF Technology Assessment Projects	RN-2556 7SP0806	Tech. Assess	8,700
5/77	Information Transfer Rockville, MD	Proceedings of Conference on Sludge Management	RN-77026 7SP6756	Environment	6,250
5/77	International Planning Management Bethesda, MD	Problems of New Business Ventures Utilizing High Technology	RN-71217 7SP0795	Indus. Prog.	9,707
\$/77	Kappa Systems, Inc. ArTington, VA	RANN II Exhibit	RN-2401 7SP0740	Communication	iš / 5,882 (:
1/77	Underwater Systems, Inc. Silver Spring, MD	Statistical Analysis of Data Collected on the Evaluation of RANN Proposals	RN-0745 7SP0453	Research Evaluation	7,500
3/77	Woodward-Clyde Consultants San Francisco, CA	Implementation Measures to Reduce Earthquake Hazards of Dams	RN-6182 7SP1044	Environment	1,000
3 /77 2. st. e.s.	Harold Wise, Planning Consultant Washington, D.C.	Information on Federal Programs with Maximum Impact on State Policy Formulation	RN-6961 7SP0970	Intergovern- mental Scienc	9,959 æ
Awards	made with funds carried forward	from Transition Quarter:	$\mathcal{F}_{\mathcal{F}} [\mathcal{H} \cap \mathcal{H}]$	Subtotal: \$ 7	,669,242
- 11/77 Buth	Forecasting International Arlington, VA	Development of a Methodology to Forecast Events Affecting Productivity	75-16374 A02	Productivity	12,900
3/77	Bernard Wolnak & Assoc. Chicago, IL	Workshop on Enzyme Economics	76-10166	Resources	12,000
9.9 9. . 1					,694,142

- 11 -

* Awarded under Program Solicitation 77-12 - Small Business Innovation Applied to National Needs

 \hat{V}

12

861

BIOLOGICAL, BEHAVIORAL, AND SOCIAL SCIENCES DIRECTORATE

	DATE OF AWARD	FIRM	NAME		PI	OJECT TITLE		۰.	AWARD NUMBER	PROGRAM	AMOUNT
	8/77	Institute for S tion Philadelphia, F		Informa-	A Citation to 1930	Index for Ph	ysics: 19	20	7714957	Social Science	\$82,700
		annuacipiata, i						÷			
			de en				ыл 1 А				
	· •		1			1		•	•		
1							19 1				-
							an gar				41
		esta de 192	1								
	1.1				n geografie g			2	· .	: *	
Extra	2.15	and applied states of a	and in the same Th	19 - 19 C	ung yang tahun di	n kiya dalamiy dalah i B	e vin fizie	14 B	100.00	a definition and a	
	. 3	e sature s		1772 1772	u <mark>ns</mark> ajas de la c	(1) 13 (1) (2) (2) (1) (1) (1) (2) (2) (2) (2) (2) (2) (2) (2) (2) (2	n 29 - Andre	- - 			
1×10^{-1}		n an an geo	a î r	- 57	landi. Tana Tani we yaar	na interneta	eget i -		ARE S	eAfrica a com	$\sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{j=1}^{n} \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{j=1}^{n} \sum_{i=1}^{n} \sum_{i$
	ge pr	e de suit stât Se regiserer stât grec			e je stalik		•	· ·		•	
				N ¹	n, et interên s		n given der Tr	÷ 1	89. J. D. 1	i (1986) stalio o stalio S	2,42,780
					N ^a riei	Table E. J			2012) 201 <u>8</u> ["行人"。 "你们不是	
									- 190 -		ца
			:		第二世纪, 第二世纪	- FSA XUZ I	anter a				
			: ·			a sti		i Sec			
		· ·	-						1.	· .	<u>}</u>
						2 ¹				. *	
			÷			• • •		ti i i			ан 1911 - 1911 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 - 1914 -
										÷ .	

OFFICE OF GOVERNMENT AND PUBLIC PROGRAMS

DATE OF	FIRM NAME	PROJECT TITLE	AWARD <u>NUMBER</u>	PROGRAM AREA	AMOUNT
2/77	Dick Young Productions New York, N.Y.	Treatment/Concept of NSF Film	7708839		\$ 5,000
11/76	Executive VideoForum Inc. New York, N.Y.	Content Analysis of Videotape from Project: Клоwledge 2000	7684534	Community Affairs	\$23,055
· .					1-
					1
•			E.		:
					•
		· · · · · · · · · · · · · · · · · · ·			
					et en le te
					.:
					i e
					-
			1 - E		
					:
			* .	·	

867

(a) An and the second s second se

Automatic

79.

Table S-9. Distribution of doctoral scientists and engineers by field, 1973 and 1975

Ċ,

1 A		N.,					100 C		
7			Number		Pi	Percent			
<u>.</u>	Field	18 N.	1973	1975	1973	1975	.		
Total			244,921	277.517	100	100			
Physical :	cientists		53,425	59,267	22	21			
 Čhemis 	15	<i>.</i>	33,081	38,784	14	14	· · · · ·		
Physici	sts and astronomers		19,544	20,483	8	7.			
	ical scientists and	·		,				· · · ·	
	er specialists		16:458	18.204					
	alicians		11,984	12,729	5	5			
	ians		1.531	1,813	1	1 T			
Compu	ler specialists		2,943	3.662	1 1 1 1 A			- 19 A.	
Life scien	tists		64,540	72.316	26	26		1	
Biologie	al scientists		41.035	43,754	17	16	1.1.1.1.1.1	1. Starte	
Medical	scientists		11,612	14,285		5			
Agricult	ural scientists		11,893	14,205			1.1.1.1	1997 - C	
Environm	ental scientists		11.074	12,783	2	5			
Environm	sentists		9,142	10.076	3		1994 (N. 1997)	the second second	
					4	4	1. The second	4 N N N N	
	graphers		1,227	1,353	1 .	. <u>(')</u> .			
	heric scientists		705	1,353	(')	(1)	1	12 1 4 21	
			37,569	44,425	15	16			
	jists		28,288	31,613	12	11			
Social sci	entists		32,773	38,251	. 13	14	•		
	uists		9,678	11,049	4	4			
Sociolo	gists and anthropolo	gists	7,455	8,775	3	3			
Other s	ocial scientists		15,640	18,427	6	7			
Field not	reported			658	· · · (*)	· 79			
1.000									

12:00

1 Less than 0.5 percent.

NOTE: Detail may not add to totals because of rounding.

SOURCE: National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States, 1975 (NSF 77-309), p. viii.

See Table 5-16 in lext.

Ъ

869

Table 5-15. Doctoral R&D scientists and engi by field and type of employer, 1975

n an an an Anna Anna Anna Field	Total	Business and industry	Four-year colleges and universities	Government	Other employers
	- 8 top	<u></u>	Number		
All fields ²	113,796	45,352	41,776	15,470	11,198
cientists	88,830	28,489	37,819	12,891	9,631
Physical scientists	31,753	18,010	8,322	3,321	2,100
Mathematical scientists	3,154	711	1,776	495	172
Computer specialists	1,892	1,137	GANC 418 NO	185	152
Environmental scientists ^a	6,236	1,553	2,147	1,874	662
Life scientists	33,847	5 711	19,070	5,386	3,680
Psychologists and social scientists	11.941	1.367	6.079	1,630	2,865
ngineers	24,966	16,863	3,957	2,579	1,567
and the second	oods in w	Percent of	distribution ac	ross fields	•
Ali fields ²	100	100	100	100	100
All fields ²	78	63	91	83	. 86
Physical scientists	28		20		19
Mathematical scientists		. 2		3	2
Mathematical scientists	2	i	ner a ferra	· · ·	1 -
Environmental scientists ¹	5		5	. 12	Ġ
Life scientists	30	13	46	35	33
Psychologists and social scientists	10		15 15 15 C	11	26
noineers	22	37	9	17	14
		ercent distribu	ution.across t		
All Golde?	100	40	37	14	10.
All fields ²	100		4342		11
Diversional econtrists	100			10	1
Physical scientists Mathematical scientists	100	57	56	16	
Computer specialists	100	23 60	22		2
Environmental scientistel	. 100			30	
Environmental scientists ³	100	25	34 56	30 16 -	11
Psychologists and social scientists	100				11
					24
ngineers	100	68 0 0 0 0 0 0 0 0	16	10	6

Those whose primary work activity is R&D or R&D management.
 Includes 7 who did not report their field.
 Includes earth scientists, oceanographers, and atmospheric scientists.

المرادية فبدا والإخطارة

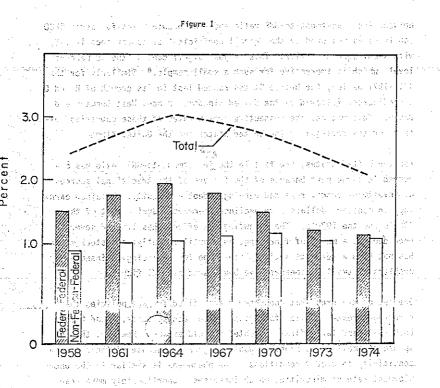
1 march 4

NOTE: Detail may not add to totals because of rounding: here the because of sounding

SOURCE: National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States, 1975

See Figures 5-23 and 5-24 in text. The second strength selfener and since the constant Less Bursters

and the second second provide mage specified and A the second the state of and in the second second second second second we have and to prove why work that one was to the terms of the An an the earlier to pass the constant with a first factor with the of story was a sec ware was charged a na kaj di Carlor of the American Strategies (



ે તેમ જે તેમ છે. તેમ છે તેમ પ્રતાસ પ્રસાધ પ્રતાસ પ્રાપ્ત કરે છે. દેવને પ્રેથમિંગ પ્રાપ્ત કે જે સ્વયત્ત્ર પ્રાપ્ત કેરે કે કે પ્રાપ્ત કરે થયે. તે કે પ્રાપ્ત કે કે સ્વયત્ત્ર કે સ્ સે અને પ્રેથમિંગ પ્રાપ્ત કે જે સ્વયત્ત્ર પ્રાપ્ત કેરે કે કે ગુજરાવ તે કે સ્વયત્ત્ર કે સ્વયત્ત્ર કે સ્વયત્ત્ર કે

المانية من المحكوم على المحكوم في المحكوم المحكوم المحكوم مع يعهد من المحكوم المحكوم المحكوم المحكوم المحكوم ا المحكوم الم المحكوم ال

- さばやり 繰び 正確に ひとうほうし がくちょう おくならい うちゃ

(a) and a set of the second se Second sec

R and D output, i.e., in terms of technical change, the contribution of small firms may well be much greater than this percentage. Unfortunate very little has been written about R and D of small firms or about R an D that occurs outside the context of a formal program due to the lack or basic data concerning them. There is a considerable amount of literatur concerning R and D and firm size, but the smallest firms considered are generally larger than our small firm definition. The minimum size of the typical firm considered has more than 1,000 employees and, when small re firms are included, firms, with less than 1,000 employees are lumped together as the smallest size class. Consequently, some of the results reported here are for this size class and are noted specifically.

We wish to distinguish among the <u>three different Product phases of R an</u> <u>D</u>, i.e., *invention, development* and *innopation*. By *invention*, we mean the production of a model or an idea sufficiently developed to be paten able. There are important inventions, especially in the form of ideas, that would not be covered by this definition; however, for our purposes the definition has substantial advantages of specificity. *Development* refers to the process of bringing the innovation to the stage of connercial application. By *innovation*, we mean the actual adoption of the developed invention.

ilone of these definitions is entirely satisfactory, but they do convey useful sense of distinguishable product phases. The actual definition not very important since there is so little empirical work distinguishiamong these different phases under any reasonable definition because there are little basic data available. This is also unfortunate for our purposes, since an appreciation of these product phases is germane to questions about the role of small firms in R and D.

Although there is a considerable volume of work concerning larger firms and formal R and D programs, this almost uniformly suffers from importalimitations whose effects are to leave many of the important empirical and policy questions unsettled. These limitations arise from basic prolems such as the absence of any well-regarded measure of R and D output or input. Some regard measures of R and D input as the best measure of R and D output; but the limitations of such measures, especially in considering the efficiency of R and D expenditures, is obvious: Beyond the measures of R and D input suffer from limitations of their own. Techni-

Peterson. For a sample of Nebraska firms, they found that 38 percent of firms with less than 500 employees engaged in R and $D.^{17}$ This is consistent with the results of a questionnaire study covering eight states

by McConnell and Ross.18

Confidence in the McConnell and Péterson and McConnell and Ross results is increased by their consistency with the results of an earlier Harvard study containing a similar definition of R and D. For the early 1950's, 32 percent of firms with less than 500 employees had R and D programs. The definition of R and D in the studies used to obtain these results included the improvement of existing products and the development of new products or new production methods. The definition excluded market research, quality control and product testing, and R and D performed by part-time personnel and by specialists external to the firm. When the definition included part-time personnel and outside specialists, an additional 7 percent of the firms qualified for categorization as having R and D programs.

Where results were reported by industry, a wide variance was found in the percentage of small firms with an R and D program. For example, in the McConnell and Peterson study this percentage varied from a high of 1927 68 in the chemical industry to a low of 13 percent in the transportation equipment industry. Size differences among small firms is the major explanation for this variance. The simple relationship reported by McConnell and Peterson between firm size and the percentage of firms engaging in R and D was striking. Only 11 percent of firms with one to five employees engaged in R and D, but this increased to 93 percent for firms in the largest category of 151 to 500 employees. The same trend is found when firms with more than 500 employees are considered. Even if the high 38 percent figure suggested by McConnell and Peterson as the portion of small firms engaging in R and D is accepted as reasonable (and I think it is), larger firms have still higher percentages. The relationship appears wirtually monotonic with size. Yes: 101

The probable creasons for this factor are straightforward and important. Be used 2019 The most important reason is the differential financial constraints faced (ge public reaby smaller firms. The availability of capital is often the crucial reactive of the question determining the survival of the small firmber Research and develop 1 and a point opment imposes a capital drain and increases the vulnerability of the 1.4 and 1.4

96

春日 后间的 ACH 化热性酶 CHA 化热电子分析

マンターしゃ しんせいか 登手

accounted for about 65 percent of R and D spending as reported by the National Science Foundation, and by 1975 this figure had declined to about 58 percent.²² Since federal R and D funding goes mainly to larger firms, this alone should contribute materially to a relationship between firm size and R and D size. Even on a percentage basis, the discrepancy is large. In 1965, federal funds apparently financed 57 percent of large company R and D, but funded only about 35 percent of R and D for firms with less than 1,000 employees.²³ Probably for firms with less than 500 employees, the percentage was much less than half of this. When federal funds were excluded, Smith and Creamer found that R and D expenditures as a percentage of sales tell from 5 percent to 2:1 percent for the largest size class and from only 1.8 to 1.4 for their smallest size class of less than 1,000 employees.²⁴

However, the surprising result is that among small firms the relationship is generally quite weak between firm size and R and D spending. For McConnell and Peterson's sample, a simple regression of R and D employment against the number of employees indicates that only 34 percent of R and D variance is explained by firm size ²⁵ Separate regressions indicate a range from 72 percent for the chemical industry to 6.9 percent for stone, clay and glass. Again, there is some tendency for the relationship to be stronger for the more capital-intensive industries. Smith and Creamer's figures show that 83 percent of the R and D program of firms with fewer than 1,000 employees was less than \$50,000 in 1965. This generally meant a staff of two people.

Intensity of R and D generally is measured by R and D employment or expenditures as a percentage of total employment or sales. McConnell and Peterson show a marked negative relationship between R and D intensity and firm size, where both are measured in employment terms. The rank negative relationship between firm size and R and D is perfect for their sample.²⁶ Research and development intensity falls steadily from 42 percent for firms of the smallest size class of less than five emoloyees to 2 percent for firms of the largest class of between 151 and 500 employees. Probably there is a minimum size necessary for a successful R and D program. This means that while fewer small firms undertake R and D, the firms that do undertake the effort have programs larger relative to the size of the firm.

are among the five industries found by Gruber, Mental and Vernon to be of the second dominant and crucial importance in U.S. export trade due to their R and 114 - L C 37 D characteristics. Chemicals was one of the other five industries and. ter to by bord according to Scherer, exhibits diminishing returns to R and D input excluding the Targest firms.30⁴⁴ Schërer measured inventive output intensity (44) in the form of patents rather than input intensity. The chemical findus-341. H 44.8 try showed decreasing returns of patent output to R and D until it 1. 1989 ¹ 79 reached sales of about \$1.5 billion, at which point increasing returns 5. appeared. This effect was due to essentially a very few glant chemical companies. When Togarithms of the sales variables are taken to compress the sales the effect of the Targest firms and the regression is rerun. diminishing a second second in acress returns occur throughout. The electrical industry also was found by St. Company 1. Scherer to exhibit diminishing returns. The chemical and electrical in-1 35 - 37 9³ 1 - 1 dustries were the only two industries for which separate, unappregated runs were madele au sectore 270, di terri et alt di ci di di focce autori di and a construct of the and the second second

Stitk

100.07 20

an two

Scherer's general results are fairly consistent with those of McConnell (2014) and a source of the second s and Peterson. Scherer found that "inventive output increases with firm sales, but generally at a rate less than proportional." The less than proportional contribution of larger firms to innovation is also consistent to the second tent (except for their results for the largest four firms) with the workof Johannisson and Lindstrom³¹ for Swedish firms in twelve industrial and the last a second sectors

> and the determinant. L'ACRAMA A ANAL

Quite different results, generally for a different set of industries, are reported elsewhere. Mansfield³² found that maximum innovational intensity occurred at about the size of the sixth largest firm in the petroleum and coal industries and at about the size of the twelfth largest a second size of firm for the pharmaceutical industry when patents are weighted for important as a set tance, and at a slightly larger size when they are not. Freeman³³ found that firms with less than 200 employees accounted for a much smaller sector that the proportion of the innovations than their share of employment or net worth. Their share of innovations was slightly less than one-half of their share of employment and networth. However, the bias toward largers: firm R and D produced by government funding may be considerably greater sequences in Britain than in the United States, where it is nevertheless important. and then Possibly the disproportionate share of larger firms in R and D in Britain is an and a consequence of a greater proportion of R and D funding coming from the government there, with a similar bias toward large firms - Salasses - as deturing

industrial laboratories. In a way, Mueller's results⁴¹ are even more striking. From a sample of the twenty-five most important innovations actually developed by DuPont Co., in the 1920-1950 period, he found that only about 40 percent were discovered initially in DuPont's laboratories. This is especially impressive since the findings relate to an industry in which economies of scale in R and D have been noted, especially among the very largest firms, of which DuPont is one.

Even more persuasive evidence for the thesis advanced here that smaller firms have a comparative advantage in inventiveness is found in the literature survey of Hamberg⁴² who surveyed studies with six different samples of major inventions. He concluded that large industrial laboratories mainly tended to produce minor inventions. Other inventive sources produced more important inventions. In sum, there is fairly strong evidence that the most important inventions come from small firms, or sometimes one-person operations, or from academic settings. As Hamberg motes, "----the probability that inventions will be significant thus appear to decline as a firm gets bigger---."⁴³ Schumacher's⁴⁴ "small is beautiful" thesis may be especially true for inventiveness. It appears likely that independence, freedom from bureaucracy and, perhaps, personalities antipathetic to that of the "organization man" are characteristics associated with inventiveness. Greater inventiveness perhaps would be achieved if a greater portion of R and D resources were invested by smaller firms.

However, not only are smaller firms more likely to produce more inventions, but also they are likely to do so at less cost. R and D expenditures per patent pending by size of firm for six different industry groups (machinery, chemicals, electric equipment, petroleum, instruments and all other industries) for 1953 showed just such a pattern.⁴⁵ In every industry except chemicals, firms employing more than 5,000 people spent more per patent than did firms employing less than 1,000 people. In fact, the cost per patent for the larger firms was about twice that for the smaller firms.

The notion of inventions of decreased importance at increased cost is nicely consistent with Comanor's study of the pharmaceutical industry in which he found that "marginal productivity of professional research appeared inversely related to firm size."⁴⁶

.**)02**

881

A 1900

Unfortunately, Connor does not separate invention from development or innovation. His questionnaire includes the three stages, which is somewhat at variance with the hypothesis here that the primary comparative advantage of small companies lies in invention, not in development or innovation. However, many of Connor's interviewees were from the electronics industry. From the material presented in the second section of this article, this appears to be an area in which R and D intensity is greatest for small firms and, thus, probably the sum of inventive and development costs in this industry tend to be less for smaller firms.

But, Connor presents a study of the parallel development of a product by large and small chemical companies. Costs for the small company (two research personnel) were about one-eighth those of the large company. Perhaps one should emphasize, though Connor does not, that this product was one for which the small company knew that a market existed because of customer requests and one for which development costs were not large (probably about \$15,000). The point is that the risks associated with a developmental expenditure were not large and that this was a feasible project for a small company. Certain types of projects are clearly not suitable for development by a small company because of the specialization and investment required.

Further indication of the relative inefficiency of Targe firms in the state of a production of knowledge is indicated by Sanders' results" that reveal a state of the biggest companies use about 50 percent of their patents, while the smallest companies use about 76 percent. Similar results are shown the shown the patents Foundation of George Washington University 5000 minutes are shown to be the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington University 5000 minutes are shown to be appreciated and the patents foundation of George Washington Universi

1. 1. A. B.

an an an an an an an an fairte an said

Evidently, as the size of the firm increases, there is a decline in the importance of its inventions, an increase in the cost per invention, a decline in the proportion of patented inventions used commercially and, for some products, an increase in the development cost per invention.

The argument being made here is not that smaller firms are more efficient dia and in R and D, but that they are more efficient in certain, especially ini-aldered of tial, stages of the product cycle, i.e., in inventiveness and even in development information instances. We also argue that they are relatively more efficient in certain industries such as electronics and scientific instruments. This view sees a certain complementarity between large and

large for developing an invention into usable form is, of course, important in its own right. But what gives it a special urgency is that it runs counter to current myths created by Schumpeter⁵⁵ and emphasized by Galbraith⁵⁶ regarding firm size and structure and innovation. Schumpeter's hypothesis is usually interpreted as requiring monopoly power and large firm size for the most efficient innovation. Hence, Schumpeter's thesis usually is tested by measuring the relationship, if any, between industry concentration as a measure of monopoly and innovation and by measuring the correlation between firm size and innovation.

include the factor of systematic contract contracts and the test of

The correlation of monopoly power and innovation may be inappropriate as a measure of Schumpeter's thesis. Schumpeter stressed large firm size, the possibility of acquiring on holding monopoly power by innovation and the effect of potential or actual competition in stimulating innovation. It is quite unclear that the Schumpeterian thesis would lead one to expect any correlation between existing monopoly and innovation. Certainly, if innovation can lead to successful monopoly, which it clearly can, one would expect to find at least some correlation between monopoly and lagged R and D. However, this would not mean that monopoly is the market form best suited for producing innovation. The failure of existing studies to generally find correlation between industry concentration and innovation suggests that actual competition may be more important than monopoly as a spurito innovation. This is not necessarily inconsistent with Schumpeter's thesis; he notes:

"in a capitalist reality, as distinguished from the textbook picture, it is not that kind of competition (price) which counts, but the new technology, the new source of supply--. It is hardly necessary to point cut that competition of the kind we now have in mind acts not only when in being but also when it is an ever present threat. The business man feels himself to be in a competitive situation even if he is alone in his field."⁵⁷

As kamien and Schwartz interpret Schumpeter, "immediate imitation of a firm's new product or process by others as in perfect competition, would eliminate realizable rewards and thereby its incentive to innovate."⁵⁸ Essentially this is simply an argument for an effective patent system and an antitrust policy that exempts monopoly power acquired by technological superiority. This view is consistent with Common's findings that moderate barriers to entry were best in stimulating invention.⁵⁹

106

would be optimal. Unfortunately, the assumptions necessary for this the ideal system are far from metric Uncertainty in invention is especially a free data great, and uncertainty is the enemy of efficient long-term contract.⁶¹ Contracting costs become greater with uncertainty. One of the compelling data are reasons for the expansion of firms is the difficulty of making contracts made in the presence of uncertainty; the expanded firm is an alternative to the sum of a simply incorporates within itself those functions that previously were for the expansion of the contract of the sum of the sum of the sum of the sum of the expanded functions that previously were for the sum of the sum o

Thus it is not surprising that research intensity, measured say by R and D expenditures per unit of sales, increases with firm size up to a point of sales. and then decreases. Approximately the same pattern holds for research the same same output except that research output persunit of size may peak atsa, some-stor at these what smaller firm size than for R and D input. In part, this general pattern relating firm size to R and D may arise from the phenomena noted as the state earlier with regard to inventiveness and development across firm size, and took over Inventiveness tends to decrease as firm size increases: but developmental - telefox efficiency increases. Up to some firm size, the oreater advantages of greater firm size on development outweigh the loss of inventiveness. Be-ord lines vond this size, the marginal contribution of greater size to developmental efficiency and miskureduction discoutweighed by the marginal dosseofaeth names. inventiveness. Actually, as firm size increases beyond some point, there is the set is probably also a loss of efficiency in purely developmentals work aside a state of the from inventivenession Thus, there are definite and considerable forces in the approximation preventing proportional increases in R and D efficiency beyond some point. Unfortunately, this point occurs at a firm's size, that is absolutely a second second quite large, certainly for most industries we are talking about firms of a self and with sales in the hundreds of millions of dollars. The sale of a contract which a

PROPOSALS FOR REFORM

March Course State Law 2 1984

The preceeding analysis indicates that proposals for increasing the efficiency with which R and D resources are allocated should work to decrease uncertainty in patent ownership rights, increase the efficiency of contract between inventive and developmental firms and, in general, seek to lower these types of transactions costs. A step in this direction would be a more careful and definite awarding of patent rights than is presently the case. More rigorous standards on patenting could be imposed so that, in general, under ceteris paribus conditions, the

sey water of stational and statements. In the Kathar tendent file to state

R. A. Strand can better guarantee the inventor really substantial rewards in the case which assured of success than most alternative arrangements. vento:fandis:

2.27

2 1 1 mm

2.5.50

5.36

1191

However, perhaps the most appealing proposal lies outside the patent system. This is a system of direct grants mentioned by Machiup and proposed originally by James Madison at the Constitutional Convention in 1787.⁶⁴ The government would give awards and bonuses to individuals and firms for invention in amounts related to the importance of the invention. Scherer, while noting the attraction of such a scheme, noted the drawback posed by the difficulties of estimating the value of inventive contributions.⁶⁵ However, this difficulty did not need to be a substantial one; awards could be made in two parts. The first, and perhaps smaller, part could be made at the time of invention. A second award could be made perhaps 10 years later on the basis of the value of the state of the invention as shown by the intervening period. This second award also would serve as an disincentive to hold inventions idle, a practice for which the present patent system is criticized. This sort of system need not replace the patent system, but could as well serve as a supplement. The policy mentioned earlier of discrimination between large and small firms probably would be more acceptable and easier accomplished under a 5.65 system of direct awards_than_through the patent system.

Any proposals for reform clearly need a more thorough working through than given here. In terms of both increasing allocative efficiency for R and D and of promoting smaller firms, the necessary effort seems worthwhile. Perhaps the suggestions here will encourage thinking in productive areas. .a., 15, 83

FOOTNOTES

*The author gratefully acknowledges the support of a grant from General grant and the Electric to the program in the Social Management of Technology at the University of Washington. Sector destable

¹R. Solow, "Technological Change and the Aggregate Production Function," Review of Economics and Statistics (August 1957), pp. 312-320

²E. F. Dennison, The Sources of Economic Growth in the United States and the Alternatives Bafore (New York: Committee for Economic Development, 1962), pp. 271-272.

³There is good evidence of a postive relationship between R and D expenditures and profitability. However, my guess is that much of this, as for advertising, is due to the tax treatment of R and D as current expendi-tures rather than as depreciating assets. Presumably there is an argument that R and D is a depreciating asset.

19Smith and Creamer, "R and D and Small Company."

 $^{20}\text{McConnell}$ and Peterson have data for eight industries. For each of these, I obtained the capital invested per worker in 1964. The top fouriers industries by percentage engaged in R and D had a mean dollar invested per worker of 26.15, while the bottom four had a mean of 7.24. The t value calculated for small samples as

$$t = \frac{\sum_{l=1}^{2} \frac{1}{2} + \sum_{l=1}^{2} \frac{1}{N_{1} + N_{2} + 2}}{N_{1} + N_{2} + 2} \sqrt{\frac{N_{1} + N_{2}}{N_{1} + N_{2}}}$$

give a t value of 5.94. Anything above 2.31 is significant at the one percent level.

²¹Smith and Creamer, "R and D and Small Company," p. 36. 22U.S. National Science Foundation, National Patterns.

 23 However, it is worth noting that Smith and Creamer find almost no drop of this percentage [from 39 percent to 35 percent] in moving from firms in their intermediate size class, 4,000 to 4,999 employees, to the size class of under 1,900 employees (p. 28). A CONTRACT

²⁴Smith and Creamer, "R and D and Small Company," p. 7. ²⁵McConnell and Peterson, "Research and Development."

26Ibid., p. 359.

²⁷Smith and Creamer, "R and D and Small Company," p. 36-37.

²⁸J. Schmookler, "Bigness, Fewness and Research," Journal of Folitical Economy (December 1959), pp. 628-632.

29Professional and scientific instruments is a larger industry group than scientific instruments.

³⁰F. M. Scherer, "Firm Size, Market Structure, Opportunity and the Output of Patented Inventions," American Economic Review 55(5) (December) 1965), pp. 1099-1135. av

³¹B. Johannisson and C. Lindstrom, "Firm Size and Inventive Activity," Swedish Journal of Economy 73(4) (December 1971), pp. 427-442.

32E. Mansfield, Industrial Research and Technological Innovation-An Econometric Analysis (New York: Norton for the Cowles Foundation for Research in Economics at Yale University, 1968).

³³C. Freeman, "The Role of Small Firms in Innovation in the United Kingdom since 1945," Research Report No. 6 (London: Committee of Inquiry on Small Firms, 1971).

³⁴A. Phillips, "Concentration, Scale and Technological Change in Selected Manufacturing Industries, 1899-1939," Journal of Industrial Reconcilion, 4 (June 1956), pp. 179-193.

³⁵A. Phillips, "Patents, Potential Competition and Technical Progress," American Economic Reviso, 56(2), Part II Supplement (May 1966), pp. 301-310; _____, Rechnology and Newket Structure: A Study of the Aircraft Industry (Lexington, Mass.: Health, Lexington Books, 1971).

36Scherer, "Firm Size."

37L. Philips, Effects on Industrial Concentration: A Cross Section Analyeis for the Conver Market (Amsterdam: North Holland Publishing Co., 1971, pp. 119-142.

112

. 'sv

the state of product

0.00000000000000 and 2 states in

e sange i la la seco

Sec. 13. House &

ARTICLE, "IMPROVING THE CLIMATE FOR INNOVATION-WHAT GOVERNMENT AND INDUSTRY CAN DO," BY ELMER B. STAATS, RESEARCH MANAGEMENT, SEPTEMBER 1976, PAGES 9-13

(Elmer B. Staats is Comptroller General of the United States. This article is a condensation of a paper he presented at the Annual Meeting of the Industrial Research Institute last May.)

Both attitudinal and tangible conflicts are hampering Government-industry cooperation in civilian-sector R&D. The U.S. Comptroller General suggests approaches to a more constructive partnership.

In times of crises, such as World War II and the threat of Soviet preeminence in space technology, our Government mobilized industrial resources—and industry responded well—in a partnership effort with industry to meet specific national goals. Such partnerships continue in defense and aerospace. However, we have yet to find the solution to the more complex interrelationships necessary to deal effectively with civilian sector problems, such as the energy crisis or the problems associated with environmental protection and safety.

Today the Federal Government is playing an increasingly important role in international economic relations by helping to establish better sharing of critical resources and by assuring American competitiveness in the international marketplace. More and more American companies are entering into world markets, not only through exports but also through investment in foreign subsidiaries. Many companies have developed into powerful multinational corporations. Consequently, a whole new dimension of industrial accountability has emerged. This partnership responsibility is highly important in fostering world peace, assisting the developing nations, and sharing critical resources for the benefit of all mankind.

The question, therefore, is how can we improve the communication, understanding, mutual goals, and working relationships between Government and industry, especially technology-intensive industry, in meeting both national domestic needs and international obligations.

Many people have attempted to diagnose the barriers to innovation and to offer solutions for improving the climate for Government-industry cooperation. The problems that have been identified generally fall into two broad categories. The first is to a large extent subjective and attitudinal. The second comprises a number of more tangible factors.

BARRIERS TO INNOVATION

745

计算机 法公司保留证

214 LA 1. 19

Laster de

age yn lyn dre

Perhaps the major subjective problem inhibiting Government-industry cooperation is the lack of mutual trust. Many Government officials are suspicious of industrial motives and the potential economic and political power of large corporations, especially those with multinational affiliations. On the other hand, industry is concerned that Government officials do not understand and appreciate the profit motive. Industry also believes there is a lack of understanding by Government officials of the technology innovation process.

Also, the meaning of public accountability is commonly misunderstood. Some Government officials believe that public accountability means that every Federal dollar spent should be tagged with a program directive, management control, and Government ownership of whatever results.

There are situations in which a broader view of public accountability is appropriate which would not provide for specific direction and management by the Government nor Federal ownership of the resulting product. In such cases, the question to ask is whether Federal funds are being spent wisely in the public interest, such as to stimulate useful innovation. An example that comes to mind is Federal policy regarding patent licensing. Some Government officials believe that patents derived from federally funded R&D must be owned and controlled entirely by the Government. However, in most cases, the public interest may best (893)

ESSENTIAL COMMERCIAL VENTURES

There are controversial views concerning the Federal Government's role in mobilizing combined nationwide scientific and technological resources required to develop major commercial products needed to meet national goals. For example, although the Energy Research and Development Administration, in combination with industrial firms, is investing heavily in nuclear power development, some experts question what the specific role of the Government should be in the energy area.

The basic argument is whether the Government should finance and manage such programs directly or attempt to provide the right climate and incentives for innovation by the private sector as well as insurance against the risks, with oversight sufficient to assure adequate public protection from potential hazards and monopolistic advantage or excessive prices.

The energy problem involves extensive industrial participation and its products ultimately will be commercially delivered to public utilities and other users. The technological and market uncertainties, combined with the long time frames and magnitude of capital investment, require that the Federal Government be involved. The question is: To what extent and how?

Two case studies, which shed some light on this question, are presented in the General Accounting Office reports dealing with the Liquid Metal Fast Breeder Reactor Program and the Federal Coal Research Program. In the case of the Breeder Reactor Program, the delicate question of judgment is at what point will the technology—largely Government financed—be sufficiently reliable, economic, and safe as to make it a viable commercial enterprise and how will the transition from major Federal involvement to commercial implementation by the private sector be accomplished.

Similar questions are involved in developing the means to convert coal to synthetic gas or liquid fuel, a problem made more complicated because of the environmental concerns associated with mining and developing coal as an energy resource and the fact that much of our coal reserves are located in areas which will require large-scale construction of public facilities, such as hospitals, schools, and roads.

These are only two of a number of examples which could be cited to illustrate the point that we have not yet established a consistent policy concerning the respective roles of Government and industry in developing major long-term commercial ventures to meet national needs. It is unlikely that a formula for general application can be devised, but I believe that studying of policy alternatives should be continued in an effort to establish a general policy and criteria for guidance in determining the Government's role in each situation of this type.

MANUFACTURING PRODUCTIVITY

Improving productivity in both public and private sectors has been generally recognized as one of the most effective means to stimulate economic growth. Since 1970 the General Accounting Office, in cooperation with executive branch agencies, has been fostering efforts to measure and enhance the productivity of Federal activities. In addition, we have recently completed a comparison of programs in the United States and other countries concerned with advancing the state-of-the-art of manufacturing technology, particularly in the manufacturing of parts and components produced in medium and small lots—with special attention to the potential for further application of computers to the design and manufacturing process.

We concluded that the United States generally uses more advanced manufacturing technology than other countries in the world. The U.S. total output and output per employed person is higher than any other nation's. However, our advanced technology is concentrated in a few high-technology and/or capitalintensive firms. It is not well diffused throughout medium- and small-sized companies. Our study also suggests that, without some added impetus; the advanced technology will not expand or diffuse widely to small- or medium-sized firms.

Our international competitors are capturing increasing shares of foreign markets and are increasingly penetrating U.S. markets. It is significant that they are competing in those markets with U.S. high-technology manufacturers. The principal U.S. exports for the future appear to be essentially the same as at present; i.e., primarily agricultural products, aircraft and components, electronics (principally computers), and nonelectrical machinery. Unlike the United

بالالتحاد والمرجع والمحاج

Discussion and debate in forums and panel meetings, such as those sponsored by the National Science Foundation, the National Bureau of Standards, professional societies, and trade associations can help; especially when all interested parties or sectors, including labor and consumer groups, are represented. I am told that workshops, such as those jointly sponsored by IBI and the National Bureau of Standards; have been productive.

Congressional hearings also are useful for improving understanding and perspective. For example, the Subcommitte on Domestic and International Scientific Planning and Analysis of the House Committee on Science and Technology has just completed hearings on "R&D and the Economy".

With regard to the more tangible issues, I believe several initiatives can be or are being taken. One of these is in the area of basic research. In proceeding from exploratory research to product development, risks tend to decline but costs increase. For example, the cost involved in basic research and exploratory development to demonstrate technological feasibility of an innovation is generally much less than the cost to complete prototype development, tooling for manufacturing and market development. These characteristics of the R&D process are suggestive of the respective roles of the Federal Government and industry.

For specific missions, such as defense and space, the Federal Government supports all phases from basic research to product development. For technology primarily related to commercial products, the role of the Federal Government, with few exceptions (notably agriculture and nuclear energy), generally has been limited to support of basic science and exploratory development of emerging technologies.

The private sector generally does not support basic research and education unless it can identify a direct, prompt, and adequate return on its investment. A few exceptions are large corporations and philanthropic foundations. As part of the Federal Government's responsibility, therefore, it must continue to provide major support for basic research and graduate education in both physical and social sciences and the engineering disciplines.

We have not been able to develop any "best" formula for the level of Federal support of basic research—a percentage of the total Federal budget, a percentage of the total R&D budget, a percentage of the gross national product, or the consensus of experts in various disciplines. However, I believe that a rationale can and should be developed and criteria established to assure continuity and stability of federally sponsored efforts.

In funding basic research and graduate education, the Government not only supports industry's R&D efforts by augmenting the science and technology base underlying the innovation process; it also supplies a stable base of scientists and engineers. Basic research should continue to be conducted at Government laboratories, universities, and private institutions, depending on the capabilities of each.

Some reorienting or rethinking of Federal policies and priorities toward funding the science and technology base may be appropriate. This reorientation could be based in part on increased distinctions between R&D policy supporting defense and space on one hand and consumer-oriented technology on the other. Several noneconomic criteria are important in decisions concerning defense and space R&D. While there are "spin-offs" from defense and space R&D to commercial markets, they are not crucial elements in the decision to fund defense and space R&D projects.

Federal financing of applied R&D in support of commercial technology should be considered in the context of potential economic and social benefits to the Nation and in relation to the private sector's ability and motivation to invest its own resources, as well as in relation to other Government initiatives that can influence the climate for private-sector innovation.

Some recent initiatives by the Federal Government both within the executive branch and by the Congress are aimed toward establishing more definitive and enlightened policies and priorities for resource allocation and for dealing with issues that transcend the purview of individual agencies and the private sector. Among these are:

The pending legislation, now passed by both the Senate and the House, to establish a Science and Technology Policy Advisory Office in the White House.

The Office of Technology Assessment comprehensive study of National R&D Policies and Priorities;

The National Science Foundation R&D Assessment Program.

The National Bureau of Standards Experimental Technology Incentives Program.

Appendix XVII

s - and the action of the contraction of the second states and the second states and the second states and the

6.001200414 (0.02014 H

1 40 A

n et sælar her stadt storer her f

4368 1312-16

ALLE ANTA THE AREA ACT

1.14

Sec. Sec.

STATEMENT OF DR. BRUNO O. WEINSCHEL, VICE PRESIDENT, PROFESSIONAL ACTIVI-TIES, INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS, INC., WASHING-TON, D.C.

STATEMENT

Dr. Bruno O. Weinschel*

on behalf of

The Task Force on U. S. Innovation in Electro-Technology of the U. S. Activities Board, Institute of Electrical and Electronics Engineers, Inc.

To The Senate Subcommittees on:

Science, Technology and Space; and

International Finance

Concerning

U. S. High Technology - Impacts on U. S. Policy

Affecting World Markets

May 16, 1978

*Vice President, Professional Activities The Institute of Electrical and Electronics Engineers, Inc. 2029 K Street, NW Washington, DC 20006

ra C. S.e. Andrea Arabet

TABLE OF CONTENTS

	Executive Summary	가지 가지 속 가지가 있어요. 카이카	1
: 1 .	The Role of the Institute of El Electronics Engineers	lectrical and an angle of a state of a	3 [°]
2	Background	de l'altre de la compa	-
. 3	The Importance of Technology	1997 - 1998 - 1999 1997 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999 - 1999	11
4	The Characteristics of Technolo	989 Bassari kova filo ocus Galera culto del secol	13 🕺
. 5	National Technological Strategy	y Options	17
6	The United States Posture	n ng tao nan di	20
, ⁸¹ 7	The Children of or organo	$\mathcal{L}^{(1)}(\mathcal{J}^{(1)}) = \mathcal{L}^{(2)}(\mathcal{L}^{(1)}) = \mathcal{L}^{(2)}(\mathcal{L}^{(1)}) = \mathcal{L}^{(2)}(\mathcal{L}^{(2)}) = \mathcal{L}^{(2)}(\mathcal{L}^{(2$	22
	Problem Summary	a de anna an Consta Iodhrach Arthrait I an Anna	۹۰ .
9.		ush and gal in the ca	
10	Conclusions and Recommendations	i al son a contra Pl	
11 \^*	Bibliography	rena <mark>tigali</mark> anas sa el inter astrativa artek	68
5 - 1 <u>-</u> - 7 - 7	ರ್ಷ-ಪ್ರಾಣವರ್ಷ ಕ್ರೀತಿಕ್ಷಕ್ರೇ ಕೊಡಿಸಿದ್ದ ಪ್ರವಾಣಿಗಳು ಪರಿಕ್ಷಣಕ್ರ ಕ್ರ	alalaren 218 ile terriar erat erebi	<u>.</u>
- - 38	an a	e engenen och var et standelter var Den att men i den gestären i tet sta	n tana A sha
1.2 C	нын бардоолоо саронносы ма	a las manda services	N . jež
· · ·	an a	n allande en antalande antalande Received allande Maria (1993)	
			· · ·
	$V_{1} \in \{0, 1\} \cup \{0, 1\}$	n an tha chair an an the state	4
t+	99. 826	en e staard kereke	1
	nood and the averages for some factors for the second	Honda (Bork Switch B Statement	<u>.</u>
8 c	an a	ora bal ≵oro⊷iarmen	; z.
		2 - ¹	
		S na ser med landstage deservation de serve de s	
. Source Replace and sources	an a	n an an the fact of the second state of the se	n New York States of the State
1 A. 1			

Executive Summary

In this document we have attempted to provide a brief review and evaluation of current U. S. policy concerning the development and commercialization of high technology, and suggested possible measures for improving our position. The essential points of our findings as they relate to the questions posed by the Joint Committee, may be summarized as follows:

- There is a significant correlation between levels of R&D investment and the maintenance of U. S. technological leadership. There is no such strong direct relationship between U. S. exports of goods and services derived from such investments, but there could be if the time-leg prior to implementation and commercialization could be decreased.
- 2. Private investments in R&D in the U. S. are generally doclining, and this has serious implications for high technology exports. The factors contributing to these trends, however, are many and complex, and are discussed in the body of this document along with recommendations for policies which may provide incentives to increased these investments.
- 3. If we over-simplify our comments, we could say that the role of the small firm is larger in the innovative process, but it is less equipped to capitalize on this lead in terms of exporting goods and services where management/marketing skills and especially the availability of venture capital play a dominant role. The need for incentives to further capital formulation is therefore essential. The larger firm is in a better position to play this "follow up" game, but is less likely to innovate because of its heavy investment in existing equipment, processes and product patterns.
- 4. Some U. S. R&D activity is indeed moving abroad, and the trend is likely to increase. Government actions could slow the process but would not stop it. The transfer is desirable from many points of view, and inevitable, but steps must be taken to minimize its negative effects on the U. S. economy.

905

1. The Role of the Institute of Electrical and Electronics Engineers and the second states and the second stat

On behalf of this Institute, usually referred to as IEEE, I wish to as and the express my appreciation for the opportunity to present out viewpoint on the around matters being considered by this Joint Committee. The IEFE is well-qualified to address these issues. This organization has as its origin the incorporation in New York State in 1884 of the American Institute of Electrical Engineers, which merged with the Institute of Radio Engineers in 1961 to form the Institute of Electrical and Electronics Engineers. The aim of the original organization was "to advance the art and science of Electrical Engineering" by all appropriate acts and activities. In its 96 years of existence the membership has grown from 46 to over 185,000, and its scope has continuously expended as a unique leader in its field and a major institution in the field of engineering on both the domestic and the international scene. Its members cover the entire spectrum of associated interests, including teaching, research, government and industry, private individuals, small business, and mammoth multinational enterprises. We are deeply involved in the high technology areas of electro-science, from sircraft electronics through computers, lasers and microwave repeaters to satellite communications.

Our role in the current investigation is to try to point out the complexity, diversity and interrelationships of the factors which must be considered. We cannot propose a solution to all the related problems; we do believe that we have a contribution to make in terms of clarifying the issues, presenting the legitimate concerns of the affected parties, and making recommendations (in Section 10) for a phased program of investigation and supportive actions which will enhance understanding of the

3_

. <u>. .</u>

2. Background

The typical pattern of Research and Development in the United States has changed radically since the time of the inventor working independently in a laboratory in his own home. At the start of World War I, the American Chemical Society offered to help President Wilson in any areas of chemistry or chemical engineering, to which his response was "Thank you very much for the offer, but we already have a chemical engineer working at Edgewood Arsenal." In contrast, we now have a formalized team structure to attack almost all aspects of Rab.

The U. S. has not in the past always been a leader in Science and Technology, but rather an "early adaptor" of R&D performed typically in Europe. We have made progress in the "four Is": generation of breakthrough <u>ideas</u>, and application and development phases - <u>invention</u>, <u>innova-</u> <u>tion</u> and <u>imitation</u> (or diffusion) - and as recently as 5 years ago it appeared that the U. S. had achieved and was likely to retain the position of world leader. * However, we are now in the process of letting this advantage slip away.

Measures of international stature are difficult to quantify, but we can get a general idea in the realm of <u>science</u> by looking at indicators, such as the citizenship of Nobel prize winners for Science. Table 1 shows the improvement in relative standing of the U. S. since the beginning of the century, moving up from fifth place prior to 1930, and subsequently maintaining a significant lead over other nations, until in the most recent

Cetron, M. J., "Technology Transfer: Where We Stand Today"; <u>Technology</u> <u>Transfer</u> (Eds.; Davidson, Cetron & Coldhar), NATO Advanced Study Institute Science; Noordhoff; (Leyden) 1974; pp. 1-28.

5

· 医结合性 医鼻骨下的 计相关 医结束 医结束 化化合物 化合物

list the U. S. has more than all others combined. This rather sudden acceleration may be attributed in part to the substantial influx of scientists who were educated abroad and migrated to the U. S. because of the political or religious turmoil of the 1930s. It is also a result of the great material resources which are available in the U. S. The scientific areas where we lead are those which require expensive experimental equipment, which some nations cannot provide. (However these are not necessarily areas which can be readily commercialized.) Even here, however, if we examine the number of Nobel prizes as a function of population (Figure 1), the United States -- although still a leader -- no longer dominates as it did prior to 1950.

In the realm of <u>technology</u>, the U. S. has been pre-eminent over a much longer period. Two crude measures of comparative standing are shown in Table 2. Column A indicates by nationality the number of authors of major inventions from Colonial times to the present day. Such a tabulation can be regarded as distorted both by chauvinism in the selection of responsible individuals, and lack of discrimination in the choice of inventions. The remaining columns show the average patenting rate in the 1930s and in 1975, for the countries listed. By either criterion, the U. S. was ahead of other nations; however, this position of leadership has been eroled over the last decade, as shown in Figure 2. In a recent report, * OECD states that except for the computer, aerospace, and heavy electronics industries, technology is primarily transferred <u>into</u> the United States from other

Caps in Technology, (Paris, France: Organization for Economic Cooperation and Development, 1970).

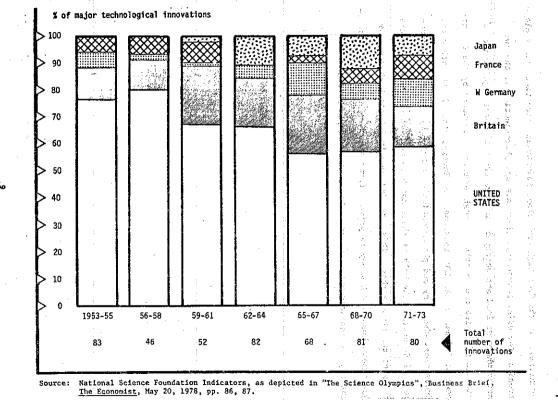


Figure 2 PERCENTAGE OF MAJOR TECHNICAL INNOVATIONS

3. The Importance of Technology

Both technology and technology-based products are of major significance to the U.S. in terms of international trade as well as in generating jobs and products for domestic consumption. The export of technology, as distinct from the export of products, brings revenues to U.S. companies, and thus to the U.S. economy, in the form of license fees and royalties. In 1977 the gross income from such sources was \$2.95 billion, compared to \$.66 billion in 1965. The <u>net</u> income (technology export minus technology import, neglecting products) for 1977 was \$2.67 billion, comparable in magnitude to the \$3.25 billion U.S. trade surplus for all manufactured goods:*

The total contribution of technology to our economic welfare however cannot be measured solely in terms of trade balance. The tremendous increase in productivity of U. S. industry over the past thirty years can be attributed primarily to the application and utilization of technological advances. Between 1947 and 1965, the average annual increase in output per man in private industry ranged from 2% to 6%, the greatest change being in the communications and utility sector, ** where the growth in real output reached 7.5% p.a. by 1970. Advances in productivity are responsible for a large part of economic progress, in terms of GNP per capita, and these trends are expected to continue through 1990. *** One of the most important weapons in our arsenal against inflation is such increased productivity, which can

n managereith a season as a constant in the same same in the set of the set o

Langan, Patricia, "Those Worrisome Technology Exports", <u>Fortune</u>, May 22, 1978. These data are confirmed by the latest figures provided by the U. S. Department of Commerce (Private Communication), excluding the category of management and aervices.

Private communication from the National Bureau of Economic Research. *** The Conference Board, "The U. S. Economy in 1990", in <u>A Look at Business</u>

in 1990, White House Conference on the Industrial World Ahead. Washington, D. C., 1972.

4. The Characteristics of Technology

The most obvious characteristic of technology in general is that it changes; old products and procedures are replaced by new. This is a continuing process, so that at any given time and place the technology being practiced covers a spectrum from the old and stable to the new and rapidly changing. The impetus towards newer technology is a consequence of its potential to increase the productivity of a society's stock of resources. Solow^{*} estimates that over the past century, 80% of the growth in the U. S. economy has resulted from advances in technology. The remaining 20% has been due to increases in the amount of resources.

915

In general, the increase in productivity is more rapid when the technology is new, and it thus yields greater returns to society than does a mature technology. There may be argument as to the distribution of these returns -- the major profit almost never accrues to the original innovator -but there is general agreement that all members of the society benefit.

The growth of a new technology follows the familiar S-shaped curve as shown in Figure 3. An incipient period of rapid technological change --"leading edge" technology -- is followed by a period of high growth but less change, manifested by increasing standardization. This is succeeded by a "mature" period of relatively slow change and slowing growth, and maximum return on the investment. Because of this growth pattern, the bulk

Solow, R., "Technical Change and the Aggregate Production Function", in Review of Economics and Statistics, August 1957.

of a technology being practiced is relatively mature and approaching stability.^{*} If a new technology were to disappear in its incipient stage -- as many do -- it would hardly be noticed in aggregate statistics. However, the industry and the nation alike suffer when this happens, since it is the subsequent stages which provide substantial economic rewards.

Once a technology has been firmly established, and incorporated in a product or set of products, the frontier -- the place "where the action is" --- shifts from science and engineering to production and marketing. Instead of concentrating on making a single item work, the company concerned must learn to produce in quantity: to make the same item every time, and optimize the work flow. Customers must be acquired, and shown how to use the product. Service men must be trained -- much of the rapid post-war growth of "hi-fi" and TV equipment sales was spurred on by the training of radar technicians in the military. Ultimately the major benefits of a new-technology accrue <u>not</u> to the technological innovator, but to those who solve the production and marketing problems.

Not only does the technology <u>change</u> over time, but it <u>moves</u>, and cannot be confined. Those whose command of a technology permits them to enjoy a position of monopoly have always tried to keep this advantage to themselves. Such attempts have invariably failed, and are doomed to failure by the very nature of things. The sale of any product embodying the technology necessarily reveals the most important item of information -- that the technology is possible. The processes of technical marketing also provide other data, and the more complex the product, the more information must be disseminated (concerning application and maintenance).

However, in order to ensure continued national economic health, a portion of the profits from a mature technology must be reinvested in new and efficient research and development; otherwise the technology well will run dry.

15

5.

National Technological Strategy Options

919

Loi dous Ave in

. Sector and the

There is more than one attractive strategy in playing the "technology game" on the international scene, and by no means all of the advantages lie with the innovative leader. Before attempting to discuss policy options for the United States, we must consider the implications of "leader" and "follower" roles. The discussion which follows is based upon an excellent summary by Horn, of the Institut für Weltwirtschaft in Kiel.

Technological progress continuously creates new products. Therefore, technological leads and lags are a steady source of international trade. A country which is able to generate a higher rate of innovations than other countries will be able to permanently produce a greater proportion of new goods. Countries which are less capable of producing technological innovations will have to specialize in the production of traditional goods.

This leads to the question of which factors determine international differences in the inno-orbit of a second vative activity of countries. The answer to this question is suggested by the so-called of a second second and product life cycle approach to international trade.⁵⁵ Simplified, the product life cycle is a second se

Horn, Ernst-Jurgen, "International Trade and Technological Innovation: The German Position Vis-a-Vis Other Developed Market Economies", in Karl A. Stroetmann (Ed.) <u>Innovation, Economic Change and Technology</u> <u>Policies</u>, Bonn, Germany, 1976.

Vernon, R., "International Investment and International Trade in the Product Cycle". In: <u>Quarterly Journal of Economics</u>, Vol. 80 (1966); and Hirsch, S., <u>Location of Industry and International Competitive-</u> mess. Oxford: Clarendon Press, 1967, and Gruber, W. H., Mehta, D., Vernon, R., "The R&D Factor in International Trade and International Investment of United States Industries". In: <u>Journal of Political</u> <u>Economy</u>, Vol. 75 (1967), and Wells, L. T. Jr., "International Trade: The Product Life Cycle Approach". In: Idem (ed.), The Product Life <u>Cycle and International Trade</u>, Boston: Harvard University, 1972.

e de la constante de la constan

This option is open <u>only</u> to those nations/corporations whose technical level is similar to that of the innovator. The American Indian, for instance, could not imitate the settlers' firearms because he had no knowledge of the requisite skills in making and forming steel, casting lead, producing nitre, sulfur, etc. There are plentiful modern instances, also, where major problems have arisen due to disparities not only in a specific technology, but in the necessary supporting infrastructure and in a whole range of ancillary technologies.*

Bolgang al gerta lago sate edite, the Schlägers Frientry plantan (a. 1999) of totaget the teathering resting the level of a second field of the teath of the lago determine teathering for a teather and the exploration of Friend, "The level teath determine teather and the structure of the exploration of Friend, "The level teath of the teather and the structure of the second of the teather of the lago second of the structure of the second of the teather of the second of the lago second of the second of the second of the teather of the lago second of the structure of the second of the teather of the lago second of the second of the second of the teather to the second of the lago second of the second of the second of the teather of the lago second of the second of the second of the teather to the second of the second second teather teather of the second of the second of the teather the second of the teather the second of the second

See for example Baranson, Jack, <u>Industrial Technology Transfer by U.S. Firms to Overseas</u> <u>Affiliates Under Licensing Agreements: Policies, Practices and Conditioning</u> <u>Factors</u> (Arlington, Va.: Forecasting International, Ltd., 1975)

innovations. Says J. Fred Bucy, President of Texas Instruments: Today our toughest competition is coming from foreign companies whose ability to compete with us rests in part on their acquisition of U. S. technology... The time has come to stop selling our latest technologies, which are the most valuable things we've got." Horace D. McDonell, an executive vice president of Perkin-Elmer Corporation, sums it up more piquantly: "We want to sell more milk and fewer cows."

Before we can evaluate the validity of this viewpoint, we wish to examine more closely the situation of the United States in the light of the technology flow pattern we have defined; given that our perception of our national role is that of a leader, what are our achievements relative to establishing, maintaining and capitalizing upon a technological lead?

1.00 C 1.

NEARS HERE AT STREETS TO LET

ANDA LEBORTS & RATIONAL FORM AND TO DESCRIPTION

- 5

141006.20

second out these sets as see a second started

1. S. 1. 1. 1.

18 18 24 1

i su regel da

1993 - A 497 - NU 21

i ser a ta

1.593

REPARTS AND A REPART AND

Second ever

An Analysis of Export Control of U. S. Technology: A DoD Perspective, Report of the Defense Science Board Task Force on Export of U. S. Technology, J. Fred Bucy, Jr., Chairman (Washington, D. C.: Office of the Director of Defense Research and Engineering, February 4, 1976). Langan, Patricia, op.cit.

"我就是你们,我们就是我们的你们,我们就是你们也能让我?"

INCREASED IN pes l 19070000 50 G 3 $c \in Are$ bed dawayow RE INVEST use vol lata a province and the second s ≈ 1 1.1.2.2.2.4.4 anto a da **P**oleg 376 963 ange Artenderer armen. 8.77 8.1 ai ar a and the state of the S. 18 11111111 IMPROVED PROFITS el syd raad 94 (11) ***** 46 (10) 1.745 1961 Sec. NR 132 3 3 3 Charley Course Jan Herrie Press and the case of the sec 163 (S end there south as Augustable werd ander ig der s FIGURE 4. Harden THE R&D GYCLET AND DECEMBER STOL 32 .

sime water and stong for tand between the real A stand to be an a particular 24 etrical gladele televice beid ogene beid over og 12.55 SVI) 179 4440 "这是是得到结节 遗憾理病已经不 一次不不 102569 31 油品盒 常装饰 心静脉的 50 オウシイム 20 American Trans j. erta 2015 757 6.5.9 ಜಾಧಾರಿ ಮಹುವೆ ಬಂದುಗ 11.1220 goodlingth an eleve . Taxas e anyst af 621.241.2 16 1.1.531 1.032 1.0531 Co. 654, 28 We water Federal Republic of Percent 71 1.200 Germany_ wi a gé braissoné en contration dang ala anto ava <u>. 77</u>93 8 (203) \$1 $(1,2,2) \rightarrow \infty$ Japan 2.2 $\int dx = 0$ 13 an cara $I \sim \tau_{\rm c}$ n (4)] s an india 3,720,924 $q_1/2$ ê pt 64 66 $\Delta (\zeta)$ 68 20 70 20 72 2 74 76 egente alter i consta activi di conigitario della soluzioni i 3.2 All gotto 23 ant a del promo demonstrations and 12.52 85 1. 1. 192 - 19 - E 2012/07/28 Figure 5. Share of the Total World Export Market (All products and raw materials) N. 111 and the state state of a second second $\mathcal{A} \subseteq \mathcal{A} \subseteq \mathcal{A}$ 164317 NERVER SHOP 14 R.O. M.S. 1.50 0.0086 12117-1-64 - 3332 n third and 10.000 which with each providents eter of an analysis in the lease

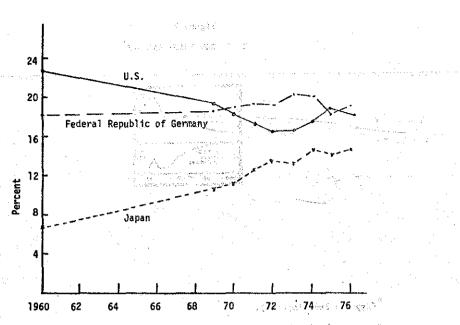


Figure 6. Share of the Total World Export Market (Manufactured Goods Only)

which he calls "revealed comparative advantage" (RCA) * provides insight into what is happening in the world arena concerning the international sale of high technology products.

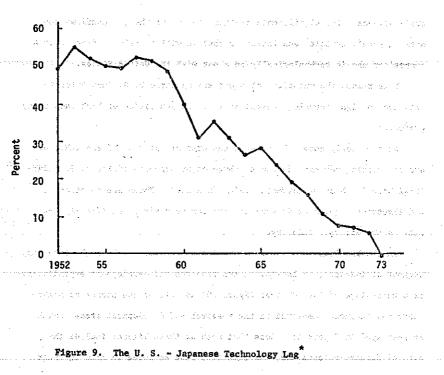
Figure 8 shows RCA values for the United States, the Federal Republic of Germany and Japan for the periods 1963 through 1973 as well as a projection of these figures into the future. Note that the United States position has been eroding significantly, decreasing by about 30 units during the time period under examination; that the Federal Republic of Germany's position appears to have remained relatively constant although weakening somewhat; and that the Japanese position has improved, also by about 30 units. (In this figure a negative value means that they started at a disadvantage.) The cross-over between United States and Japan in this particular segment of the market would occur somewhere in the period 1980 through 1985, based upon extrapolation at the current rate of change.

A similar conclusion was presented in a document issued by the National Planning Association^{**} in which a measure was defined of the lag^{***} between U. S. and Japanese technology, a graphic representation of which is shown in Figure 9. The relative lag impacts upon the future relative

This indicator measures the extent to which foreign trade surpluses (deficits) in one product group diverge from the trade position of this country in total manufactured goods. The measure has been normed so that it can assume values between + 100 and -100. High positive values of the measure indicate a high international competitiveness. For method of calculation the reader is referred to the article as cited, page 144 et seq.

New International Realities, (National Planning Association, Washington, D. C., 1978).

This is expressed in terms of the relative technological change over time: the rate of growth of output holding all inputs constant. For a precise definition of the measure, see Christensen, L. R., D. Cummings and D. W. Jorgenson, "Economic Growth, 1947-1973: An International Comparison," in J. W. Dendrick and B. Vaccara (Eds.), <u>New Developments in Productivity Measurement</u>, Studies in Income and Wealth, Vol. 41 (New York: Columbia University Frees), forthcoming.



1.114 S. 61 - 1 en proposition de la com-Stranges millions where a prove the second s

This is expressed in terms of the relative technological change over time: the rate of growth of ourgut holding all inputs constant. For a precise .. definition of the measure, see Christensen, L. R., D. Cummings and D. W. Jorgenson, "Economic Growth, 1947-1973: An International Compari-son," in J. W. Dendrick and B. Vaccara (Eds.), <u>New Developments in</u> Productivity Measurement, Studies in Income and Wealth, Vol. 41 (New York: Columbia University Press), forthcoming. ಲಿ ನಿಲ್ಲೆ ಗಳುತ್ತಿನಲ್ಲಿ ನಿಟ್ಟಿಕೆ ಸೇವಿ ಮಾತ್ರವು ೆಲ್ ನಿರ್ದೇಶಸೆ ನಿರ್ಮ

258³¹

Sector Constants

31

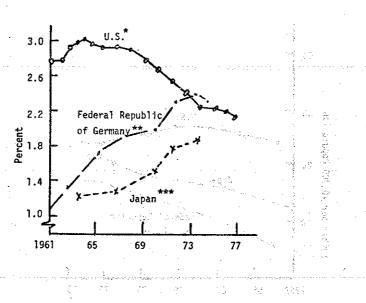


Figure 10. R & D Expenditures as a Percentage of National GNP

*This includes about 50% defense-related R&D, most of which cannot be adopted to commercialization.

This includes about 11% defense-related R&D.

This includes about 2% defense-realated R&D.

"technical wizardry" are expanding their share of U. S. and world markets in those less technologically exciting goods which make up the bulk of world trade.*

The rationale for examining the high technology manufactured goods is based upon material previously generated for the U.S. Senate Committee on Finance.^{**} Data were presented which indicated that high technology industries (that is, product industries whose products depend upon the application of high technology) provided for the U.S. a significant positive balance of trade as opposed to the lower technology manufactured goods or raw materials. This was previously shown also in Figure 7. A reproduction of the table for the period 1960 through 1971 is shown in Table 3. The specific industries categorized as high technology, medium technology and low technology are listed in Table 4 for reference, ranked in decreasing order of R&D investment as a percentage of shipments (1966 dats)

To bring the problem into focus, let us look at specific examples, as previously: in the semi-conductor industry the lead clearly has been with the United States for many years; the development of transistors, integrated circuits, etc. has placed the United States in a very strong position in this particular area. However, starting in about 1965 several developments occurred which ultimately must have serious consequences upon the balance of trade for the United States in this area. First, these semi-conductor

"The Science Olympics", loc.cit.

⁷Implications of Multinetional Firms for World Trade and Investment and <u>for U. S. Trade and Labor</u> (Committee on Finance, U. S. Senate, February 1973).

35

Based on U.S. Census of Manufactures.

the search of this with the second of the se second a pay Electrical mechinery and apparatus, include a suble by Starts household appliances-----Drugs -----) : . (> . (a.: 6) -Industrial chemicals-----Radio, T.V., electronic components------Farm machinery and equipment-----Electronic computing equipment and miscellaneous nonelectrical machinery----Medium Technology Industries Boaps and cosmetics Industrial machinery and equipment------Miscellaneous chemicals not included clsewhere-----Store, clay, and glass products the store and glass of the store and the

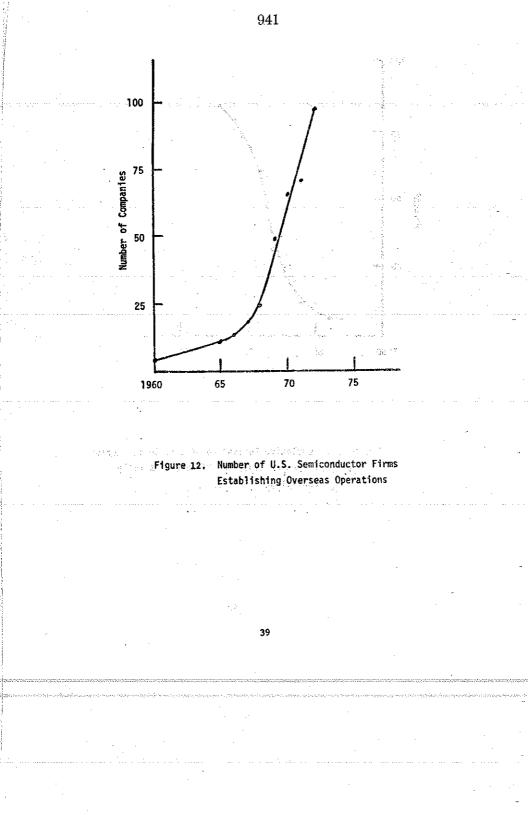
autor finde for Plastics la succession for account of the set of a set of the set of the

- Berningslagen in and wer were end are prepared with Barwhart a die were with Barwellinds Bar (were provided) of the direct of Bars and were direct water and a set of the s

Table 4. Composition of Industrial Segments

ى ئەر بەتلەتلىڭىمىمە قەر بارلىپ، بارلەڭ مىلەرمەتلارىت «يارىمۇرلۇش». بارلەتتارىما قانىما مىلىيە قاناتارىلا مەمەنلىرىلىرىمۇ بارلۇپ،

361. 04.3



The implication of the long term effects focuses the need for our industrial structure to maintain a technological lead in the semi-conductor area. This means that we must encourage innovation and the application of leading-edge technology at an ever increasing rate.

The Institute recognizes the importance of this issue and the complexities involved in trying to evaluate the variety of impacts. To attack this problem, the IEEE is in the process of convening a study group which will bring together industrial, governmental and academic experts who will examine the causes, modes and consequences of the transfer of high technology from the U. S. to foreign sites. This task force will examine, to the extent possible, the technical, economic and socio-political aspects of these and related issues.

In the context of the present discussion, let us now examine the question of what is the relationship between funding of research and development and high technology, and the product output by that industry. To do that we will examine the computer industry where some statistics are available; this may give us some insight into at least one segment of the total high technology area.

In examining the research and development investment as a percentage of the total revenue of five major organizations in the computer industry, we produced the results shown in Figure 14. It is interesting to note that the National Cash Register (NCR) Company as well as Burroughs maintained a relatively stable input of research and development dollars as a percentage of their revenue over significant periods of time. On the other hand IBM increased its percentage of research and development from approximately 4% in the late 1950s to nearly 7% in the period 1970 through 1974.

The two remaining companies examined were CDC and the Digital Equipment Corporation. CDC shows a sporadic fluctuation in its research and development investment, particularly during the time period 1958 through 1964. From that period on it began to decrease its research and development investment although it was not until 1967 that the percentage dropped below the IBM level.

During the time period 1958 through 1967 CDC was applying high technology to its product line and developing very rapid penetration of the market for various new devices and systems which were produced.

DEC was utilizing approximately 16.6% of its revenues for research and development investment in 1964 and 15.2% in 1965. This appears to be decreasing asymptotically. However, during the time period when DEC was investing significant amounts of money in the research and development effort it was a recognized leader in developing mini-computers and microcomputers for sale in the United States. This penetration was successful and it is today one of the leading organizations in that particular subarea of computers and computer applications.

Figure 15 provides additional information as to the impact of research and development upon the growth and viability of various organizations which can be classified as high technology, innovative and mature. In this figure we have presented the average annual growth of these three groups of organizations or companies. The specific growth rates spanned the time frame 1969 through 1974.

Another issue which relates to the questions posed by the Subcommittees concerns company size. Without external support, only large organizations can afford the huge research investments needed to practice innovation in

43

specialized high technology areas. Yet in the U. S., businesses with fewer than 1000 employees produce 17 times as many major innovations per research dollar, while "medium-size" companies appear to be about 4 times as innovative. Organizations such as Bell and IBM register a patent a set day throughout the year, but are often either too inflexible to exploit innovations, or are inhibited from doing so by Federal regulations.

and when a source to all with the second displayed as an additional and the end of the set a de la companya de l a ne staar i ne staarde kan een berne berne in 16 september staar een s Conferences and a president and a compare again the second of and

and generated in the state of the original set of the set of the set and the state of the set of the set , And de complete la constante de la constante en en sen de la companya de la comp n. Alben bereit na alben in der einer Bernaus under ergebenen Fristenen iste stateten im Der Bernausen som Bernaus ane was the effect which they can apply a construction was the share of a second district with the second and the second of the second to a subscript the second second second second second second second a company com (魏] on a company part and a promotion of the CS [[]] (# where we want the second of the second constraints and the second s Beneration of the second second second of the second second second second second second second second second se

45

al second s "The Science Olympics", op.cit. a inversees?

our large high speed computer system design technology not just to Fujitsu, but to Japan, because of the national solidarity of outlook. Japan has an integrated national policy designed to support its role as a modern industrial leader, and administered by MITI, the Ministry of International Trade and Industry. Because of this philosophy, there is no clear distinction between one firm and "Japan Inc." as far as relations with other nations is the grant of the state of the second second are concerned.

A second example is the LITEX light bulb case, where the inventor, Don Hollister, could not find funding for his new energy-conserving light bulb. The major U. S. manufacturers of light bulbs apparently were not interested in breaking down their production lines in their plants and sector and the and a stant process of the starting a competitive business. Since venture capital was not available. しょうしゃき 花をかってかみ しいちょうかん いちんしんかいかん Los Artis in this instance the government intervened. ERDA (now the Department of Energy) agreed to underwrite the research and development costs (\$310,000). The Government owns the patent, but Hollister has free licensing and use and the states of rights provided he exercises them. Otherwise, the patent lapses (similar to provisions of the Thornton Bill) and the patent enters the public (1) Structure and the second contract state of the second state domain

The third example is more general. It concerns the U.S. aircraft وبارج وري بالمحمد and the second of industry and its competitive position in the world market a conservation to end to get a

Alexand Alexan

20100

See e.g. Oshima, Keichi, "Technology Transfer in Japan", in Cetron, M. J., H. F. Davidson and J. D. Goldhar (Eds.) <u>Technology Transfer</u> (Leiden, The Netherlands: Noordhoff, 1974).

CERNAL ADDRESS

HR 6249 (95th Congress, First Session, 1977).

13.3 C X

A Study of How Technology Transfer Affects the Competitive Position of the United States in the World Aviation Market; Forecasting International, Ltd., Arlington, Va.; 1972; and <u>A Study of the Key Aspects of Foreign</u> Civil Aviation Competition; Forecasting International, Ltd., Arlington, Va.: 1976.

DC-9. Other competition in this category is Britain's the second Rolls-Royce which is trying to putstogether an engine a stand of the consortium with French, German, Swedish, Italian and the statement of the second statement of the seco l a lasar a la trata de paragrama da sua. El tempeto como este el sua decaración de la trata Belgian manufacturers.*

The penetration of the American makret can take several forms. Note a com-1.11.1 only can the foreign organization sell to American firms, it can invest and obtain access to the technology via that approach. A very insightful analysis of this area was published in 1971 by Business International S.A. In that report, the author examines the value to the European organization An in the second second second of investing in the U.S.

> The biggest reason for the greatly expanded and expanding European corporate investment in the U. S. lies in the attractions of the market descent of the second the attractions of the market -- its size, its profitability, its research and development stream, its new products and industries, its new process development and applications engineering. As one group of observera have put it as regards the office equipment, electronic components, and computer industries: "Operating on the American market is no longer the natural consequence of success on other markets, but a precondition of success on the world market." Des by a second of the second of the

> Manufacturing in the U.S. brings far quicker and far closer access to the innovative stimuli of the U.S. 1993 and 200 per se business environment. The U.S. thas played the role of a good debender. of technological and marketing beliwether for Europe and State And State Stat and the world throughout the postwar era. True, the U. S. has no monopoly on invention or discovery of new products and processes. However, of 110 postwar first commercial introductions ("innovations") qualified as "significant" by the OECD***, 74 were first commercialized in the U. S. and practically all 74 were first marketed by U. S.-owned firms.

Cetron, M. J. and James L. Duda; "International Technology Transfer in One Industry - Aircraft", in Cetron, M. J., H. F. Davidson and J. D. Goldhar (Eds.) Technology Transfer (Leiden, The Netherlands: Noordhoff, 1974). Longe and the Constant of the Annual States and the States of the States

"European Business Strategies in the United States"; Business International S.A., Geneva, Switzerland; 1971.

Organization for Economic Cooperation and Development.

and south a party

The majority of large European companies with U.S. operations are in relatively high-technology industries. 21 of the 49 firms examined - or neerly half - are in the "secteurs de pointe" in which Jean-Jacques Servan-Schreiber so feared American domination of European industry. These sectors are chemicals, pharmaceuticals, machinery, and electrical machinery. The average percentage of sales revenue spent by the 49 firms on research and development was an impressive 3.7%, without doubt a figure far above that of European companies not investing in the U.S. Indeed, if one compares this figure with the data available on most international U.S. corporations, it is still high.

Not only do European companies investing in the U.S. seem to have more technological competence than other European companies, but, within the former group, those companies that spend heavily on research and deviopment have done much better in terms of sales growth in the U.S. than those that do not. There is a significant correlation (.67) between the percentage of total revenue which companies in our sample spend on R&D and their rate of sales growth in the U.S. market between 1965 and 1969. Almost all the European companies in our study that spent less than 1% of their total group sales revenue on R&D had stagnant or negative growth rates in the U.S. during those five years. Also, there appeared to be a relationship between total group revenue spent on R&D and U.S. profit growth over the 1965-69 period (the correlation coefficient was .7 for 10 companies for which we had sufficient information).

The primary reason for European companies' preference for wholly owned ventures in the U.S. (and incidentally for the high joint-venture divorce rate) seems to be related to the nature of the U.S. market. The desirability, perhaps the necessity, for a European company to do R&D in the U.S. has already been mentioned. Yet, insofar as "the management of technical innovation is much more than the maintenance of an R&D laboratory" but is rather "a corporate-wide task...too important to be left to any specialized functional department*... the subsidiary's response to the everchanging U.S. market may require a closer coordination between marketing and R&D than is possible with a joint-venture relationship.

Based on 23 companies for which data were available. The reader should be warned that this and other correlations could be the result of other factors that, for one or another reason, could not be examined. They should be interpreted in the context of other qualitative evidence presented.

51

า และกลุ่มระวัฒนนี้ แต่แห่งของ และหรือของการที่สุดการที่สุดการ และมีมีผู้สุดเหลือการที่ ได้หรือมีหรือ แต่ และก แหละกลาย (การการกรุ่มนายาวซี่ (การกรุ่มนายาวชาว และ อาจเป็นสุดภูมิตาม แกรง) (การผลิตระเจาการที่ ก็หลุ่ม

经公司 网络德国圣秘圣 化分子医输出输出分子检测计

in a second part of

...953

the advance of technology by investing money primarily in joint R&D ventures with industrial firms and also with private investors, and receives a fair commercial return on its investment. The Government gets a portion of the business and a percentage of the profits, and also has a seat on the Board of Directors. The profits derived from these ventures are reinvested in other high risk technological ventures. Two of the noteworthy successful projects were the Hovercraft and cephalosporins, one of the most significant groups of antibiotics discovered since penicillin. The latter was one of the largest royalty earners ever to have emerged from academic research, and represents an excellent example of the type of basic invention that NRDC was expected to handle when it was established. Not only has the Crown's initial investment been repaid but the revolving funds have brought about the funding of many other R&D projects in high risk technology. These include major contributions to the establishment of the electronic computer industry; development of selective herbicides; development and production of the first high speed linear motor hovertrain and of the first large superconducting electric motor; extensive research and development of fuel cells later used as the basis for the power plant in the Apollo moonlanding programi etc., etc. a contractor a transport des instantes an assume as a personal

Attempts have been made to evaluate contributions of NRDC-supported innovations at the national level but appropriate techniques of measurement are still controversial. The Corporation believes that, unlike other

人名法格 化乙酰胺酸乙酰乙酸乙酸乙酯医乙酸

Evidence Offered to the Committee to Review the Functioning of Financial Institutions (The Wilson Committee), (London, England: NRDC, 1978).

aden i de Collecter viere de Fritze d'Altaria

sources of venture capital, its success will not be judged solely by reference to its balance sheet. It's aim is to continue to create new business opportunities in the U. K. from the research work and inventions available to it, with increased employment prospects and foreign currency earnings from exports or license income. The total NRDC investment in both private and institutional support is not large; the rationale is that:

The cost of most of the civil development work in this country will continue to be met out of industry's own resources but there may be cases where individual firms are unable to undertake, entirely at their own expense, the development of potentially valuable projects. In the export field the need for the United Kingdom to develop and market technically advanced products egainst strong international competition puts a heavy development burden on much of the country's manufacturing industry. In such circumstances there say be merit in a collaboration between industry and NRDC.

It is a natural consequence of the Corporation's statutory functions that it is prepared to undertake projects where the degree of risk is greater than that which a commercial undertaking would regard as justified.*

Having operated at a deficit for its first 27 years, the Corporation for the first time in 1975-76 was able to carry forward a net surplus. The total investment in external R&D support over that period (1949-76) was 48.2 million pounds sterling (about \$87.4M at current exchange rates). In 1977 alone it is estimated that the gross amount of new industrial production which the NRDC helped to generate was 100 million pounds on this was sterling (\$181.25M), with a ten year accumulated total of 600 million

* <u>National Research Development Corporation: An Introduction</u> (NRDC, London, October 1970).

54

Constant and a strategy

²7th Annual Report and Statement of Accounts 1975-76 (London, England: NRDC, 1976).

Although generalizations are perilous, the case of a company that had a joint venture with its one-time U.S. importing agent during the first few years in which it manufactured in the U.S. seems typical. Prior to developing its own marketing competence under its own ownership umbrella, this subsidiary was effectively cut off from new developments in its marketplace and was not able to get information about new applications for the particular product it produced. After buying out its partner's sales network, it was able to reintegrate the marketing and R6D functions in the U.S., and went from rather dismal failure to quite considerable success over the subsequent five years.

Acquisition seems to provide the quickest way to learn U.S. technology and marketing skills that are new to a European group. This was a key reason for Plessey's acquisition of the U.S. company Alloys Unlimited. The acquisition by a European oil company of a small U.S. refinery had a similar motivation - but this time for purposes of learning marketing skills rather than technological skills. The European firm's executives remarked that they felt, in order to be a viable worldwide petroleum company, they had to learn marketing in the market where most of their major competitors came from. The company did not feel that its marketing was strong enough to enter the U.S. first by setting up an exploration company and then gradually working its way into competition in refining and distribution with other U.S. petroleum companies.

A pharmaceutical company, which originally entered the U.S. shortly after World War II by forming its own subsidiary, noted that it had recently taken over 100% of a U.S. hospital supply company. The company indicated that as far as possible it preferred to avoid acquisitions "and the digestion problems that acquisitions usually cause," but that in this particular case it felt that the pharmaceutical business was changing so rapidly that it could not take the time to learn medical electronics and hospital servicing without making such an acquisition.

One experiment designed to address the problem of technological lag and insufficiency of funds is the National Research Development Corporation (NRDC) in the United Kingdom. This is an independent public corporation, financed by government loans, established in 1948 under the Development of Inventions Act whereby new high risk R&D ventures can be funded. The fields covered are the biosciences, industrial chemistry, scientific equipment, mechanical engineering, production engineering, electrical engineering, electronics, computers and automation. NRDC assists the advance

52

Being inside the fast-changing and competitive U.S. 2010 2006 market brings two advantages. First, new developments can be allow transmitted more rapidly to the European parent company, so that it that it can compete with U.S.-based and other European firms as 2000 new products and methods are introduced in Europe. Second, a corporate lead in high-income, labor-saving products in the developed wit U.S. prepares a European firm for competitive battles in Europe, as European markets take on "U.S." characteristics. Advances in the developed with

A good many European managers admit the need to learn-by-doing in the U.S. in order to face what U.S. companies (or more daring or lucky European competitors with U.S. operations) might employ on the European market in future.

Olivetti is one company that has not hidden its desire to learn from U.S. marketing and technology. Plessey is another European group that has publicly stated its desire to learn from U.S. practice. In its proposal to shareholders for the acquisition of the U.S. firm Alloys Unlimited, Plessey stated that the acquisition would allow it to "acquire immediately a number of products and know-how which are important to our successful development." Plessey's deputy chairman notes that it "would be uneconomic for us or any other European manufacturer to learn (on his own) the skills evident in the Alloys organization."

A similar rationale underlies part of Unilever's longstanding interest in U.S. operations. And managers of one European petroleum company commented that "in order to be really successful in Europe and elsewhere, we have to compete in the market where the greatest petroleum marketing advances are being made. We have to compete in the U.S. by direct investment operations because the quota system prevents us from simply exporting to the States."

11.93

and a contract of the second second

 $I \in \{A_1, A_2\}$

In all, nearly 50% of the European company managers in the study emphasized the importance of being in the U.S. in order to "feed back" technical or marketing skills to the mother company.

In one of the most notable cases of a significant product breakthrough by a European firm in its U.S. subsidiary - Sandvik Steel's development of "throwaway" carbide cutting edges - perhaps the most significant factor was the fact that the Sandvik group's development director at headquarters had himself worked for two years in the U.S. and was receptive to new product improvements. He was able to convince group management of the usefulness of transferring this innovation from the U.S. to European operations. A development team from headquarters was sent to the U.S. to work with the U.S. R&D group and further develop the new product. These improvements have accounted for a great deal of Sandvik's impressive growth during the last decade and now account for no less than 40% of the group's worldwide sales.

50

u ne uvgoku je

we will in the past (since 1925) the United States has contri- Gald open 2 we buted most of the significant technological advances and in the field. Although 22% of the ideas for advances a company

originated in Europe, less than 5% were implemented by European countries first. Clearly, the U.S. is very the Adda efficient at taking a working prototype and incorporwhere ating it into an actual flying component for military component for

and commercial use. It is in making the transition is from a model to a successful in-service system that is a consumation the U. S. is particularly capable. The first group of a work and another and

In order for a country to adapt a technology developed elsewhere, the 1012-1-02-04

process of technology transfer is of infinite importance. It is a

well-known fact that the acceptance, production and utilization of an ad-かんわ みんし vancement is often delayed for long periods of time after the initial elle entre glasserent film. S (20) za a traticiana c - マスティン development of that advancement. The effects of the U.S. ability rapidly n an theory in the second of the second second second the second second second second second second second second to apply these technical advances has contributed significantly to increases 一般的 医马克尔氏 网络斯特尔 医二氏试验检尿道 医小子 医小子子 化二乙二乙基乙烯酸 化二乙基乙烯酸化 化二乙基乙烯酸化合物 in performance capability of U.S. aircraft. In the past this has resulted a threader of the core when the state that the second shift and in an increasingly advantageous market position for the United States.

计标识 计通知分析的 化丁酸盐 化分子分子 CRANE LINESS The cancellations of both the SST and B-1 efforts have contributed to in state of the Adorage -1.1 Constant State State an erosion of our previous position. The recent sale of the French A-300's (AIRBUS) to Eastern Airlines indicates that the American aircraft industry 化试验器 情 施理的 化可可定 医腹股上的 化乙酰氨基乙酰氨基乙酰氨 may be on the verge of losing its monopoly here in the States in the medium haul aircraft area.

1.9

The second state of the second state of the second state U.S. aerospace firms are forming joint ventures with foreign countries. Boeing will join with Japan on a \$600 million venture to build a small (150-200 passenger) wide-bodied, low-noise, short takeoff airbus for use on domestic Japanese routes. The General Electric Co, has joined forces with SNECMA, owned by the French government, to produce the CFM 56 aircraft engine for use in STOL aircraft. Pratt & Whitney will join forces with a German consortium, MTU, and an Italian group formed by Flat and Alfa Romeosto (1999) Rede for produce the JTIOD, a competitive engine. These engines will compete to power the next generation of commercial aircraft replacing the Boeing 727 and 737 and the McDonnell-Douglas

8. Problem Summary were used of the set of the set of set of set of the set o

Let us examine the problem from a different standpoint -- what are the same the effects of the lack of adequate funding? Several examples and some 244 44 quotations from competitive nations may help to place in proper focus the same more important aspects of the subject.

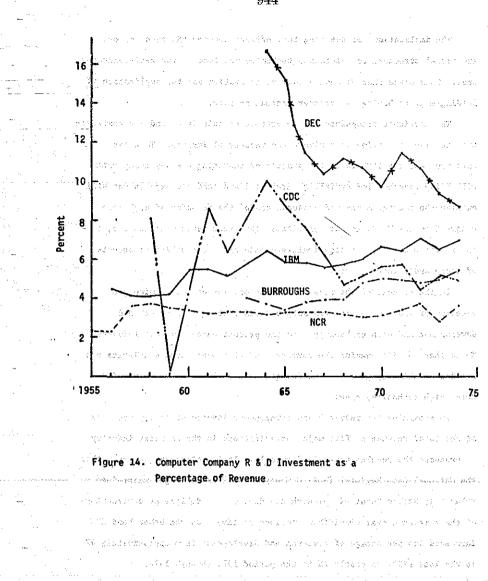
Some consequences of the lack of available research funds within the U. S. will serve as typical case-studies. The first of these involved Dr. Amdahl, a computer research scientist who worked for IBM, having design responsibilities for IBM models 704, 709 and 7030, and who managed the architectural planning of IBM System 360. Amdahl left IBM in order to pursue a proposed design of a future large scale system, which would have involved a radical change from IBM's then "present generation" computers.

Since Dr. Amdahl believed he had a technological idea whose time had come, he established his own firm in 1970 and when sufficient financing was not available from American firms, or venture capital sources, he proceeded to negotiate financing from a Japanese Company, Fujitsu, which now owns 28% of the stock. Some domestic support was provided by a Chicago business development firm, Heizer Corporation, which owns 23%. The Board of Directors controls 8%. First revenues were recorded in late 1975 for the 470 V/6 computer which competes with the larger, faster IBM System 370's. By 1977, Amdahl announced a net income after taxes of \$27 million, on a turnover of \$189 million -- a better profit rate than that shown by the industry as a whole.^{*} The need for foreign financing effectively transferred

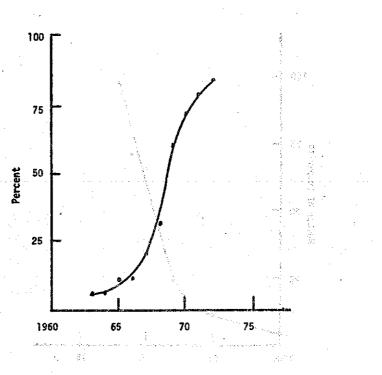
"'Burope's Chance of a Computer Revolution", Business International, <u>The</u> <u>Economist</u>, April 22, 1979, pp. 105, 106.

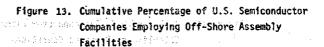
renderste son processe, sessere and and a transformation of sources song stranger and attracts and sources and t

en alter alle alter a
en al antipatente de la companya de 1975 - La companya de la companya de 1976 - La companya de
1.0 m 🖉 40 - transformation that the state of the state
Ripher an
n al an
entana o e g i 2007 ane generati o entro n'el estro di tradici entro per per per generatio
a normal a sintra e Senta da esta de la compacta de las tradicios e esta de seguera de seguera de la compacta de
The second se
the second of the second of the second s
An
Companies Companies High
Technology
and an
Talinda sha ara ara ara shi a sa kita a sa ku a sa ku a sa ku a sa s
e a chu ann an shekarat an ann an la shikar gel sear an an shekarat an sh
Figure 15. Companison of Several Typical Companies - Annual Average Growth Versus Technological Classification
7 AND DESCRIPTION AND DESCRIPTION (1969 through 1977 and and a gate of a
n taitan 1820 - Annasis kana kana kana penangan penangan penangan penangan kana penangan kana kana penangan pen Ter
n an an an an an an tais na bhfill ta stàinn an stàinn an stàinn ann an airte ann an ann ann ann an an an stàin Tha an an an an tais an tais an tais an tais an an tais
andigan a salah kalin angara salah kalin kalin kalin kali A
·····································
्रिय अने दिस्ता के विद्या अनेक सुराधिन्ताल राज्यते करावतुः 🥵 व्या केले त्या विद्योगेक अस्यान्त्र विद्योग्यक व विद्या
a de la servición de la servic A construir de la servición de l
a sense settere i substantistice de sense sense angles de sense de sense de sense i sense and a sense sense a La sense de sense i sense de sense sense a sens



andre and a set that a stable of a set of the set of the





companies begin to establish overseas operations. This is shown in Figure 12 which shows the number of firms who established overseas operations. Note that this number moved very rapidly from approximately 15 or 20 in 1966, to almost 100 in 1971. Further, we can examine the actual investment in overseas assembly facilities by the same semi-conductor industry. In Figure 13 we see the number of firms as a percentage of the total who established overseas assembly facilities. Starting in 1963 a very rapid development began of new overseas assembly plants by the semi-conductor industry, which reached a level of approximately 80% in 1972. Thus, most assembly or a significant portion of the assembly of semi-conductor products is currently being performed overseas by subsidiaries and joint ventures of U. S. semi-conductor organizations.

Several counterbalancing consequences of this action can be identified. On the positive side, the establishment of overseas production facilities has in several cases preempted the establishment of Japanese semi-conductor companies of production facilities in the area, and has also given the U.S. semi-conductor industry a local sales advantage. A second positive effect -- resulting from one of the probable primary reasons for the overseas movement, the availability of a large, semi-skilled labor force -- was the containment of total costs, resulting in consumer prices lower than could be achieved with U.S. production.

On the other side of the ledger, we must note the loss of employment opportunities here in the U.S. (at least in the short run) and the loss of national income (in the longer run) due to:

a. diversion of profits and tax income, and a context

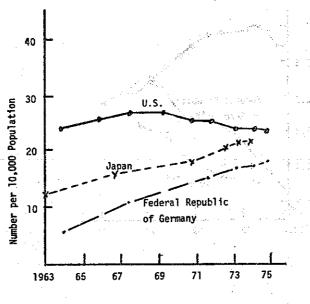
 establishment of potential competitive capability (through the transfer of the technology).

38

4 - 62 - 0 202

Structure light light of the service set in Contribution in Billions of Avia Current Dollars 医马克氏病 法法人 网络马克勒马克斯特拉马马斯特 建油 1960 1965 1970 1971 High technology manufactured goods ----- +6.6 +9.1 +9.6 +8.3 +1.9 Agricultural products ------ +1.0 +2.1 +1.5 Low technology menufactured goods ----- -0.9 -2.9 -6.2 -8.3 Row materials------7 -2.8 -2.5 species that open and the standard of Annaester of the state and shows interests as where so shows a structure for structure and states and transfer ag allgebraggere ell'harente all gebreren. Érev i barri legt de berretekter to be there are a consistent with a second straight and there are an a start of a second start and Table 3. Contribution to the U.S. Balance of Payments by Industrial - The second field one we see the state and the second Segments en til sere and been and the second to be see book progetter and all the second second second second second second water where the teacher party set is unit is where the particle are starting to the first (Lines and the second was appreciated a second state the second state the second state for the base (1) Merrit al the country with a the function of the second states of an i wilde de l'Elimente Reparenter (Theres are the consequence whe permut from a borner for the second second second in contract start and the second start and the second start starts and the second starts and the second starts aussenational ference little austa at graanse, essenation erste ratee little terre terre 36 മം പാകുംപൂർ പടി പടില്ലാം മോപപ്പെട്ടാണ് മുംബം മിലാം പോഷ് മണ്ട് സ്റ്റില്ലാം പാഷ് മത്തിന് പ്രത്തേണ്ട - conservation of the state of LUIGENSE LEADERS STY ากกับการสมให้สายสาวารไฟตร อธิมหารีการให้การสำนักขึ้น กระการให้สายสมบัณฑ์มีเมื่อสำนักการสายสมบัณฑ์ ได้ การแสบาบการี (อ.ศ. 2012) เป็นการการการสายการสายสาวารสายสีวิธีการสายสมัย เสียงสายสมบัณฑ์ 1888 1899 22

ules de la complete d



A server be a start to structure of the server of the serv

Figure 11. Scientists and Engineers Engaged

per levels descention and increase and Development and the fee

trade balance. The significance of this closing of the gap confirms the data in Horn's article, and indicates that we will shortly be faced with a competitor who is technologically on a par with the United States.

This raises the question of where are specific U. S. industries in relation to high technology development or the generation of high technology products?

As previously noted, because of the area of interest of the IEEE, we are restricting our examination to three major segments of the U.S. industrial base in which we currently maintain a lead. These are electronics and electrical equipment in general, the computer field specifically, as well as the aircraft industry.

In the broadest sense we must examine the inputs to the high technology segment of industry, by looking at the research and development expenditures as a percentage of the GNP (see Figure 10) as well as the number of scientists and engineers employed in the research and development areas, which is portrayed in Figure 11. Note that both of these Figures include the area of defense-related R&D, and this fact must be borne in mind in their interpretation. Half the total government outlay for R&D in the U. S. is related to defense, whereas the comparable figures for FRG and Japan are 11Z and 2Z respectively. The commercial emphasis in both Japan and Germany is paying off. These countries have led a huge increase in the number of foreign inventions being patented in the U. S., and by the addition of

Technology Assessment and Forecast, 7th Report (Washington, D. C.: U. S. Department of Commerce Patent and Trademark Office, March 1977).

1000 C

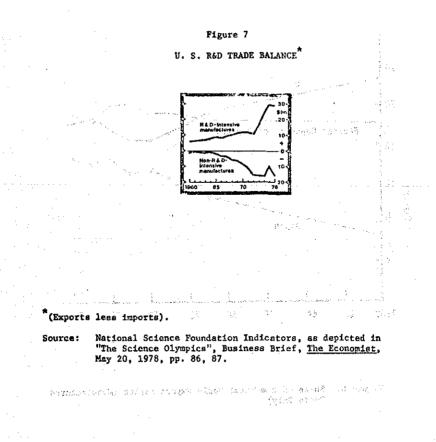
100 Factor Restativenes 9 142.302 San San A الأندية وتدريبه 19 8 18 18 19 19 · · · · · · · · · · · 1.1.1 80 1033 6-31 60 <2 j < iSec. As -561,525 141 - 40 1. 11. 11. Federal Republic of Germany 20 Revealed Comparative Advantage**0** Consecutive 1973 1070 1063 at seasons 2.233.500 ·· 8 · -20 1.151.95 All the School Sectors nan redece o. -40 A CALENCE FRANK P -60والمتحدث والمحرج والمح

Figure 8. Revealed Comparative Advantage Versus Time, for the U.S., Federal Republic Of Germany and Japan

This indicator measures the extent to which foreign trade surpluses (deficits) in one product group diverge from the trade position of this country in total manufactured goods. The measure has been normed so that it can assume values between + 100 and -100. High positive values of the measure indicate a high international compatitiveness. For method of calculation the reader is referred to:

Horn, Ernst-Jurgen, "International Trade and Technological Innovation: The German Position Vis-a-Vis Other Developed Market Economies", in Karl A. Stroetmann (Ed.) Innovation, Economic Change and Technology Policies, Bonn, Germany, 1976, page 144 et seq.

30



Section 1

Contractor and antipation of the programme

CARGANIC SERVICES

goods, we see in Figure 6 that the United States' position in the world market has improved only slowly during the past five years. The position of the Federal Republic of Germany has remained relatively stable over this total period. On the other hand the Japanese have increased their portion of this export market from 6.5% in 1960 to 15% in 1978. The steady increase in Japan's export of manufactured products is significant and appears to be far more important than the previous penetration by Japan of the total export market. In particular, Japan's production of consumer electronics has increased by a factor of five over the past 10 years, and 62% of the 1976 output was exported (\$4.8 billion).^{*} 30% to the U. S:

Data become more difficult to obtain when we focus upon high technology and its impact upon exports and world trade. As shown in Figure 7, this is the only area in which the U. S. has not only maintained but increased its trade balance. A recent symposium^{**} on "Innovation, Economic Change and Technology Policies" provides some insights in this area. This symposium, sponsored in part by the National Bureau of Standards, contains several presentations which provide some insights into the problem and possible solutions to that problem. Of particular note is a paper presented by Ernst-Jurgen Horn (pages 129-147), which was cited earlier.

Norn has developed a measure of the significance of high technology products upon the international competitiveness of nations. This measure,

"Japan's New Electronics Goodies", Business Brief, The Economist, April 22, 1978, pp. 84, 85.

Stroetmann, Karl A. (Ed.) Innovation, Economic Change and Technology Policies (Bonn, Germany, 1976).

from 3.3% GNP to 2.6%, and by 1976 was down to 2.2%. The U. S. figure also includes about 50% for defense-related R&D, which has limited "spill-over" to the commercial sector.

Gross expenditure on research and development (as a percentage of GNP) and gross research and development expenditure per capita also correlate highly with relative market share for research intensive products. Thus we can use research and development expenditures as a rough measure of performance in trade in research intensive products. In general, such studies as Horn's have shown research and development activity to be the most important determinent of the structural pattern of international competitiveness. The influence of the research and development variable in the U. S. appeared to be even stronger than in the case of Germany, with which it was compared.*

At the broadest level the relative position of the U. S. in the world export market between 1960 and 1976 is shown in Figure 5. During this period we can see that, in round terms, the U. S. share has dropped from 18% in 1960 to 12% in 1976, while that of the Federal Republic of Germany has moved slightly upward from 10% to 11% of the total world market. On the other hand we find that the Japanese have improved their position from 4% of the total market in 1960 to 7.5% in 1976, approximately doubling their total export share.

This figure includes not only products based upon high technology and mature technology but also the exporting of raw materials, etc. It is useful only for presenting a broad overview. Focusing upon manufactured

U. S. Tariff Commission figures, and Norm, Ernst-Jurgen, op. cit.

7. The Current U. S. Status

There is no standard equation nor set of tables that can be employed to determine our current achievements in the application of technology to improving either the national well-being or the U.S. position in the export trade arena. Further, and probably of even greater importance, statistics that could be applied to examine this question are scattered and in some cases imperfect. However, we can begin to develop a feeling and in some cases gain both insights and indications by examining the information and data that are available. According to the product cycle hypothesis discussed in Section 5, innovative activities of countries depend on per capita income as a measure of the stage of the country in the development process. A study of 19 OECD member countries showed a significant correlation between expenditure on research and development as a percentage of GNP, and per capita income. (At the level of the corporation, Mansfield has demonstrated that a high level of research and development expenditure leads to increased productivity, and thence to improved gross profits, which permits and again tends to increase research and development funds. This relationship is depicted in Figure 4.) In response to this perceived relationship, both the U. S. and U. K. since 1945 have consistently spent over 2% of GNP on R&D. However, German expenditures increased from 1.4% of GNP in 1963 to 2.1% in 1971, whereas U. S. expenditure dropped

Horn, Ernst-Jurgen, op.cit.

"Manafield, E., "Research and Development and Economic Growth/Productivity", National Science Foundation Colloquium (Washington, D. C.: GPO, 1971).
*** "The Science Olympics", loc. cit.

STAR TO START A CONTRACT STREET

6. The United States Posture States and the state of the state of the state

Whatever the relative economic advantages and disadvantages, it appears to be the consensus of both government and industry opinion that the U. S. should strive to retain technological leadership, and both interests are a supconcerned that the U. S. is unduly eroding its position by exporting technology without adequate safeguards/recompense. The concern of governmental policy-makers is manifested by such meetings as this present hearing..... under the joint auspices of the Senate Science, Technology and Space Subcommittee and the International Finance Subcommittee. Other aspects of the problem are being examined by a House Subcommittee, the Congressional Office of Technology Assessment, the National Security Council, the Office of Science and Technology Policy, the International Trade Commission, the National Science Foundation, and the departments of State, Defense, Treasury, Commerce and Labor. In view of the widespread interest, we are hopeful that the outcome will be a systematic program designed to establish U. S. priorities and to define a responsive approach for achieving identified objectives.

Industrial representatives are also very much aware that a review of our policies and practices regarding the creation and transfer of high technology is an urgent requirement. Foreign products incorporating technology acquired from the U. S. are beating out American productions in markets around the world -- including the U. S. itself. Because of this, U. S. manufacturers are harvesting too little of the return from their own

20

of new technologies, e.g. in R&D, and in the product of the state tion of goods during the early phases of the cycle. On the one hand, these countries are relatively; abundantly endowed with skilled manpower which is intensively used in the above mentioned activities and whose availability determines whether these activities can or cannot take place. Furthermore, the defined risk capital to finance R&D activities is relatively abundant. On the other hand, a high per capita income provides domestic markets capable of absorbing new products, e.g. new consumer goods, labour-saving household devices and new laboursaving investment goods. When products become more mature, highly qualified manpower becomes less critical and the other factors of production gain influence in determining comparative advantage. In the course of increasing maturation of products set wash or processes of production the comparative advantage shifts to less advanced industrial countries which can already handle the technology in question blocks and are able to compete successfully with them that successfully innovating country because they enjoy the advantage of lower wages. In the late phases of the cycle and when products are mature and standardized, comparate inclusion tive advantage shifts to the developing countries.

e contral general contrategies

Even in the high technology phase, there are advantages in occupying second place, in that the high risks and dnevitable "false steps" will be taken by the leader. A nation which can maintain a minimal gap can then be prepared to buy the products of leading edge technology, but produce and sell slightly less advanced products where the margins are less, but the volume is much greater. For example, Japan buys avionics and sells color

 $\sim N_{\odot} - 2$

celevision.

Constant and a second second second second

*Haitani, K., "Low Wages, Productive Efficiency, and Comparative *Advantage". In: <u>Kyklos</u>, Vol. 24 (1971). See for example

Hufbauer, G.C., <u>Synthetic Materials and the Theory of International</u> <u>Trade</u> (Cambridge, Mass.: Harvard University Press, 1966) and

Vernon, Raymond (Ed.), <u>Big Business and the State</u> (Cambridge, Mass.: Harvard University Press, 1974)

The need to provide acceptable technical service requires that the form of the product, its is a series of virtues and limitations, and extends beyond this to require knowledge of the the design and fabrication of the product as well as its mode of functioning as such that one is able to diagnose field difficulties and make the requisite for as repairs or modifications.

The transfer of technology and of intellectual property is perhaps accomplished most readily through the mobility of people. This process occurs not only through hiring practices deliberately designed to acquire advance technological information, but through the routine day-to-day mobility of the work force within and between companies, industries and nations.

It is of course underlable that technology transfer is facilitated by him of foreign assembly, foreign manufacture of components, and complete foreign assembly manufacture. But it is essential to understand that the absence of these woods may have other negative effects for the industry involved, including both to what the loss of foreign markets and the creation of new sources of foreign competition, and even so will not result in protection of the basic technology. The dissemination of technology cannot be stopped: it can a what only be controlled and slowed down.

Steele, Lowell W., <u>The Economics of International Technology Transfer</u>, in Karl A.Stroetmann (Ed.) <u>Innovation, Economic Change and Technology</u> <u>Policies</u>, Bonn, Germany, 1976.

and the second to be added as taken in any the total.

y dhulaa saan y yaa yi waxay u dhi in daya yi ba aha Tayoo yax boo salaxii ah u u xay rafii daalaa yaba

serienen in des their ser coltar inden ar in the area interaced

elen signalenet, elle es paintenien e suagalenation e destruado obrahibis

1.1520-2-1

How Technology Transfer Affects the Competitive Position of the U.S. in the World Aviation Market (Arlington, Va;: Forecasting International, Ltd., March 3, 1972).

	1	Mature	(profitable)		ê
÷.	ali at breas i m	u anarra u a airtigat	nierich geotiens	$(a, x) \in \mathcal{S}_{+}^{*}$	
*^6	- "我上了了,我有不能?	and the second sec	ny ha contrar	a bia jesege d	12
uo] o	an Nga Newing ang Pilipina ang		n ander det indense	onu – verbagg	
Development of Technology	Growing	(requiring heavier			
ۍ - ۲			èn astro lato - 1	e l'apagante	
ment.	/	Anne 🖡 👘 🖓 Silanda		r na Villando	
elop		ala (basa di bia) a	1	i kanaka seria	19 - 14 14
Dev	Leading	· · · ·	lo serà Asrèn.	4	
		enture capital)			
	Y I	 Magnetic School (1997) And Charles and Control (1997) 			
ter de la companya d	ing synthesis and a second	TIME Serverus is simply is	nego a tras gradi	al against sta	
i në të esetë	to charter courts o	er gel d'aller président de	V ATMAN (YSBA)	(993) - 21.44	.3
	energia deservativa de la construcción de	ener maan terrinit teaanl	an er seras	at wit n	2
	Figure 3, Technology		24 - 2 8 35 2 - 520 Cres	5 - 4 93-862 - 2 2	s.
•	THE STREETHOUGH		elane was la se e	ાજાપણ હત્વો	
· · · · · · · · · · · · · · · · · · ·	- Norfe Lore (andoac	Abus to Adres see	literet de la service	neylî el swar	<u>.</u>
	<u>n i Kino</u> sy ngan (o m	ారాజు దర్ఘణముగులో ఇది ఇది		under um Consel	a:
*A typical	1 measure is the perce	ntage of firms in a			
arca wiitt	ch adopt the new techn	01053.			
	an thuật thư tháng triến thư thán thế thến thế	uite des la companya de la companya. La companya de la com		hillin di shekartikiti Li k	: X
		anti attanti attanti attanti attanti		n na na Line nen na na n Ne Stanne na na	
	an a	14 (H-344) (H27) (H			
· · ·		· .		2	
an an tha an tha an a Tha an					
$(A_{i}) \in \{1, \dots, n\}$	- -				
•					
	·				
	· ··· · · ···· · ·	·			
		and the second			
		1			
			• .		
			teria. Alteria de la composición de la composi		
- **					

However, the direct economic gains on the international scene resulting from the sale of technology-based products have been declining rapidly. In the area of semi-conductor electronics, where U. S. corporations have made nearly every technological breakthrough, the U. S. trade balance has been negative since 1968, and now stands at minus \$2 billion, excluding only one category -- that of computers -- in which the U. S. retains a favorable balance.^{*} Further comments concerning this particular situation will be made below, in section 6. An OECD report^{**} cites the computer industry as one of only three areas in which the U. S. retains its technological lead, in terms of net export of the technology base. (The other two are aerospace and heavy electronics.)

Other studies have confirmed that the competitive strength of U. S. manufacturing industries in world markets is closely correlated with the performance in technological innovation. *** However, with regard to particular products, technological leads only temporarily provide comparative advantages, for the duration of the so-called imitation lag.

In the following section, therefore, we will examine the characteristics of technology and its evolution, to assist in determining an optimum policy in controlling and/or capitalizing upon its development, application and dissemination.

Boretsky, Michael, W. S. Department of Commerce, as quoted in Fortune, May 22, 1978, p. 108, class an an an article structure of the structure

"Gaps in Technology, Organization for Economic Cooperation and Development, 1970.

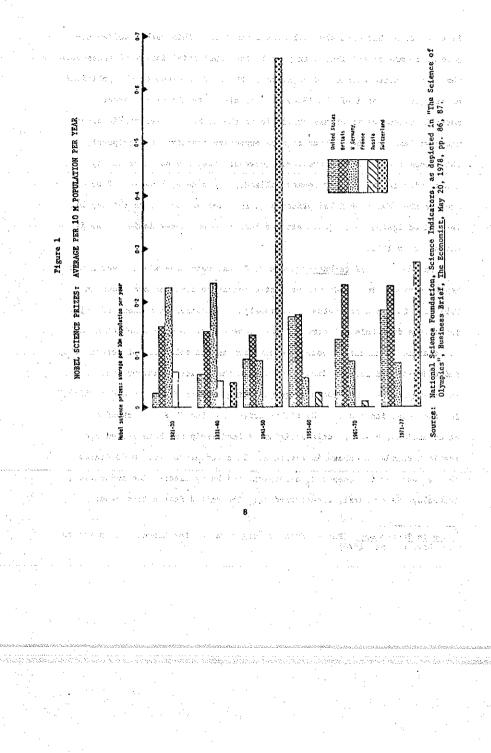
See for example: Vernon, R., "International Investment and International Trade in the Product Cycle". In: <u>Quarterly Journal of Economics</u>,
Vol. 80 (1966); Keesing, D. B., "The Impact of Research and Development on United States Trade". In: <u>Journal of Political Economy</u>, Vol. 75 (1967); Baldwin, R. E., "Determinants of the Commodity Structure of U.S. Trade". In: American Economic Review, Vol. 61 (1971).

Posner, M. V., "International Trade and Technical Change". In: Oxford Economic Papers, Vol. 13 (1961).

countries. In the four high technology industries, aerospace, heavy electronics (including computers), chemicals and pharmaceuticals, the two areas where we lead are aerospace and electronics, where significant amounts of monies are funneled through government agencies by the Department of Defense, NASA, HEW, Department of Energy, etc. In the other two industries, chemistry and pharmaceuticals, since they are mature technological industries the bulk of their money comes from internal corporate funds or the stock market. This provides some indication that when the government funnels R&D money to private firms (as in electronics and aerospace), the industry prospers and we have a technological lead.

10

\$2.



Sume of State

30

Table 1 Nobel Prize Awards, by Country, 1901-1977 . Terefinieren iz eta iza zuez errez elemente errezitare izalen errezitare errezitaren errez 1931-1960, 1961-1977 1901-1930 Germany United States 33 United States 53 1.118 England 1 6 England England France 11 Germany Germany 6. <u>.</u> 8 ar Sweden k Switzerland 5 France Austria United States 6 4 Sweden 4 14 : • 1 Š ć 2 Sweden USSR Holland 6 Italy they are Austria Denmark 2 2.5 (1.2.8.1.3.67) 19 M 19 Austria ò ٦ USSR Belgium Denmark 2: 5 g assain Argentina Australia 1 arradon na arrani 7225 CONTRACTOR STATE 25.3 - 40 L ÷ Canada taly Italy 1 4.5 22. una da la secola de la d 14380 31-6 ١. and and the second Norway stations the state and an analyzing with the set Same 2002.27 10-2**5**7 NORSE TO MARK TO STA I is contractioned from the contract planetation Related Lendersk issty Table 2 is los a indiración de matricial 1919 J. 18 18 Selected Invention and Patent Rates, by Country Sec. Car Contract Section of the C** to special and THE ST REPAIL CONTRACT Total Inventions Average Annual Anoua1 Patenting States on Selected List Patenting Rate -1600-Present 1930-1939 Rate - 1975 12-44 11-12-203 United States 38,300 56,509 58 12,322 Great Britain 9,050 a lang Rela-37,733# 32 14,600 Germany 3203 **13,386**° - 33 #5 35 29 9.550 France Italy 14 3,900 4,369 Switzerland 3,130 9,100## Sweden 1,030 . 1787 nament des Associ ېرورد مې خان 1.101.20 Bode, H., Basic Research and National Goals, (Washington, D. C .: National Academy of Sciences, March 1965). Private Communication, U. S. Department of Commerce, Patent and Trademark essi (1994) - Charles and an Office, May 1978. West Germany only (FRG). This is made up of 7,233 foreign filings, and only 1867 by Swedish nationals.

et = 81 - 5 674-1

relationships between research, technology, and economic growth, and assist in the definition of the appropriate role of Government in improving the international technological and economic standing of the United States.

adaran barran barran barran barran barran bebarra bebar baber (1984) Shafi a lan bin garan 1993 - 1993 - a gener antaran a Gira manarita bina bas an bin barran barran barran barran barran barran barran 1996 - Androna Barran barran an Gibi da barran manaran barran an bina an antar

(a) and the second s Second s Second seco

(1) a segur temperative products in the second second of the second second terms of the second terms of the second terms of the second second terms of the second second second second terms of the second second

(a) A set and a set as a set of a set of a set of the set of a set of a

- 5. R6D investments can be increased by direct government funding of long-range mission-oriented research, and by tax policies directed toward the encouragement of private-sector support. The many other obstacles to the maintenance of U. 5. leadership are addressed at length in the body of this document.
 - Foreign investment in U. S. firms, while increasing rapidly, is at present only a minor factor in the erosion of our technological lead. The resulting transfer of technology need not be harmful if we ourselves act promptly and positively to capture and protect potential markets. However the extent of such investment needs to be monitored and, if necessary, controlled by a central authority.
- Again, U. S. exports of technology and high technology products are not necessarily detrimental to our international stature. A two-way flow, and a coherent national policy, are essential to our well-being.
 On the other hand, it should be noted that our society is becoming service/information oriented. The sale of knowledge must be placed on a business basis.
- 8. Licensing and joint ventures abroad can be beneficial to the U. S. if we can maintain the two-way flow of technological innovation. Potential exports are being lost due to the export of technology, but this need not be the case with careful planning at the national level.
- 9. Our recommendations for improving export performance in high technology goods and services are given at the end of this document. It is our contention that this needs to be considered as an intrinsic component of a total technology policy which recognizes the need for balance and negotiation at an international level.

and the providence of the

end a new

na standina atang kadang ka ng pang sala na si pang

An end of the contract of the second seco

LIST OF FIGURES

Figu	re		м ^т	Page
1	1.	Nobel Science Prizes: Average Per 10 M Population Per Year		8
2	¥,	Percentage of Major Technical Innovations	ŝ	9
3	2	Technology Growth Curve		14
4	in de la composition de la composition La composition de la c	The R&D Cycle	2	23
5.	÷.,	Share of the Total World Export Market (All Products and Raw Materials)		25
6	00	Share of the Total World Export Market (Manufactured Goods Only)		27
7	Ас	U. S. R&D Trade Balance		28
8	65.	Revealed Comparative Advantage Versus Time, for the U.S., Federal Republic of Germany and Japan	\$	30
9	े ह	The U.S Japanese Technology Lag	2	31
10	22	R&D Expenditures as a Percentage of National CNP	Ϊ,	33
11	28	Scientists and Engineers Engaged in Research and Development	÷.	34
12		Number of U.S. Semiconductor Firms Establishing Overseas Operations		39
13		Cumulative Percentage of U.S. Semiconductor Companies Employing Off-Shore Assembly Facilities		40
14		Computer Company R&D Investment as a Percentage of Revenue	e [']	42
15	···	Comparison of Several Typical Companies - Annual Average Growth Versus Technological Classification		44
. •		LIST OF TABLES		
<u>Tab1</u>	e			Page
1		Nobel Prize Awards, by Country, 1901-1977		6
2		Selected Invention and Patent Rates, by Country		6

Contribution to the U.S. Balance of Payments by Industrial Segments

Composition of Industrial Segments

3

NEAR STATE OF A STATE

6 36

37

NATIONAL CONTRACTOR OF THE AND THE AND

Acknowledgment

AN E STONES &

This statement was developed with the assistance of various individuals both within and outside the formal organization of The Institute of Electrical and Electronics Engineers, and was approved at a meeting of its Board of Directors on May 23, 1978. I wish to acknowledge especially the contributions of:

Dr. A. Astin

Dr. M. J. Cetron

Ms. Audrey Clayton

Br. George Foster of State (With State States)
 Br. George Foster of State (With States)
 Br. George Foster of State (With States)

ille Harled

Mr. Norman Nisenoff

Mr. J. Rabinow

Dr. S. Raff

and a windown of the break with

347 (ALPAN) いた (株式の構成の) (1)(1)(32)

Alternation of the state of the

ふんり ひまやかったい

经总理公共 化化物 网络新闻作用 网络副桃 网络小鼠 雅兰希尔马

化化化物学 化化物化物 化乙基乙基乙基

Bruno O. Weinschel, Vice President, Professional Activitie

Professional Activities

196 g. A. 200

The GAO effort to introduce an improved classification structure for the Federal R&D budget.

eral R&D budget. As part of a planned GAO study on the impact of various Federal policies on industrial capital formation, we will review the interrelations among Federal R&D activity, private R&D activity, and industrial capital formation. This study will consider the direct impact of Federal tax, patent, and regulatory policies on private R&D expenditures. In addition, the impact of various Federal poli-cies on the business environment and the effect of this environment on industrial R&D expenditures will be investigated. More specifically, we will analyze the effects of Federal regulatory and economic stabilization policies on how business. men perceive the riskiness of their environment and how changes in these perceptions affect the level and allocation of their R&D expenditures.

We also plan to analyze the impact of the level and composition of Federal R&D expenditures on industrial R&D expenditures and industrial capital formation. In this effort, we will attempt to develop more effective methods for allocating Federal R&D expenditures.

cating Federal R&D expenditures. agi na dina

ೆ ಸರ್ವಾರ್ಷವರ್ಷ ಬೇಕೆ ಕೊರಿಸಿದ ಕಾರ್ಯಕ್ರಿಯ ಕಾರ್ಯಕ್ರಿಯ ಕಾರ್ಯಕ್ರಿಯನ್ನು ಸಾಧಾನವರು ಬೇಕೆ ಬೇಕೆಯಲ್ಲಿ ಬೇಕೆಯಲ್ಲಿ ಬೇಕೆಯಲ್ಲಿ ಅಯಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಕೇಳಿಯಲ್ಲಿ ಸಿಮ್ಮಿ ಕೇಳಿಯಲ್ ಸಾಧಿ ಸಿಮ್ಮಿ ಸಾಧ್ಯಕ್ಷೆಯಲ್ಲಿ ಸಾಧ್ಯಕ್ಷೆಯಲ್ಲಿ ಬೇಕೆಯಲ್ಲಿ ಸಿಮ್ಮಿ ಕೊರಿಸಿದ್ದರು. ತಿಲ್ಲಿ ಬೇಕೆಯಲ್ಲಿ ಸಿಮ್ಮಿ ಕೇಳಿಯಲ್ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಾಧ್ಯಕ್ಷೆಯಲ್ಲಿ ಬೇಕೆಯಲ್ಲಿ ಸಿಮ್ಮಿ ಕೇಳಿಯಲ್ಲಿ ಸಿಮ್ಮಿ ಸಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮ್ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ ಸಿಮ್ಮಿ

Anderson and Antonio and Anto

المراجع (1995) من المراجع (1995) من المراجع (1995) من من عن المراجع (1995) من المراجع (1995) من المراجع (1995) المراجع (1995) من المراجع (1995) المراجع (1995) من المراجع (1995) المراجع (1995) من المراجع (1995) المراجع (1995) من المراجع (1995) المراجع (1995) من الم المراجع (1995) من الم

and a second second

ได้รับประวัติเป็นที่สุดไม่ และสาวการเป็นสาวการเป็นไป การเป็นสาวการเรื่อง การเร็นสีว่า โดกการได้เสียงการเป็นสาวการเสียงการเกิดการการและการเป็นสาวการได้ได้การเสียงการเป็นการเสียงการเสียงการเสียงการเ

States, our principal foreign competitors have well-developed government-directed programs and special institutional structures for overcoming barriers to diffusion of existing manufacturing technology and for advancing the state-of-the-art through coordinated research and development programs.

In addition to improving traditional manufacturing methods, computers and numerically controlled machines are changing both the management and the engineering technology of manufacturing. There are indications that manufacturing methods are about to change—not incrementally but radically. The changes are already taking place in other countries where the productivity-improving institutions and mechanisms were created to recover from the adverse effects of war.

Such institutions exploit, develop, and diffuse the new computer-integrated manufacturing systems and are well-designed to continue development of their nations' manufacturing productive capabilities faster than that of the United States. Their success is evidenced by their increasing share of the international markets—in some cases at the expense of our own manufacturers.

But our principal concern is for the future. Short-term benefits are possible through improved diffusion of the available technology. For long-term sustained productivity increases, R&D is necessary to find new methods and to refine existing technology so that it can be economically used outside the few highly capitalized, high-technology firms.

In the most successful foreign countries, both programs and institutional models have involved joint public and private efforts. The United States has no comparable national program, although several Federal agencies are interested in this subject. A new organization has been created which could provide the central focus and leadership. This agency is the National Center for Productivity and Quality of Working Life, established by the Congress in November 1975.

We have recommended that the Center take the lead in developing a national policy and appropriate means for achieving balanced productivity growth in the industrial manufacturing base. Further, we propose that the Center, in carrying out this recommendation, seek the cooperation and assistance of the Department of Commerce and other agencies. The expertise within the Department of Commerce, particularly in the National Bureau of Standards and the National Technical Information Service, would allow that Department to play a major role in providing technological leadership and support.

The combination of expertise of the Center and of the Department of Commerce and their close coordination with other public and private organizations can provide the much-needed focal point to coordinate all the disparate Government and private work in developing, standardizing, and diffusing manufacturing technology, and assist the emerging State and regional productivity organizations to advance manufacturing technology.

A number of specific functions should be embraced by this central focus and leadership. Three of the major ones are:

Collect and evaluate manufacturing technology information from all available sources and establish means for disseminating state of the art knowledge to potential users.

Foster the development and acquisition of new technology in various ways.

Analyze public policy options and formulate recommendations that will improve Government-industry cooperation in stimulating productivity improvement.

WHAT CAN WE DO?

What can we do to improve the climate for Government-industry cooperation? I have no panacea to alleviate the attitudinal constraints that continue to retard the development of a more constructive partnership between Government and industry. It behooves all of us—individually and collectively—to make extraordinary efforts to achieve better communication and mutual understanding of our respective needs and interrelated goals in the context of our total responsibilities and obligations.

Continued studies and publication of resulting reports clarifying the issues and alternatives should help improve understanding. An excellent example is the July 9, 1975, report by Robert Gilpin, "Technology Economic Growth, and International Competitiveness," report prepared for use by the Subcommittee on Economic Growth of the Joint Economic Committee. Another good example is the 1973 report, "Barriers to Innovation in Industry: Opportunities for Public Policy Changes," hased on study sponsored by the National Science Foundation and performed as a joint effort by Industrial Research Institute and Arthur D. Little, be served when private industrial contractors, with a few provisos, are granted exclusive licenses for commercial development.

When developing and marketing commercial products, industry naturally prefers to exercise its own discretion independent of any Government assistance or influence unless it needs help to deal with serious threats from foreign competition or another domestic enterprise which it believes is exercising unfair competition. Industry is particularly concerned about the constraints of Government regulations which tend to divert capital from innovative R&D to R&D and other investments necessary to comply with regulatory requirements. Furthermore, some multi-national corporations may not be inclined to share strategic information with the Government and to plan and conduct their business in such a manner as to assure harmony with the international objectives of the United States.

As a final attitudinal concern, there are many in both Government and industry who are unwilling to assume responsibility for what others would judge to be reasonable and necessary risks for investment in exploratory research and development when the payoff is uncertain in terms of time or economic return.

Many factors have been identified as real or tangible constraints that tend to cause a decline in technology innovation. Among these are the uncertainty of the economy, the high cost of capital, and the slowdown during the last few years in Federal spending for research and development.

The myriad of regulations established by both Federal and State governments affect the cost of doing business and may involve conflicting requirements imposed by different agencies. For example, in Federal procurement of conventional commercial products, the public would be served better in many cases by bestbuy competition based on superior or innovative performance and life-cycle costs, rather than by the prevalent procurement practice which tends to favor the lowest bidder who offers products meeting acceptable quality or minimal specifications.

In the larger sense, criticism is levied that the Government has not established a consistent national policy and strategy for Government-industry relations to balance incentives and constraints and assure a favorable climate for technology innovation by private enterprise. This contrasts sharply with other nations, notably Japan and West Germany, that have policies and special institutional arrangements to foster industrial technology innovation and improved manufacturing productivity.

Part of this issue is the question of whether our antitrust laws, established primarily on a domestic basis, need to be reexamined in an economy which is becoming increasingly world interdependent in market relationships and competition. This question is highlighted by the increasing number and size of multinational corporations and the fact that foreign corporations are growing faster than U.S. corporations.

Most of the other industrialized nations have developed closer relationships between government and the private sector on capital formation and R&D directed to the private economy. This is an area in which we perhaps should explore new perspectives for Government-private sector interaction within the framework of American institutions.

Improved productivity and advances in science and technology cannot take place separately from other aspects of national policy; advances made in the laboratory and on the testing grounds require adequate financial support obviously. However, these advances can be similarly flawed if such support does not go hand-in-hand with policies developed which will make it possible to use and develop these innovations. The Internal Revenue Service, Securities and Exchange Commission, Justice Department, and Department of Commerce all must play a part. Too frequently, these organizations go their individual ways for their own reasons and possibly for even socially desirable purposes. This does not mean, however, that their actions will coincide with adequate accounting as to their impact and consequences for risk-taking and technological innovation.

There is currently no procedure for measuring the effect of these Government decisions on science and technology. Thus, industrial risk-takers lean toward hedging and zero-risk decisions. Innovation under these conditions can be, at best, incremental. Hopefully, the new Office of Science and Technology Policy will recognize that innovation must come as the result of total Government policy—not the more frequently narrowly construed concept of science and technology.

38N. S. Comanor. "Market Structure. Product Differentiation and Industrial Research," Quarterly Journal of Economics, 81(4) (November 1967-1958), and the second and the transfer of the second s pp. 639-657 ³⁹J. Jewkes, D. Sawers and R. Stillerman, *The Sources of Invention* (New York: St. Martin's Press, 1959). York: St. Martin's Press, 1959). later en cree Sources and 140 1.1 ⁴⁰Hamberg, "Invention," pp. 95-115. ⁴¹W. F. Nueller, "The Origins of the Basic Inventions Underlying DuPont's Major Product and Process Innovations, 1920-1950," The Rate and Direction of Economic Activity, NBER Conference Report (Princeton: Princeton Uni- Sa versity Press, 1962), pp. 323-346. 42Hamberg, Essays. ⁴³Hamberg, "Size of Enterprise," p. 48. ang taga ⁴⁴E. F. Schumacher, *Small is Beautiful* (New York: Harper and Row, 1975). 45W. S. Comanor, "Research and Technical Change in the Pharmaceutical Industry," Review of Economics and Statistics, 47(2) (May 1965), pp. 182-190. and shares and shares فالإيجاب أراريجي الاراجي الأدام الأنوار ⁴⁶Hamberg, "Size of Enterprise." and the second second 47A. C. Cooper, "R and D Is More Efficient in Small Companies," Harvard Business Review (3) (May/June 1964), pp. 75-83. 48Conversation with Richard O. Zerbe Sr., Patent Agent for Monsanto Chem-The second second second ical Company. 49Scimooller, "Bigness, Fewness and Research." 1. 1. 1. 1. 1. 1. CONTRACT NOT A CONTRACTOR ⁵⁰Hamperg, "Size of Enterprise." 51Pavitt and Wald, "Conditions for Success." ⁵²Kamien and Schwartz, "Market Structure and Innovation: A Survey," And Constant States and States p. 13. 53F. M. Scherer, Industrial Market Structure, Ch. 15-16. 54 Ibid., p. 351 Depicture of the second se 55J. A. Schumpeter, Capitalism, Socialism and Democracy, Third Edition (2007) (New York: Harper and Row, 1950); Ch. VII and VIII. and () State and side and the 56J. K. Galbraith, American Capitalism (Boston: Houghton-Mifflin, 1956, and and revised and edited), pp. 86-87. ੀਲ ਦੀ ਸ਼ਿਆਵਿਤ ਦੇ ਇਹ ਹੈ। ਇੱ ⁵⁷Schumpeter, *Capitalism*, pp. 84-85. in my strate internation with the strategict 58Kamien and Schwantz, "Market Structure and Innovation," p. 14. ⁵⁹Comanor, "Market Structure," pp. 639-657. n in the second ⁶⁰Galbraith, American Capitalism, pp. 86-87. Series Se 61R. H. Coase, "The Nature of the Firm," Economica (November 1937), . Rin m 14. DD. 386-405. Res 1 a 62 Ibid. 63Scherer, Industrial Harket, p. 395. and the second second second second **د در** ۲۰۱۱ - ۲۰۱۱ ۲۰۱۹ - ۲۰۱۹ valies i . .343 ⁶⁴Ibid., p. 398. d distant 65Ibid. 5. SE -Strand Corse and s 104 and the second nde av de bestende for den bester de bester bester in de state de bester bester de state de bester bester beste

892

.113

"Donald B. Kessing, "The Impact of Research and Development on United or your task States Trade," Journal of Political Sconomy (February 1967), pp. 38-48. 5K. Pavitt and S. Wald. "The Conditions for Success in Technological Innovation" (Paris: OECP, 1971). W. Gruber, D. Mehta and R. Vernon, "The R and D Factor in International" Trade and International Investment of U.S. Industries," Journal of Political Economy (February 1967), p. 22. 7Calculated from data in a newsletter published by Economic Evaluation Associates (Chicago: 1975). With such a small sample, even if the correlation were perfect, the chi square distribution barely would be significant at the 5 percent level. ⁸The R and D figures are from U.S. National Science Foundation, National Patterns of R and D Reserves: Funds and Manpover in the United States. Reports for years 1958-1975 (Washington, D.C.). ⁹In 1965, a sample of firms in important industries showed that companies with less than 1,000 employees accounted for only 5.2 percent of industry R and D expenditures. This had fallen from 7.0 percent in 1957. 10J. M. Blair, Economic Concentration: Structure, Behavior and Public Policy (New York: Harcourt, Brace, Joyanovich, 1972). A story wash as sufficient 11M. Kamien and N. Schwartz, "Market Structure and Innovations A Survey," Journal of Economic Literature 12 (1) (March 1975), pp. 1-37. 12C. R. McConnell and W. C. Peterson, "Research and Development: Some Evidence for Small firms," Nebraska Journal of Economics and Business (1968), pp. 356-364. ¹³C. R. McConnell and I. N. Ross, "An Empirical Study of Research and Development in Small Manufacturing Firms," *Nebraska Journal of Economice* and Business (Spring 1964), pp. 37-46. ¹⁴D. Hamberg, Essays on the Economics of Research and Development (New York: Random House, 1966); ______, "Invention in the Industrial Re-York: Random House, 1966); _____, "Invention in the Industrial Re-search Laboratory," *Journal of Political Economy* (April 1963), pp. 95-115; ____, "Size of Enterprise and Technical Change," Antitrust Law on Economics (1) (July/August 1967), pp. 43-51. ¹⁵W. J. Smith and D. Creamer, "R and D and Small Company Growth, A Sta-tistical Review and Company Case Studies," *The Conference Board, Studies in Business Economics*, No. 102 (New York: National Industrial Conference Board, 1968). 16D. C. Dearborn, R. W. Kneznek and R. N. Anthony, Spending for Industrial. Research 1951-52 (Boston, Mass.: Harvard University, 1953). 17McConnell and Peterson, "Research and Development." These percentages refer actually to those firms responding to the questionnaire. My feeling is that firms with formal R and D programs would be more likely to respond. If this is correct, the true percentage of small firms engaging in formal R and D would be lower than the 38 percent reported, but those with informal R and D could be either higher or lower. 18Smith and Creamer, "R and D and Small Company," from combining MSF and seen Census data, found that only 4 percent of firms with less than 1,000 employees had R and D programs compared with about 57 percent for firms with between 1,000 and 4,999 employees and about 91 percent for companies, with more than 5,000 employees. Their figures for the smallest class of firms are almost certainly too low. Possibly the combining of NSF and Census data introduced inconsistency into the sample in the Towest size class; they themselves recognize the possibility of inconsistency.

expected value of a patent would be greater, reflecting greater immunity of the from legal attack and from "patenting around." The courts should not be. Provide a called upon to so often make the distinction between weak and strong of the solution between viable and nonviable patents in This would require a solution more careful comparison of pending patent applications with existing of the distinction of inventions into categories for septements and perhaps, a separation of inventions into categories for septement and the basis of their importance as in Germany.⁶² These solutions changes would require a greater Patent Office budget as well as more explanation of the patents of the budget as well as more explanation of the basis of the solution of the budget as well as more explanation of the budget as well as more explanations are explanation of the budget as well as more explanations.

Another approach might be to allow suit for treble damages in patent in- 1999 and fringement cases. This clearly would increase the bargaining power of 1998 and patent holders and win so far as smaller firms have a comparative advantic work of tage in patenting, would increase their bargaining position as the suit data and for the

A final proposal for patent reform is considerably more radical. This does and the is that the patent system, and/on the proposed direct award system, distant from the basis on size. The patent rights of the system smaller firms could be defined more broadly and the life of its patents is could be greater.

An en esta a tener el la contra des deservados presententes en esta en esta en esta en esta en esta esta esta e

strategical contraction of the contract of the backter of the most selection defends queen

Larger firms undoubtedly will react with indignation to proposals alonged the such lines. Yet they have a considerable appeal even on the basis of equity. Most governmental regulations are disproportionately expensive for smaller firms. Except for possibilities of not getting caught, there are clear economies of scale in idealing with government regulations and bureaucracy. The type of change proposed would help balance the effect search of other regulations. Moreover, this country has always put a premium on smallness. Large concentration of power in any areas are quite rightly mistrusted. Policies calculated to recognize this set of values command a certain force of their own.

Firms on their own can effect reform. Firms themselves can, and do, make purely internal arrangements that promote an efficient allocation of R and D by size. Research units can attempt to duplicate these conditions associated with the smaller firm that are nost productive. In fact, larger firms sometimes fund research efforts and have a minority stockholder position in relatively small firms headed by a highly creative inventor. Such an arrangement may create a better work atmosphere, but it

Presumably, barriers should be low enough to present threat of competition, but high enough so that inmediate entry would not climinate the rewards of invention too quickly. Such monopoly power would presumably deteriorate over time in accord with Schumpeter's notion of creative destruction.

cited allocate construction and all little construction allocate end of the second of the secon

"There is no more pleasant fiction than that technical change is the product of the matchless ingenuity of a small man forced by competition to employ his wits to better his neighbor: Unhappily, it is a fiction. Technical development has long since become the preserve of the scienter tist and engineer. Most of the cheap and simple have, to put it bluntly and unpersuasively, been made---. Because development is costly, it is follows that it can be carried on only by a firm that has the resources which are associated with considerable size."⁶⁰

The maniference as an to be pass the president

Galbraith's statement about the demise of cheap and simple inventions is reminiscent of the late nineteenth century patent commissioner who resigned on the grounds that all the important inventions had been made Every year thousands of simple and important inventions are made by small firms or by individuals. Penicillin, the Polaroid camera and electrostatic duplicating were perhaps not simple inventions, or discoveries, but even these were the product of the single invention or small firm. What Galbraith is doing is confusing the inventive function with the development function. <u>Galbraith's confusion would result in a failure to</u> seek means to combine more effectively the inventive efficiency of the larger firms. To this subject we now turn.

The direction in which solutions lie can be seen by considering a perfectly efficient patent system, the absence of uncertainty, a perfect capital market and sufficiently low transactions costs. In this situation, one would find an optimal allocation of R and D tasks among firms. Activities leading to original invention would tend to be concentrated in smaller firms, and developmental activities would be concentrated among medium-size or larger firms. Smaller firms could sell or contract original inventions to larger firms in an efficient market setting and the allocation of resources devoted to the various aspects of R and D

small firms, which is also a view held by Pavity and Wald. In an exam-
ination of empirical evidence from the 1960's, they concluded that show the concluded
larger and smaller firms play complementary roles in innovation. Smaller
firms concentrated on smaller-scale, specialized and sophisticated equip-
ment and made major innovations after larger firms had let the opportuni-
ty slip away. 51 Pavitt and Wald-also found that "opportunities for $a = 0$ in Cashe 2
small firms tend to be greatest in the earliest stages of the product $\mathcal{I}_{\mathrm{constant}}$, where the stages of the product $\mathcal{I}_{\mathrm{constant}}$
cycle, when economies of scale are relatively unimportant, market shares $\omega^{-1} = \omega^{-1} \omega^$
volatile, and rates of entry and failure high."52 second set when a subsystem of

This view of the complementary tasks of the large and small firm is also that if suggested by the detailed examination of the development of important and be suggisted by the detailed examination of the development of important and be suggisted by the detailed examination of the development of important and be suggisted by the studies. These investigations show (implicitly, as well the point is sometimes overlooked by the authors) that the initial pate of all the point is sometimes overlooked by the authors) that the initial pate of all the point is sometimes overlooked by the authors) that the initial pate of all the point is sometimes overlooked by the authors) that the initial pate of all the point is commercially useful and marketable. The expenses involved in these states of stages of development after the original invention are, more often than the stars not, prohibitive for the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the stars of the smaller firm 53 expenses involved in the smaller firm 54 expenses involved in the smaller firm 54 expenses involved in the smaller firm 54 expenses involved in

The patentable concept of electrostatic machine copying was developed by one man, Carlson. Since this was a new process substantially differbent from existing processes, a relatively small company (Haloid) could develop the process successfully and become the leading producer (Xerox) in the new field.⁵⁴ This is to be contrasted with, say, an innovation that improves the performance of existing copiers. Discovery of such an improvement by a laboratory becomes somewhat more probable, but it is much more likely that the development of work necessary to convert the invention into a useful final product will be performed by a larger firm. Even the expense of certain types of initial inventions are beyond the means of smaller firms. What is uncertain is the extent to which capital constraints, inherent riskiness of invention and the large costs of development discourage inventiveness by smaller firms. Chances are that this interis a problem of considerable magnitude.

Just recognizing the problem is an important step since current mythology and accepted obscures it. The proposition that smaller firms have a comparative ad-variable descent vantage in invention, while medium-size firms are usually sufficiently advances ad

and the second of the second of the second second

This general pattern is borne out by the questionnaire survey of Cooper^{4,7} who interviewed twenty-five people with experience in research and development, primarily in chemicals and electronics, most of whom had managed development in both large and small companies. The estimates derived from these interviews indicated that large companies must spend from three to ten times as much as small ones to develop a particular product. The reasons for this are presented below.

First, the average competence of technical people in smaller firms is higher than in large firms. Greater freedom of a smaller company apparently is attractive; research personnel may own significant amounts of the stock of small companies so that the incentives for successful invention or innovation may be significantly greater; and small companies are less likely both to tolerate unproductive personnel and to hire unseasoned people. Although Conner does not comment on this, apparently greater productivity of R and D personnel in smaller plants derives in part from their higher salaries--either because they are more experienced or more competent, or because of their direct ownership which acts as an incentive to produce. Nevertheless, if Connor estimates are correct, it would seem that the additional expenses are more than offset by the increased productivity. In so far as the increased financial incentive increases productivity, one may wonder why large companies do not adopt some incentive system. An experienced patent agent with a large chemical company suggests that this is true because in a large R and D organization such a system would restrict information flow within the company and create 253 C 12 difficult rivalries and jealousies.48 1. 1. 1. 1. 1.

Second, technical people are much more cost conscious. Somehow the small firm is better able to achieve an atmosphere in which technical personnel are left alone to pursue work and, because of the closer identification of the personnel with the company, the personnel place a high priority on the way their efforts contribute to the company's success.

n North Anthr

Third, in the small company there is greater ease of communication and reduced problems of coordination. In smaller companies, technical personnel are more likely to be sensitive to the needs of the market because of closer contact with people concerned with this area. To be sure, these various advantages must be weighted against disadvantages of breadth of experience and specialization, but Connor's study indicates that the advantage lies with small companies.

Santa and a state of the state of

Series Carlos Constanting and a series of the series of th

Support for the thesis that large firms in concentrated industries show a support greater evidence of technical change is furnished by A. Phillips. 34 to In sectors and general, Phillips found that those industries "which had large-scale and the second producing units in 1904 had significantly greater rates of decrease in a second second the number of wage earners perjunit of output between 1899 and 1939 than the started did the other industries." Phillips' results are too facile because ta set at they probably do not measure the effects of large size and concentrations assure they on invention or development. Greater technological opportunities probably exist for capital-intensive firms so that their capital/labor ratio. naturally would tend to grow more quickly over time. Thus, the casual influence probably runs from technology to concentration rather than the supervision and reverse, and is shown by Phillips' own subsequent work³⁵ and by studies by Scherer³⁶, Philips³⁷, and Comanor.³⁸ Scheremand Philips found that differences in the scientific knowledge base accounted for as much of the science of the total variance in corporate R and D as did interfirm differences in corporate works when porate sales; Comanor's results were supportive of Scherer and Philips' conclusions. Second a process of the 一般,我的现在,还在那边,一个人的感情。

A Provide the second second

وروسه والأحط المحمد وراري

An important and cogent argument can be made that, from the social point of view, smaller firms should invest more than they do in R and D and that they should invest more than larger firms in proportion to their size. This argument rests on the rather substantial amount of evidence which indicates that smaller firms have a greater efficiency in invention than larger ones.

- . . i ł

. 30

a sele kata a

en el ser engen

Some evidence of this from works by McConnell and Peterson and Schmookler and Scherer already has been offered. However, none of these separates invention from development or invention or development from innovation. Scherer's results mainly concern patents and, therefore, relate to invention, but these are not only unweighted as measures of the importance of invention, but also are only for Fortune 500 firms.

The work most relevant for the present argument deals with the origins of the first of the first of invention. Jewkes, Sawers and Stillerman³⁹⁰ in their analysis of the first of the fir

However, McConnell, and Peterson's results are not duplicated in studies of larger firms of Typical results for larger firms are either that there a contrain is no relationship between firm size and R and D intensity or that R and on St conde D intensity increases up to a point and then diminishes. Some studies show a negative relationship between firm size and R and D intensity. Los and a mini-

Smith and Creamer's results are somewhat typical.²⁷ One of the industries (scientific and measuring instruments) in Smith and Creamer's twelve-industry sample also shows a negative relationship for research intensity and firm size. For two additional industries (other chemicals and communication and electronic equipment), the intensity of the small₇ est firms (under 1,000 employees) was greater than for any other class when federal funds were excluded. In the categories of other chemicals drugs and other medicine, and scientific instruments, the peak intensity occurred at less than the largest size class. Finally, in seven of the twelve industries, the peak intensity of the smallest size class was greater than that of the next largest class.

10 . sh Solidat Assertion (Antonia) and a state of the Schmookler's results for larger firms are fairly consistent with the relationships shown by Smith and Creamer.²⁸ For a six-industry sample, Schmookler found across four industries no relationship between firm to the source and size and R and D intensity. However, for two of the six industries, Service (19) Schmookler data show that the R and D intensity of the smallest firms . (49-499 employees in one case, 500-999 in another) was greater than that adden ag of any other size class. It is worth noting that these two industries (fabricated metal products and ordinance, and electrical equipment) are among those in the McConnell and Peterson sample. In two other industries, peak R and D intensity occurred at less than the largest size of more than 5,000 employees; for the professional and scientific instruments industry, peak intensity occurred at the second smallest size class (500-999 employees), in the food and kindred products industry, the peak intensity occurred at the next to largest size class (1,000-4,999 employees).29

Even for the chemical industry, the R and D intensity for the smallest size class (firms with less than 500 employees) was greater than for any size class, except for the largest. Strikingly, two of the industries found by Schmookler to exhibit peak research intensity at sizes of less than 1,000 employees (electrical equipment and professional instruments)

small firm to capital problems, especially in view of the inherent risks of R and D. As R and D is spread among a larger number of projects, as is more likely the larger the firm, the risks of failure of any one project are reduced. Related to the question of small firm survival is the greater life expectancy of larger firms which allows them to assume R and D investments whose payoff period is longer. The greater diversity of large firms in increasing the likelihood of being able to use an invention, and the greater market concentration of large firms are also elements, though guite minor ones, in explaining the greater propensity

for R and D programs among larger firms.

der onter standt mu wu mai win cesata R and D expenditures by small companies are distributed among approximately the same industries as for large companies. Smith and Creamer¹⁹ laten an asa show for 1965 that four of the top five industries in absorbing R and D spending by small firms were also among the top five for large firms. It would appear that the more capital-intensive industries have the higher percentages of firms engaging in R and D.20 This probably reflects the greater potential for R and D in these industries and the fact that capital-intensive industries tend to have larger firms. It would be interesting to see what the regression of both firm size and capital intensity against the percentage of firms engaged in R and D would show. deel state of the enange and the control of white a stationary end of 🕫

Given the skewed distribution of R and D spending among small firms by industry and by size, it is not surprising that Smith and Creamer find the distribution of R and D spending among small firms also highly skewed.²¹ Thirteen percent of manufacturing firms with less than 1,000 employees spent about 55 percent of total R and D spending by manufacturing in this size class. What is perhaps more interesting is that this 13 percent also showed a more continuous record of R and D spending.

has war in the result of a start of the state of the second state of the second state of the

a, frene e conversión de la companya en la contra de la con

Research Activity, Intensity and Firm Size Firm size strongly influences the probability of a firm having a formal filled and R and D program, but does firm size influence the size of the R and D program? One would expect a positive relationship as long as there were not strongly decreasing returns to scale in R and D. One also would expect a positive relationship simply on the basis of federal funding of R and D. The percentage of R and D funding from federal funding of the set mous, though recently it has been declining. In 1959, afederal funding returns

the state of the state

advances may come from departments other than those for R and D. Changes in tax treatment of R and D can result in new, arbitrary classifications of personnel or activities into the category of research 10 If these problems exist in attempts to study R and D for larger firms, how much more difficult is it to analyze R and D by smaller firms in which the data are less satisfactory or do not exist? A second state of the perce and a strength

Aside from basic problems of data availability, current research suffers from two interrelated and important shortcomings. The first is that data are not examined on a sufficiently disaggregated basis. The second deficiency is that too few factors have been introduced that might help explain the structure of R and D. Kamien and Schwartz¹¹ observe "much of the evidence on the effect of size has not controlled for other factors that may be helpful in explaining innovational effort." The same may be said of evidence concerning innovational outcome. Few studies really have attempted to explain the structure of R and D, undoubtedly because to do this requires that the data and information be generated by narrowly focused studies working to build up a data base Sufficiently Fich to understand R and Distructure stren in eigen ei

In this regard, problems of R and D are reminiscent of problems of deveioping a general theory of oligopoly. The necessary basic research is tedious and perhaps less rewarding in the short run. Perhaps economists are less willing than researchers in the natural sciences to undertake the tedious and narrowly focused research upon which the advancement of science ultimately rests. 1994 - A. I. 化合物 网络大学家 海拔的复数形式 化合金 化

R AND D CHARACTERISTICS OF SMALL FIRMS

the state

The most important studies of R and D in small firms are those of. McConnell and Peterson, 12 McConnell and Ross, 13 Hamberg, 14 Smith and Creamer¹⁵ and Dearborn, Kneznek and Anthony.¹⁶ From these and other investigations, a number of limited and tentative, though important, conclusions emerge. derivers program and to the

生物发育健康 感情子 穷悲 计内封角 化磷酸素 No Ners The Incidence of R and D Programs renderings preserver and a chaer brook // Probably about 20 to 40 percent of small firms engage in R and D in a I relatively formal way. Among the more reliable estimates are those from the detailed and disaggregated guestionnaire results of McConnell and

between the investment-to-GNP ratio and real growth rates for seven OECD countries as measured by the Kendall coefficient of concordance is .92, with a chi square of 11:2. This is just significant at the 10 percent level, which is impressive for such a small sample.⁸ Similarly for the 1967-1971 period, the United States ranked last in its growth of R and D expenditures, followed by the United Kingdom, France, West Germany and Japan. This matches the respective growth rates of these countries, except for the reversal of the United States and the United Kingdom.

For the United States, the fall in the investment-to-GNP ratio has occurred in large part because of the failure of the traditional sources of investment funds, retained earnings, debt and equity. Retained earnings in constant dollars have declined enormously during most of the 1960's and the 1970's. The "crowding out effect" has limited severely bond debt as a means of financing, and, until recently, the stock market has not been a very attractive place to go for financing. Financing problems of small businesses have been especially difficult.

One set of measures that undoubtedly are called for are policies that encourage greater capital formation. With such policies, R and D for both small and large firms undoubtedly would expand. However, the response of small firms probably would be greater because of their greater sensitivity to credit conditions. The phenomena is similar to the unemployment rate of minorities which increases proportionately more than for other groups during periods of contraction and which decreases more than proportionately during periods of expansion.

Economic growth is a matter of the efficiency as well as the magnitude of investment. In this regard, the distribution of R and D expenditures between large and small firms becomes especially relevant. After considering the relationship of R and D to smaller firms in the next section, the third section of this paper argues that efficiency requires a greater portion of R and D spending by smaller firms. The final section suggests conditions under which the improvements in efficiency might be brought about.

DATA LIMITATIONS FOR THE ANALYSIS OF SMALL FIRM R AND D

Small firms are those with less than 500 employees and probably account for less than 3 percent of total R and D expenditures.⁹ Yet in terms of

APPENDIX XV

ARTICLE, "RESEARCH AND DEVELOPMENT BY SMALLER FIRMS," BY RICHARD O. ZERBE, JR., NORTHWESTERN UNIVERSITY AND UNIVERSITY OF WASHINGTON, JOURNAL OF CONTEMPORARY BUSINESS, 1976, PAGES 91-113

Journal of Contemporary Business Spring 1975

der, "Rechigan State sed to de-·a-Firm:

, nor are

Ì3

inces Review ailer sur-

100.0

- 2 -

38.

. 1

10

RESEARCH AND DEVELOPMENT BY SMALLER FIRMS

Richard O. Zerbe, Jr.* Northwestern University and University of Washington

THE IMPORTANCE OF RESEARCH AND DEVELOPMENT

Technical change arising from research and development (R and D) expenditures is exceedingly important. Solow, 1 in his pioneering work, found that between 1909 and 1949 about 81 percent of economic growth was attributable to technical change and changes in production practice. Dennison,² in a more disaggregated study, found that 36 percent of the rise in output per worker was attributable to advances in technical knowledge, and 42 percent was attributable to improved worker education. Only 9 percent of the rise was due to increases in the capital stock. 2.25 5

Research and development is also of major importance in determining comparative advantage, the balance of payments and the magnitude of U.S. suggest exports.³ Donald Kessing⁴ found that there was a powerful correlation between the intensity of R and D activity in American industries and their export performance. Pavitt and Wald⁵ found a high correlation between national industrial R and D expenditures and national technological performance across a sample of ten industrialized countries. In a sample of fourteen industries, Gruber, Mehta and Vergon⁶ found that U.S. export. strength was concentrated in the five industries with the greatest R and D effort, i.e., transportation, electrical machinery, instruments, chemicals and nonelectrical machinery. The remaining industries exhibited a intersections are sense whet importabalance for 1962, the year investigated.7" From these and that other studies there is little doubt that R and D and technical change play a major role both in economic growth and in determining relative and economic position.

> A crude comparison suggests 'that the fall in the U.S. growth rate of recent years and the concomitant absolute and relative decline in the ratio of R and D to CNP are not unrelated phenomena. The decline in R and D has been part of this decline in the United States in the investment-to-GNP ratio. See Figure J. For the 1960-1973 period, the rank correlation

Table 5-10. Distribution of employed doctoral scientists and engineers by employment sector, 1975

80.

- No

1. e

on parties.

	scie	octoral ntists ngineers		toral Itists'		ctoral ineers
Employment sector	Number	Percent?	Number	Percent ²	Number	Percent ²
Total	262,411	100	219,055	100	43,356	100
Business and industry	65.876	25	43,341	20	22.535	52
Educational institutions	153,249	58	137,943	63	15,306	. 35
and universities	147,633	56 1	132,504	61	15,129	35
Two-year colleges	3,674	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	3,497 1,942	2	177	(³)
lospitals and clinics	7.586	3	7.562	3	24	<u> </u>
Inprofit organizations	8.510	. 3	7,277	3	1.233	Ś
Sovernment	26,755	10-	22.538	10	4,217	10
Federal?	21,634	. 8	17,855	8	3,779	9
State	3,110	ិ រំ	2,883	1	227	1
Other	2,011	. 1	1,800	· 1	211	s (*)
Other employment sector	86	(*)	- 86	(9)		
Employment sector unreported	349	·	308			

Includes 94 scientists or engineers whose field is unknown.

The budges of automatics or engineers whose here is unitative. Excluding those whose employed was unireported. I includes the military and the Commissioned Corps of the Public Health Service. Less than 0.5 percent.

NOTE: Detail may not add to totals because of rounding.

-ja SOURCE: National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States, 1975 (NSF 77-309), pp. 38-41.

See Figure 5-17 in text.

Table 5-11. Doctoral scientists and engineers by age and type of employer, 1975

					No. A A	14. C
· · · · · · · · ·				Four-year colleges and universities		ieral nment'
Age	Number	Percent	Number	Percent	Number	Percent
Total	65,876	100	. 147,633 .	100	21,634	.: 100
Under 30	2,129	3	5,772	- 4	773	4
30-34	15,117	.23	30,862	- 21	4,121	19
35-39	14,113	21	30,903	21	4,734	22
40-44	10.274	16	23,687	16	3,646	17
45-49	8,090	12	19,833	13	3.081	
50-54	7,476	11	16,146	11	2,398	11
55-59	4,610	7	10,774	7	1.533	7
60-64	2,734	4	6,461	4	953	4
65 or over	1,224	2	3,094	ź	362	2
No report	109	(2)	101	(²)	13	{?}

¹ Includes the military and the Commissioned Corps, ² Less than 0.5 percent.

NOTE: Detail may not add to totals because of rounding.

SOURCE: National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States, 197-(NSF 77-309), pp. 38-41,

See Figure 5-19 in text.

CORDENCE CONTRACT

78.

APPENDIX D

Selected Tables from Science Indicators, 1976, NSB 77-1, The National Science Board ALL MORE DISE 2 Constraints of the D. O. J. P.C. d 2 Necesia Maria

OFFICE OF PLANNING AND RESOURCES MANAGEMENT

DATE OF AWARD	FIRM NAME	PROJECT TITLE	AWARD NUMBER	PROGRAM AREA	AMOUNT
10/76	Computer Horizons Inc. Cherry Hill, N.J.	An Evaluation of University Research Productivity	7681724	Evaluation	\$ 42,495
31/76	Computer Horizons Inc. Cherry Hill, N.J.	Review and Analysis of Importance and Utilization Measures Contained in Evaluative Bibliometrics	7682854	Evaluation	\$ 18,318
9/77	Institute for Scientific Inf tion Philadelphia, Pa.	rma- A Citation and Publication Analysis of U.S. Industrial Organizations	7710048	Evaluation	\$ 64,851
	/ :				
			-		
	$\frac{1}{2} h \left(\frac{1}{2} h \right) = \frac{1}{2} \left(\frac{1}{2} h \right) \left(\frac{1}{$				
,	a Angeland an Angeland an Angeland Angeland an Angeland an Angeland Angeland an Angeland an Angeland Angeland an Angeland an Angeland an Angeland an Ang	en nen sind en en en en sind en sind. Sind form	121 ANT 121 ANT 121 ANT 121 ANT	1000 1000 1000 1000 1000 1000 1000 100	stations Geological
		and the street water you stated with which	erson (

SCIENCE EDUCATION DIRECTORATE

DATE OF AWARD 9/77	FIRM NAME Prism Productions Inc. Camarillo, Ca.	An Experimental Series of Science Pro-	AWARD NUMBER 7716196	PROGRAM AREA Public Understanding	AMOUNT \$203,100
9/77	Exotech Inc. Gaithersburg, Md.	Data Processing Support to the Science Education Directorate	7726461	of Science Special Studies	124,854
9/77 Ma	Westat Inc. Rockville, Md	Program Evaluation in Science Educa- tion: CAUSE	7723940 Deb Log (Systems S Approach	\$ 9,900
2/77 A	Courseware Inc. Provo, Utah	Learner-Controlled Instructional Strategies: An Empirical Investiga- tion	7601650	Technologi- (cal Innova- tions in Ed- ucation	207,750
	Development & Evaluation Associates Syracuse, N.Y.	Evaluation of CAUSE	7723982	Systems Approach	\$ 9,990
$1\sqrt{\sqrt{2}}$	gan an ann an Anna an Anna an Anna an Anna Anna Sanna (1993) an Anna Anna Anna Anna Anna Anna Anna	n a de la sector de la sector de la Maria de California de la sector de la Maria de California de la sector de California de la sector de la sector de la Maria de California de la sector de la sector de la sector de la sec		1. 1893 C. 1993 St. 201	e ît M
	an Alexandra († 1977) 1979 - Alexandra Alexandra († 1977)	grave water Room water water anger of the solid states	5369779 1775-55	e di Alita di Cher	6 320
- 	n ny sana yang sana Bergarah sana Terser	generalisen († 1990) 1988 - General Frida, en gelen († 1997) 1988 - Generalisen († 1997)		unte danara.	(2, 2)
			11888, 11 874 5 10		74.
		e ga e e			

DATE OF AWARD	FIRM NAME	стар начало со наранийся и слова сейност. Провение настоя и слова и слова и слова и правительского и как простояти и <u>PROJECT (TITLE</u> райодается).	AWARD NUMBER	PROGRAM	AMOUNT
5/77	Technology Associates of Southern California, Inc. Monterey Park, CA	of a Simple Liquid Piston Heat Engine	77-07489	Research	53,600
8/77	CONSAD Research Corp. Pittsburgh, PA	A Prototype Evaluation of the Program Output of the Research Applied to National Needs (RANN) Program	76-11438 A04	Contraction Research Evaluation Screens Constant	: 339 57,107 2 [°] 000
9/77	Operations Research, Inc. Silver Spring, MD	Research on Methods for Assessing the Utilization and Impact of RANN Projects	77-22190	Evaluation	63,500
9/77	Kappa Systems Arlington, VA	RFP 77-110: External Product Evaluation Management	77-26721	Research Applications	261,480
•	and the property of the	(a) (30.4 ≤ (30.7 ± 30.80)) ⊂ (30.8 ± (30.8 \pm (30	Subtot	al: \$7	,599,535
Awards	made via a purchase order:	and the second		(人口) (1) (1) (1) (1) (1)	11.20
10 No.	gan ann a' suite		4 AT 11 4 4	a far an	1.00
7/77	Belt, Beranek & Newman Cambridge, MA	Evaluation of Basic Research Progress and Future Research Opportunities in Human de Factors and Ergonomics	RN-1473 7SP0920	Productivity	3,609 10,10
6/77	Clinical Systems Associates, Inc. Washington, D.C.	Technological Needs of the Physically Handicapped	RN-1039 7SP0842	<pre>Productivity</pre>	∭9 °,8 50
9/77	Clinical Systems Associates, Inc. Washington, DC	Research Priorities to Aid the Productivity of the Physically Handicapped	7SP1121	Productivity	<u>, 6</u> ,250
8/77	Dames & Moore San Francisco, CA	Implementation Measures to Reduce Earthquake Hazards of Dams	RN-6874 7SP1045	Environment	966 978 1,000
			1 A A A A A A A A A A A A A A A A A A A		

- 10

DATE OF	G-AMATA FIRM NAME	gr a chiế guyên đà chiế tropagit. Ngàng trị của <mark>PROJECT TITLE</mark> thiếng giác troi Ngàng trị giác giác trị thị chiếng giác tri	AWARD Number	PROGRAM AREA	AMOUNT
8/77	Oneida Materials Corp. Cucamonga, CA	Development and Testing CSMRI "A" Metal Process for Recycling Steelmaking Dust and Scale Waste for Industrial Adoption	76-84256	Indus. Prog./ Resounces	75,000 (* 21.2
2/77	Amber Laboratories Juneau, WI	Natural Red Food Colorant from Beets		Resources	103,900
12/76	Anver Bioscience Design Sierra Madre, CA	Jojoba Seed Meal as an Animal Feed	76-23895	Resources	77,300
8/77	Roger Blobaum & Associates Creston, IA	An Assessment of the Potential for Applying Urban Wastes to Agricultural Lands	77-08280	Resources	92,100
9/77	Charles River Associates Cambridge, MA	An Analysis of Major Policy Issues Raised by the Commercial Development of Ocean Manganese Nodules	77-14453	e stado por el Resources por statorga el	191,900 (30,000 fro
7/77	Collaborative Research, Inc. Waltham, MA	Synthesis and Applications of Nucleic Act Action Action	77-10195	Resources	209,,100
9/77 8\.\\	Collaborative Research, Inc. Waltham, MA	Enhancement of Animal Protein Production by Novel Genetic Technology	*77-19654	Resources	24,997
8/77	DASI Industries, Inc. Chevy Chase, MD	Evaluation of Free-Falling Film Ultra- High Temperature Processed Milk	77-04162	Resources	168,700
9/77	EIC Corporation Newton, MA	Recovery of Chromium from Nickeliferous Laterites	*77-19538	Resources	24,740
2/77	e e l'acentrate de	Alternative Food Delivery Systems - An Exploratory Assessment	77-07184	Resources	25,000
220					70

			and the second		
DATE OF	eren eren ander soner in eren eren eren eren eren eren ere	 Bergelenses gener insers - zen unde Echte Bergelense en andere - de gener inserse gener in <u>PROJECT TITLE</u> 	AWARD NUMBER	PROGRAM	AMOUNT
4/77	Maurer Engineering, Inc. Houston, IX	Conference on Research in Excavation Technology	75-14405 A03	Productivity	36,900
9/77	Maynard Research Council Pittsburgh, PA	Study of a Mechanism to Foster University/ Small Business Interaction	77-14151	Productivity	100,000
9/77	Multisystems, Inc. Cambridge, MA	Remote Employment of the Physically Handicapped	*77-19497	Productivity	24,948
9/77	Precision Instrument Co. Santa Clara, CA	Slidestore: Large Capacity Information Storage	*77~19528	Productivity	24,995
8/77	Radiation Monitoring Devices, Inc. Watertown, MA	Résearch on Uncooled Cadmium Telluride Gamma Detectors às Substitutes for Ultra- pure Germanium	77-10434	Productivity	198,100
9/77	Scientific Process and Research, Inc. Highland Park, NJ	Lowering of Energy Consumption in Plastics Processing	*77-19512	Productivity	25,000
9/77 3\\\\	Scientific Systems, Inc. Cambridge, MA	Microprocessor-Based Prosthetic Control	*77≑19672	Productivity	23,670
6/77	Spectrum Research Denver, CO	Evaluating the Organization of Service Delivery: Public Health	74-08798 A01	Productivity	8,648 122 (000
4/77	Stearns, Conrad, & Schmidt Consulting Engineers Long Beach, CA	Research on Equipment Technology Utilized by Local Government: Refuse Collection	77-04424	Productivity	40 ,272
6/77	Stearns, Conrad, & Schmidt Consulting Engineers Long Beach, CA	Research on Equipment Technology Utilized by Local Government: Refuse Collection	74-20560 A03	Productivity	13,800
- K			· · · · · ·		

		nelapitente presse programmente, pare	AWARD	1000 - 1000 -
AWARD	FIRM NAME	STATISTICS AND A REPROJECT STITLE	NUMBER AREA	AMOUNT
3N 3 2		na han an a	1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.1.	1997 - 1999 1997 - 1999
9/77	Woodward-Clyde Consultants San Francisco, CA	Analysis of the Adoption and Implementation of Community Land Use Regulations for Flood Plains	1 77-13908 Environment	208,300
5/77	Advanced Research Resources Organization Silver Spring, MD	A Conference to Formulate Priorities for Research on Human Performance and Productivity	77-07886 Productivity	74,900
9/77	Agbabian Associates El Segundo, CA	Improved Design Procedures for Underground Structural Support Systems in Rock	75-80044 Productivity	179,900
9/77	Amtech, Inc. Newton, MA	Micro-Isotope Tool Wear Detection	*77-19517 Productivity	25,000
_{ð∛} 9/77	Block Engineering, Inc. Cambridge, MA	Single Ended Photoelectric Hazard Warning	*77-19478 Productivity	24,495
9/77	Ceramic Finishing Co. State College, PA	Control of Fragment Size Distribution and Darage Penetration During Machining of Ceramics	*77-19818 Productivity	24,942
4/77	Energy Research and Generation, Inc. Oakland, CA	Thermocorer for Rapid Excavation	73-03322 Productivity A06	131,200
8\ 7/77	Springfield, VA	Remote Sensing with Ground-Probing Radar	76-03300 Productivity A02	10,700
3/77	Exotech, Inc. Gaithersburg, MD	Shaped-Rulse Rotary Percussion Drilling	75-16367 Productivity A01	18,700
60.40 - 08	Exotech, Inc. Gaithersburg, MD	Shaped-Pulse Rotary Percussion Drilling	A03 Productivity	12,900

66.

DATE OF	Stabour <mark>FIRM NAME</mark>	PROJECT TITLE	AWARD NUMBER	PROGRAM AREA	AMOUNT
al	e a particular de la companya de la Na companya de la comp	, 1997年(1997年)(1997年)(1997年)(1997年)(1997年))(1997年))(1997年))(1997年))(1997年))(1997年))(1997年))(1997年))(1997年))(1997	han thài c	SUNDADO /	10.332
7/77	Building Systems	Building Configuration and Seismic Design	76-81821	Environment	199,400
- 	Development, Inc. San Francisco, CA	in the second of the second se	11-00.098	Tach, Larssi	()): [*] ()(): ()
4/77 उ∿्र∖	Clement Associates, Inc. Washington, D.C.	An Evaluation of Toxicological Information Relevant to Future Testing Requirements for Hazardous Chemical Substances and Mixtures	14 77-15417	Environment	142,793
8/77	Clement Associates, Inc. Washington, D.C.	An Evaluation of Toxicological Information Relevant to Future Testing Requirements for Hazardous Chemical Substances and Mixtures	77-15417 A02	Environment	173,444
8/77	Santa Clara, CA	Conversion of Municipal Wastewater Treatment Plant Residual Sludges Into Earthworm Castin	gs		9,700
5/77	Gurnham & Associates, Inc. Chicago, IL	Control of Heavy Metal Content of Municipal Wastewater Sludges	77-04355	Environment	110,900
3/77	Human Ecology Research Services, Inc. Boulder, CO	A Comparative Analysis of Public Response to Weather Modification	74-18613 A03	Environment	56,600
1111		per den mijst in søre ersen professer for det in medser her	jenišča.	, 19 문화로 11	会"的句
3/77	Human Ecology Research	Metromex: Social Impacts of Inadvertent	76-22041	Environment	60,300
	Services, Inc. Boulder, CO	Weather Modification: A Comparative Study	N. (1997)	anter Lynnaer	ataa Yesa
9/77	Laser Analytics, Inc.	Improved Sensitivity of Laser Absorption	77-02124	Environment	211,500
	Lexington, MA	Techniques for Atmospheric Pollutant Monitoring	ALCACE Vevea		
6/77	Media Four Productions Hollywood, CA	Synthesis of a Municipal Wastewater Sludge Management System	76-82708 A01	Environment	49,640

ASTRONOMICAL, ATMOSPHERIC, EARTH, AND OCEAN SCIENCES DIRECTORATE

DATE OF			<pre>/* Schedung of the state o</pre>	AWARD NUMBER	PROGRAM AREA	AMOUNT
2/77	- Scripta Technica Washington, D.C.	Inc.	Publication of Polar Geography	7681106	Polar	\$ 21,000
9/77	Compass Systems San Diego, Ca.	Inc.	Assembly and Analysis of Oceano- graphic Data on the Surface Layer	7724040	Atmóspheric	: \$ 30,000
	larishina of suplation large Received with Burn		(0-150 M) in the Southern Hemisphere and Preparation of the Results for Publication in an Atlas	11 x MA	opin saksi usla Çeti tirati a	$\eta_{1}=\eta_{1}(\theta)$
8/77	Compass Systems San Diego, Ca.	Inc.	Assembly and Analysis of Oceano-	7709201	Atmospheric	\$158,800
28 ³ 1	San Diego, Ca.	•	graphic Data of the Surface Layer (0-150 M) in the Southern Hemisphere	to provide the		e al ene
	a an		and Preparation of the Results for Publication in an Atlas	行政的	ge alle se tot. Net provi	X
5123	Respondent for and	. ¹	ensum och en alle och skalander för etter skalar en alle kristeren och och anderade och ander en ander förste dar krister och andere och skalar för alle och anne på och att andere på stater och ander		errande de la composition de la composi	N - Serger A
			n 1 €.2.9600 1	:		
8N1.	arenasian tartan Birthat Satana artan In		ECOLOGIC CALORIZACIÓN DE CAL DE CALORIZACIÓN DE CALORIZACIÓ	n en service Nationale en s	tu fearraí i	
NASA Alama		· · ·				With -
		Sires D	สมากษณะการสมารณะการณ์สมารณ์	11.085 (F.		6ž.

2

ຄ

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS DIRECTORATE

DATE OF AWARD	FIRM NAME	PROJECT TITLE	Award Number	PROGRAM AREA	AMOUNT
1/77	Courtesy Travel Service Washington, D.C.	Travel and Administrative Services in Support of Intern'l Science Acti- vities Sponsored by the NSF	7708322	Internat'l	\$ 500,000
1	Computer Horizons Inc. Cherry Hill, N.J.	Implementation of Evaluation Metho- dology for International Programs	7708484	Internat'l	\$ 24,915
	Metrics Inc. Atlanta, Ga.	The Economics of the Unique Functions Associated with Information Analysis Center (IAC) Services as the second	7718035	Science Information	\$ 83,800
	Charles River Associates, Inc. Cambridge, Ma.	Development of a Discrete Choice Model for the Demand of Scientific and Technical Information	7718020	Science Information	\$ 101,764
11 - 11 - 11 - 11 - 11 - 11 - 11 - 11	Innovative Systems Research Pennsauken, N.J.	Electronic Information Exchange in Re- séarch on Devices for the Disabled	7717924	Science Information	\$``51,143
2/77	Capital Systems Group Inc. Rockville, Md.	A Planning Guide on Innovation in the Dissemination of Scientific Information		Science Information	\$∷92,586
9177	Capital Systems Group Inc. Rockville, Md.	A Planning Guide on Innovation in the Dissemination of Scientific Information		Science Information	\$ 219,500
3/77	Westat Inc. Rockville, Md.	Relationship of Organization Climate to the Transfer of Scientific and Technical Information in Industrial Settings	6 7681946 678819	Science Information	\$ 10,017

- and the set of the set

60.

有以释起 化合物学 化动物学 经管理规则 计分词编码经济 计算法

teastage & values No. 1 Sugard 14 Rende Vinderad 293772228 Restauro de compositores de la comp South Astory Praktice andar the announce. FY 1977 GRANT AND CONTRACT AWARDS 1/ TO SMALL BUSINESS ्राहर्त्य के स्वरूप के स्टाइटर के स्वयंत्र अल्हा के स्वयंत्र इस्टाइटर के स्वरूप के स्वयंत्र के स्वयंत 2. $\{ e_i \}$ ŝ, s LISTED BY INDIVIDUAL AWARD BY THERE & CALLER AND AND A CALLER AND A 3 -60307-133 &n. - 9866-NSF DIRECTORATE 25 1 and thread The better the 508.94C <u>1/Includes programmatic grant and contract awards only.</u> Excludes awards primarily for NSF logistics support and purchase orders except where પુરસ્ 47 noted in the Research Applications list. opeNone cases ≤ 1 0.12 $C \leq 1 \leq 1$ 78 (s. 117 (\cdot,\cdot) . Bether Allered (2016) nest (Nord Pi sections applied to the department

7854 COB energy and an entropy of the second (C_{1}, J_{2}) MPE STR SYN nord succh report Amount if const [A No. AC 203 esti an \$ Other Math Sciences 1 3,000 ೆಂತ 7 Northop 63;7.00 Interresees Engineering/Heat Transfer Engineering Energetics 7 27,700 1216 Engineering/Fluid Mechanics 1 (7.65) (mail eolist 73,400) (1.50) (Metallurgy T 75,300 Ceramics 2 137,500 Materials Research 2 186,700 Chemical Analysis 1 60,000 Engineering 1 66,500 24,535 0ther 1 12 TOTAL : 718,335 Second and the 13 STI e entre des Policy Research & Analysis 5 217,847 **Cooperative Science Program** 1 500,000 Scientific Organization & Resources 1 24,915 Economics: of Information 2 ae 185,564.00~ 2000 33 ad 363,,229sa 🗐 👘 🤅 Access Improvement User Requirement Program 146,186 $p^{\pm}0$ Studies of Science Resources 6 534,269 1,972,010* TOTAL: 21* AE0 Aeronomy 2 136,500 Solar-Terrestrial 2 148,800 Atmospheric Chemistry 2 119,900 Solar Terrestrial Physics 1 67,500 Information Services USARP ٦ 21,000 Contract Support USARP 5 7,059,825 Climate Dynamics 3 288,800 Research Ship Support 3 295,047 TOTAL: 19* 8,137,372* BBS Regulatory Biology 3 164,856 Metabolic Bio. 1 80,500 Economics 1 12,500 History & Philosophy of Sci. 82,700 TOTAL : 340,556

FY 77 AWARDS TO INDUSTRY--BY NSF PROGRAM ELEMENT

	A Minister of			54.
	RA		No.	Amount
	Resources present assume the	NC	87	2,122,800
	Renewable Resources		1	35,000
	Societal Response to Natural Haz	zards	2 .	920,000
	Instrumentation Technology	. 122	3 .	198,600 🤤
	Excavation Technology		19 12	1,732,800
	Earthquake Engineering		94	2,013,100
	Environment	-	2	2,293,600
	Weather Modification		10	101,900 2,760,300
	Regional Environmental Managemer		13	2,780,500 3,592,400 2,269,600
	Chemical Threats to the Environm Productivity	lient?	134	3,269,600
	Regulation		2	929,000
	Technology Assessment		25	1,115,675
	Public Sector Productivity		1	5,000
	Service Delivery Technology & Sy	vstems	5	664,025
	National Productivity Measure.		2	192,000
	Service Productivity & Intergove	ernmental		10日日本の1月1日日本1日本日本日本日本日本日本日本日本日本日本日本日本日本日本日本日本日
	Relations		· 1	59,500
	Public Sector Productivity	· —;:	2	- 121,600
	Public Policy	8]	260,400
	Distribution & Equity		1	5,760
1	Systems Analysis		1	24,942
	Biomass Utilization]	280,000
	Mineral Market Behavior & Shorta		1	190,000 - 190,00
-	Resources Development & Conserva	ation		
	Advanced Processing Technology	į	Landa Martin	
	Industrial Program	ŝ	8	978
	International Travel TOTAL:	S.	431	978 \$23,829,799
	IUTRE:		-451	
		:		and the second
	BBS			enno de la secono d Esta companya de la secono de la s
		194		the first second se
	Genetic Biology		2	548,200
	Ecosystem Studies		1	198,000
	Regulatory Biology		2	112,100
	Metabolic Biology		1	319,200 72,600
	Biophysics	S .	l marine de la composition l	63,100
	Memory & Cognitive Processes	<i>i.</i>	an a	112,500
	Anthropology		1	16,200 is
	Economics		1	82,700
	History & Philosophy of Science TOTAL:	1. 2	ΤT	1,524,600
	i da de la comercia de la	4. 2		(c) A set of a set
		-		and the second
	n a substantia de la companya de la			a service a service and a s Service and a service and a
	制한 가지 않는 것 같아. 	100 A.	· .	· · · · · · · · · · · · · · · · · · ·
		11.11 A.		f = M (N + 1)
				•
52.78	alline and a subscription of a subscription of the subscription of the subscription of the subscription of the	a matala basa na sa	na ni a anni 2011 a chuirtean 1911 ann an	ana da ta da
275	(a) Constraint of the second second system is a second second system to a second se Second second se Second second sec	3471 H - NA - M N 20	second page communications such as a	en estructurator e a course contrate a No. No. No. No.

کار کوفرنده دارد. در در میره در افرانی که کارو دارد در افراد موجود که دو میران در میران در معمد در میرود. میرو امراطویی در میراد افراد میرو و کوفر این داکتر وی فارم کرو ایوم از ماهین کر میرود در اوروس ویر هم ماهوههای در از کوفرد اینی وی کاری استان میروهای بایار در داخل در ایران موجود که دارد.

化自己分析 化乙酰胺 医胸膜肌 网络外的 计时转运行

and a second second

M. Alfreis glad fika tearcus francas aran levies. Seener, electos as congenes, are bodd for conditar francas arabades endarantes for acugenerate opecate algorithm for the conditation are electore. Severable: analysis opecate algorithm and the conditation of the endarantes and endet. The paste conductor const.

化铁合金 化过滤器 化过滤器机 法公共公共公共的 NASA patent policies appear not to be a serious deterrent to industry participation in NASA basic research activities. Patent rights start with NASA but companies often are assigned development rights if the government does not plan to use the patent. NASA's congressional supporters have emphasized that NASA supported research is beneficial to U.S. industry and the national economy. Moving research results to utilization is important in meeting those objectives. See ell'is anorrador desteurs editories≧dor ab≊q2 su

bas telo steáneco NASA's publication policies in the basic research area generally resemble those of NSF: NASA encourages publication in refereed Journals and staff spoke of an increasing emphasis on that mechanism as one of the evaluations of quality to be weighed when considering further research support. In addition, for NASA contracts, particularly those let in response to specific research needs, NASA requires a technical report addressed to NASA. In one of the research areas it was noted that research findings by private firms in the natural resources area sometimes are not published readily; some companies with large research programs and labs participate readily in certain of the basic research activities, and publish results in the open

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

The Air Force Office of Scientific Research relies mainly on unsolicited proposals for initiation of new work through grants and contracts. Proposals are supported based on their originality, significance to science, the scientific competence of the investigator, the reasonableness of the research budget, and the appropriateness to the Air Force. Grants are limited to support of research at universities and not-for-profits. Contracts are used to support research in industry. n e sell sens santha nai

Research awards to industry vary according to the industry expertise and interest as these relate to the Air Force's research programs, and the interest of the Air Force in the industry expertise or the questions that a researcher may want to investigate. The AFOSR indicates that about 15% of its extramural basic research outlays go to industry, and estimates that about 10% of these awards are to small businesses.

Industry performance of basic research for AFOSR is more likely in high technology areas such as electromagnetic materials research and device concepts. In the microwave tube area, AFOSR has seven industrial research performers and because of a scarcity of trained researchers in this area Stanford University is training researchers in the field.

The AFOSR reports no special patent problems that appear to deter industrial basic researchers from Air Force work,

entermenteenen andaran andaran aan waar oo aan in ay arminen aanananan aan inaan aan araa araa waar ahaa waarii

Rest Constant South Constant South Constant

- African webb to water we restau

ONR does not have data permitting comparisons with NSF on proposal pressure. ONR interests are known generally and preliminary contact serves as a screen. Only proposals of some interest to ONR are submitted in most cases. There are few unsolicited proposals and their relative likelihood of support is not high.

In the nature of ONR relationships, contracts and negotiations, there are no serious administrative problems of a continuing sort involved with patents or publications. There are no cost-sharing requirements.

NATIONAL INSTITUTES OF HEALTH

NIH does not make grants to industry. Its awards to industry are in the form of contracts. Most of the contracts with industry are in response to requests for proposals. Within specific contracts it is sometimes necessary to perform some basic research, but such basic research is neither the major portion nor the primary purpose of the contract. This accounts for the fact that no industry basic research is reported by NIH in the annual Federal Funds report, since traditionally NIH has not split its awards for reporting purposes. Rather, the entire amount of any award has been allocated to the major research or development thrust.

There are relatively few unsolicited research proposals per year from industry. In FY 77, there were fewer than 10 active R&D contracts with industry resulting from unsolicited proposals, some new and some carryover from prior years.

In FY 76 there were about 300 R&D contracts awarded to for-profit organizations.

The determinations for awards to industry are made on the basis of competitive evaluation, with a very few awarded on the basis of "singular technical competency." NIH-supported research in industry is primarily in the life sciences.

NIH policies concerning both publications and patents resemble closely those of NSF. Researchers are encouraged to publish in the open literature and patent rights are dealt with on a deferred determination basis as with NSF. Cost-sharing is based on individual contract negotiations based on possible commercial advantage to the research performer.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Discussions were held with NASA Headquarters research management staff in three areas --engineering, life sciences, and space and terrestrial sciences. NASA's policies on the support of basic research are completely open. Anyone can apply. From one area to another, practices vary. Project announcements and knowledge of program thrusts in each field have a major influence on the support sought by research performers.

n estantatel

de elgendezi zmeno env

er en a trobado en

RALL AND

Merandia totanto dea tanta tel 19. Necessione analysis

82

S. 13 N 8 34 7 eentuss1140 一般について頭 100000 2010-08 - S <u>adaha pertek</u>i Fail Contract & Englishmethal and a set of the lost of 383,830 feligettideel afteraturat 7 (e.e. -A Letter (Arthous 1.3) 494 NGC PART IV (กฏิษณฑรสมชาติ) แล้วการขณะสะดาจร bool and eenalisk skoul v Karks Support of Basic Research in 化合物合物 化合物合物合金 Industry by Five Other Children and service Federal Agencies landrada (s. 18, 1985) 1897 - San San San terrente a l'entre s 3-9-03-03-03 Administer of the end of the 125 · 在1993年1月1日来 JATOE e l'e couse l'anne de les encourres d'élétéres de la france de la construction nassio in total nasvirelⁱⁿ . The first of the first of the set of the first first states γ , where γ is the set γ^{-1} le consequent com all fille all collected of cards of the second second second second and the second second sec station of a propagate to be part of the (E) Add (1) The ended we approximation of the test of the test approximation of the second se Second sec (An 24) amount the Alexandra (Alexandra Alexandra Alexandra Alexandra Alexandra Alexandra Alexandra Alexandra A and a state of the second s ида начали салону саласына даган толкон эрүүн Аснтаба^н басыл баббайның тарасын тарыл тары басқай алғанасы санасты алғана т

46.

-2-

18.5

Science Education Science Education	A Charles of the Solar y n Development ^(B) (Charles n Research TOTAL	1 203,100 - 1987, 4,536,009 484,648 2 19,890	
dministration		6	
)ffice of Planning a	& Resources Management	C. P. And Gratuelli (201) and provide a 295 (999) and a second seco	
)ffice of Governmen	t & Public Programs	2	
		angtarse page autoritation and antar taritation taritation taritation	
	e entration entration	a 1997 - New Alley State (1997) - Alley Alley Alley - New Alley State (1997) - Alley Alley (1997)	1.5
CONTRACTOR AND A DESCRIPTION OF A DESCRI	s more detailed list by	ang ang si susunang si si s	
·	content to a sector	La rísig srìmedig e ta sin - romen) e
11970,203 11871,204 1182,304 1182,304,20	4 01 71 - 7100	See eels is allow a mark See is allow a market	
	1	an a	y?3
	1. The second	the second and strong we deal to the most of	
- 		្លាល់ សំខាង សារការអាងស្ថិត។ ភាពសេរ ក្រោយសារដែរ សំពាក់ស្ថា តែអំ សំពាល់ សំពាក់សំខាងសំភាស់ សំពាល់សំ	
		Probatch (brog (eHC	
		Producti Edinge eiC Stradi Saradi Saradi	
1.1.1.1.1.1.152,255,253,253,253,253,253,253,253,253,2		Principal Score (Britania Score Score (Score Score (Station of Action (Station of Action (
		Processi i i sonogi ei C Processo i i i sonogi ei C Processo i sonogi e Processo i son	

44.

Table III-4

830

FY 1977 GRANT AND CONTRACT

AWARDS TO INDUSTRYLY

- C - S

let <u>na seconda</u>

<u>Directorate</u>	No. Awards	Amount	% of FY 77 Obligations	Obligations
Mathematical & Physical Sciences & Engineering	્રે. ુ 12	\$ 718,335	. 32%	\$224.4
Scientific, Technological & International Affairs	21	1,972,010		19 .4²/
Astronomical,Atmospheric, Earth & Ocean Sciences	19 19	8,137,372	3.48	233.5 ³ /
Research Applications	110	9,714,070	15.2	63.7 ² /
Science Education	s ^{(*} 7			
Biological, Behavioral & Social Sciences	6	340,556	මාවෙම හෝ බොල් .27	126.6
Planning & Resources Management	6	معنون 295 , 999	entratif a construinte	S S todansis Chorosta
Administration	6	1,115,744	۰ <u>.</u>	Ranna a canada
Government & Public Programs TOTAL:	2 189	<u>28,055</u> \$23,029,779	3.2%	\$ <u>726.6</u> 5/

 $V_{\sf Excludes}$ purchase orders

amenda Alexandra Commencial ²/These figures shown without \$1.3 million transfer from RA to STIA for the EV 107 technology assessment as shown for FY 77 for consistency in the FY 1979 Budget request.

3∕Includes U.S. Antarctic Program

4/Science Education total less Fellowships and Traineeships (\$15.3m) 5/FY 1977 Total NSF obligations (\$791.8) less Special Foreign Currency (\$4.4m),

PD&M (\$45.5m), and Fellowships and Traineeships (\$15.3m).

GENERAL NOTE

1.8 -

fimio : A

During a fiscal year some awards will be to support proposals received in the prior fiscal year. Some proposals received during the current fiscal year will not be acted on finally until the following fiscal year. In categories of small numbers, particularly where contracts are included, it is possible that for a single fiscal year awards may exceed proposals.

Table III-3

FY 1977 PROPOSALS RECEIVED FROM INDUSTRY BY DIRECTORATE AND FIELD OF SCIENCE OR PROGRAM AREA WITHIN DIRECTORATE!/

Directorate/Field	No.	n far sagain y fruituisaan dhi Nerson i <mark>Amount</mark> (1986) (1997
Mathematical & Physical Sciences & Engineering	1. 1. 	 Alexandra State (Second State) Alexandra State (Second State)
Math & Computer Sciences Engineering Materials Research Physics Chemistry Other	2 5 8 2 4 <u>1</u> 22	\$ 53,000 769;316 926,600 212,500 509;750 10,535 \$2;481,701
Scientific, Technological & International		anten er alande
Policy Research & Analysis International Science Science Information Science Resources Studies TOTAL:	8 6 24 7 45	701,039 1,623,600 2,162,686 488,613 \$4,975,938
Astronomical, Atmospheric, Earth & Ocean Sciences		য় হলে প্ৰথম কৰা উঠা জাই বিষয় জিলা যোগ প্ৰথম হ
Atmospheric Sciences Astronomy Polar Programs Ocean Sciences TOTAL:	9 5 14 ² / 1 29	1,746,600 398,700 7,679,225 <u>40,700</u> \$9,865,225
Biological, Behavioral & Social Sciences		
Biological Sciences Social Sciences Behavioral & Neural Sciences TOTAL:	7 2 <u>2</u> 11	1,250,100 175,600 <u>98,900</u> \$1,524,600

 $\underline{1'}Appendix \underline{A}$ provides more detailed list by program element. $\underline{2'}Includes$ Antarctic Research Program logistics support.

40.

ware and the second	Table III-1	An ann an tha an an an an Araba an
	RECEIVED BY NSF DIRECTORATE	0049 AF (25539) FY 1077
FROM ALL SOL	JRCES AND FROM PRIVATE INDUS	STRY State Strabers
	ta as of Sept. 30, 1977)	
	Total Erom	Josh Motal From
Directorate	All Sources	<u>Private Industry</u>
	 (a) Construction of the second s	
Mathematical, Physical & Engi Sciences	ineering 7,98 4	- 10 - 1071 - 100 - 10 - 100 - 100 - 100 - 11 - 22 -110 - 11 - 10
1. 1. 1. 如果是一次可能将把我们依旧是自己的	selonational all not chomper	-00x2 of Est or the foffer
Scientific, Technological & 1 Affairs	International 1.027	95112000.00000000000000000000000000000000
Add to redear that you	Claiss as a contribut seat	Hand a the trade at
Astronomical, Atmospheric, Ea	arth & Ocean	er al bersiteten gargeleret
Sciences: 499 stone store so		- 新闻教育的学校的学校,这些新闻的学校会会。 1719年1日
Research Applications	15. 161. SSLVT (180., 16) s41 Zeo	14 July - 1997 - 1997
Biological, Behavioral & Soc	Congletti boolit beesiis est ial Sciences di uno 7.231-se	a ara dan karang generala sa ing karang sa sa ing karang sa
BIDIOUTERT, BENAVIMAT & SOC	化十分分词 网络短口合身 网络小母子 医骨折 頭牌	2月19日11日,11日日,11日11日)(11日1日) 2月19日11日,11日日,11日1日日(11日日)(11日日) 2月19日11日,11日日,11日日(11日日)(11日日)
Science Education	7,421*	
Other (Administration; Office Planning & Resources Managem Office of Government & Publi	nent;	_13
	TOTAL: 28,122	568

*Excludes Fellowships and Traineeships.

826

38.

36. :

The fiscal year 1977 data in Table III-3 show that more proposals were received in the materials research area than elsewhere in these three directorates, with atmospheric sciences, biological sciences, engineering, astronomy and chemistry all receiving four or more proposals. (Polar programs is considered to have received five research proposals when the nine for research support services are excluded).

The greatest number of basic research program awards were made to industry (Table III-5), in materials research, atmospheric sciences, engineering and biological sciences. (When Polar programs support awards are excluded, that program category drops to the low end of the group). Appendix B lists the grant and contract awards to industry by NSE directorate and program element.

The data for awards to small business, a subset of the data for all industry, are grouped by totals for each directorate and then are individually listed by award by Directorate in Appendix C. Review of the awards to small business made by the three basic research directorates in fiscal year 1977 shows that most of these awards are for analysis or evaluation of data on research materials.

The actual numbers of awards in these areas are too small to permit valid conclusions from statistical comparisons of these totals with the data on population characteristics and distribution of basic researchers in industry.

S 757

RESEARCH APPLICATIONS DIRECTORATE

Some 1417 proposals were received by the Research Applications Directorate in FY 1977. That directorate has accepted proposals from private firms without special criteria for qualification beyond the merit criteria used for consideration and support of proposals from other sectors. In addition, small business firms that have outstanding capabilities for scientific research or technology have been encouraged to submit proposals particularly because of special legislative provisions first added by the Congress in FY 1976. In FY 1977 the Research Applications directorate received 431 proposals from private industry, amounting to approximately 30% of the total received. Of the 431 there were 329 proposals that small businesses submitted in response to the "Small Business Innovation" solicitation. Research Application made 544 awards in FY 77; 110 awards were made to industry, nearly 20% of the RA total number of awards. Of the 110 RA awards...

RANN's proposals and awards are identified by field of program thrust rather than by the traditional fields of science or disciplinary area. In FY 1977 these grouped as follows (proposals from the solicitation are in the data, shown separately in parentheses):

DER VUCLEERT DER ANDER AN AV (STREAMER AND

en completere al acartero en activencedo cas one, sociáliza

34

1. S

and here

The largest NSF obligations incurred in awards to businesses other than for through program directorates occurred in the Administration Directorate . .. support of the Foundation's data center and computer operations.

الاستركار الك Industrial proposal and award levels in NSF's basic research supporting directorates are discussed below and limit to gat to gatter as gatter at anti-

BASIC RESEARCH ONLY

This section considers proposal pressures on NSF from industry for basic 145-59 research support in terms of the data for NSE's three directorates in which nearly all of the obligations are in support of basic research--the Directorate nearly all of the obligations are in support of Dasic research, clie succession for Mathematical, Physical Sciences and Engineering (MPE), the Directorate for Biological, Behavioral and Social Sciences (BBS), and the Directorate for Astronomical, Atmospheric, Earth and Ocean Sciences (AAEO). development or bar

古たあき さいならつ The Foundation's policy on the support of basic research proposals from private industry has been expressed for many years in these words:

"Private Profit Organizations: Commercial firms are infrequent recipients of awards for scientific research project support. 网络新闻教育 医腹部 However, in exceptional cases, unsolicited proposals for basic 2012 202 202 research will be considered from industrial organizations where: NO BOO DE (a) the project is of special concern from a national point of de la companya de la compañía de Compañía de la compañía view and shows promise of solving an important scientific 1405002 853 problem; (b) unique resources are available in industry for the diversity of events. work; or (c) the project proposal is outstandingly meritorious."

This policy has been widely known. It also has been misunderstood by some 129238-1233 who have thought that NSE never makes awards to commercial firms for support of basic research; such is not the case. Awards to private firms, for basic research support have been relatively infrequent but have been made by NSF for many years. . See Ser Frid

Concerned that the long-standing wording of the basic research support . policy may have been unduly negative in tone, the National Science Board on January 19, 1978, took the following action:

andenne velatetete de la company elevelogie a abrevel a company appeldent (final Socie V is rest. is primerliv by sufferences from a sec (a substitut i transition the division of Science information

inners is which there berrouges with seathing by threads polyceast? unicommunication, cationication includes programs for high rest and under the

			and the second second second second second second second
2)		erente en de la companya de la comp El companya de la comp	an a

orgeneration of initial of the brack of population of solar black was Buggingers and initial of the brack of september of inclusion with the deta of initial solares for brack of president gradients in Hebrahmy Shows (Hebrahmy)

Same Deversed by Processes of Tomal 2, starts

		· ·		1 A.
NE PERMON				
angeranger (* 1997) Angeranger (* 1997)	1	x)s(d)	at Stiede	1255
242. S. (6248.44)			sociation :	
· 문화· 그는 것을 가장하는 것을 가		245-022	ion pagea	1. N

III	TAA9
	11.02684

Gallaerten skieksista (1.72 Tel 163Y [528]
WERE A CARD	S On 'Altsubal of sbrawA
「東京大阪時度会社」ではない。 1999年1日の日本市場合では、1999年1日の日本市場合での 1998年1日の日期時代を10月前日本市	Steve strengts (State 198
Consvers	Construction Sector (Sector Foundation)
(Person consumers)	se est transforder transforder se i TIT INHA

Fiscal Year 1977

Berge di (1) A second a second secon When the suggest a last of carries that or incomest in industry in action Suffer in these three forces if constraining for smaller valatively under unred baris restarch wird available. The statistic of these signed rights that is constrained a force of second valations. berg of both materials and supplified as from the inclusion basic research In bole lists on-sirel release. Hits seterial in emineerial are the too three in understand of movels and funding and in soch list the structure well now file of the indulat. These per summiants permised surgest a sign libble.

-model full where ectual disensions correctly are not smooth for any systematic Truminante in cluer anchriczi suprestigae il fach N cf Unic n-port, dons and suchest the Hibshinged of patrematic Reary monosti a uture or fatorist, from eminate finas is research in siner voluce of propresis and appendiate [Furnish accessible to fit accession] W siner that appears relatively indiates a [Furnish accessible to fit accession] weather that appears relatively indiates a [Furnish accessible to fit accession] accession and appears relatively indiates a

634

Squint sciencius:

1942.

0400.0225200004226007

Zε

Table II-11: Funds for Basic Research by Selected Industry for Firms With Less Than 1000 Employees, 1976

(Includes Company and Federal Funds)

818

Dollars in Millions

·	1920 - Le 19	76 Preliminar	y % of Total
TOTAL	· · · · · ·	68	100%
Food and kindred products		2 淤	3
Chemicals and allied products Industrial chemicals Drugs and medicines Other chemicals	www.inty.jata	18 3 5 10	27 4 7 15
Petroleum refining and extract	ion	ید در در ۱ در در ا ۲۰ ۲۰ اینه	2
Stone, clay, and glass product	S	- × 4 🖉 👘	6
Primary metals Nonferrous metals and produc	ts ; 1 品 虎	1 1 8 4	2 2
Machinery Office, computing, and acco machines		2	3
Electrical equipment and commun Communication equipment and communication Other electrical equipment	nications	14 4 10	21 6 15
Transportation equipment other motor vehicles and eqpt.		2 2	3
Other manufacturing industries	· . · ·	1	2
Nonmanufacturing industries	•	21*	31

*Including commercial research and development firms.

Source: National Science Foundation Preliminary Data

Table II-9: Funds for Basic Research by Selected Industry (Includes Company and Federal Funds) 1971 and 1976

(Dollars in millions)

816

inan 195 1995-1 Total - 1995 Auril		<u>1971</u> \$581	% of <u>Total</u> 100%	<u>1976(</u> P \$786	reliminary) <u>% of Total</u> 100%	Percent <u>Change</u> 35%	
Chemicals and Allied	387.4 - 64.5	216 8	37	322	41	49	
Drugs & Medicines	592 -	77.	13	125	16	₈₁₂ 62	
Petroleum refining & extraction		21	102 4 4	45	6	114	
Machinery	2 73	22	4	36	- 5 Natasatil (ste	64	
Electrical equipment	3	143	,25	148	epone 19 <mark>19</mark> , in proc	_{garet} 4	
Aircraft & Missiles	Э	: 53	<u>9</u>	52	ennotic factor	- 2	
Nonmanufacturing		.e. (31	5	29	4 2885,633,63	, - 7	
All other industries		95	ി6	154		63	
St = 1000		. 11	12	• •		193 AFT	;
	103 103	4	1.22		, ano server a leol	a da ka	
	12		र <u>ह</u>		i ka katika ya ¹ i k Provinsi ka	ala (200	
	<u>с</u>		84 j. (0.8. 9 .48	esî refil	-

Source: National Science Foundation 1/25/78

 $\Lambda \leq m \leq 1 \leq n \leq 1$

Sec. 2

in the second		<u> 18. 19. 19. 19. 19. 19. 19. 19. 19. 19. 19</u>	
	ds for Basic Research.		
(Inc	ludes Company and Fede 1971 and 1976	ral Funds)	
	(Dollars in million	s)	
).st		Percent
$\mathbb{C}[\hat{\epsilon}]$ (5)	<u>1971</u> <u>Total</u>	<u>1976(Preliminary</u> % of To	
Total Sta	\$581, 100%	\$786 <u>700%</u>	35
Less than 1,000 employee	s 36 6	69 9	92
1,000 - 4,999 employees	_	38	-26
5,000 - 9,999 employees	72 12	112 14	56
10,000 or more employees	422 73	567, 72	34
88.2 g.B	1. Č – Č – Č – Č – Č – Č – Č – Č – Č – Č		$ \langle v \rangle f(v) $
Source - National Science	Foundation	933	્ર સરક લેવા ગાંધ

Source: National Science Foundation 1/25/78

NOTE: Since different companies comprise the specific size classes in each year, the data by size of company may not be entirely comparable.

1. S	NC OF	N (N f	14.14 <u>2</u>	6187
Q. 19	9.42 1	4.20	. 8 o. l	7797
S. Ø	\mathbb{C}^{n+1}	2,27	1.54	5000
M. K	2 J.S.	o at ji 🦿		
3.8	1.23		5 (\$)	
0.2	. S.Ve	9.81	1 -st	37.421 -
122	有。例如	2. 2.43		210:
1.4		6	(e) (e)	(*22)5581
	<u>1</u> 10	4.85	$\hat{\eta}_{\pm}$ is	(221) EX 24
		· .		

setter of setter families

n oran e e second

en cesso en m

26.

812

Tal	ble N-5.m	Company Funded Bas Percent of Total C (and find find find 1970 - 1978 35 ft - 05	ompany R&D MalloC)	<u>Artisisti</u>
e en durche) Leise de <u>E</u>	<u>9899999</u>	1970 1971	4.3% 4.3	
18 1. 20 6 19 1		1972 8043	4.0	07 <i>21</i>
97	456	1973	3.8	. (6)
ana an se ara a s	685	1974° - Casson Constant	3.6	121 (S. 1997) 1799
* e* V		1975	3.6	2014) 2014)
53 - s.	252	1976 💮 (3.5 ₇₈	S. S.
- 85 -	022	1977(est)	3.4	BREE
87	12	1978(est)	3.3 ₈₀	97. 91
С.У. С.У.	10113 		• 	(nte 114#4
N.	1997		302	(1+5)5791

Source:	National	Science	Foundation
1	1/25/78	$i \in \mathcal{V}$	

22

Adam (onnae covA Legnado **Pe** Stel-Cip**e**r

~2S

Table II-3

Share of Federal Basic Research Performed by Industry^{1/} by Major Support Agency, with Percent Change, FY 1971 & FY 1976

don.	Agency	t i gali zetë në		<u>Share</u> 1971	of Total 1976	<u>Pe</u> າມສະ ໂຮງລ	<u>Funding</u> rcent Chan 1971 - 76	ge
1	NASA			63%	43%	ore:	-43%	
	ERDA	5.S	÷	16	28	<u>. (19)</u>	+45	
	DOD	0.5	ta di ta	19	21	16721	9	· · · ·
	NSF	2.5		.5	5		+700	د از رود در در داد
	OTHERS	31.		2	3	1574	+50	•
		a r	· · · ·		:	ayor		

1/ Includes federally funded research & development centers (FFRDC's) administered by this sector.

Source: Federal Funds surveys. NSF

ð.)

8.1

. 11

Source: <u>reverset factor</u> & development of teners for the second (FRENER'S) (

Rece: Funds about finds saverage

3977(est) 1976(est) 22.

sources of venture capital, its success will not be judged solely by reference to its balance sheet. It's sim is to continue to create new business opportunities in the U.K. from the research work and inventions available to it, with increased employment prospects and foreign currency earnings from exports or license income. The total NRDC investment in both private and institutional support is not large; the rationale is that:

The cost of most of the civil development work in some water this country will continue to be met out of

industry's own resources but there may be cases where individual firms are unable to undertake, entirely at their own expense, the development of potentially valuable projects. In the export field the need for the United Kingdom to develop and market technically advanced products against strong international competition puts a heavy development burden on much of the country's manufacturing industry. In such circumstances there may be merit in a collaboration between industry and NRDC.

It is a natural consequence of the Corporation's process statutory functions that it is prepared to undertake projects where the degree of risk is greater and the projects where the degree of risk is greater and that which a commercial undertaking would regard as justified.

Having operated at a deficit for its first 27 years, the Corporation for the first time in 1975-76 was able to carry forward a net surplus. The total investment in external R&D support over that period (1949-76) was 48.2 million pounds sterling (about \$87.4M at current exchange rates). In 1977 alone it is estimated that the gross amount of new industrial production which the NRDC helped to generate was 100 million pounds sterling (\$181.25M), with a ten year accumulated total of 600 million

National Research Development Corporation: An Introduction (NRDC, London, October 1970).

"27th Annual Report and Statement of Accounts 1975-76 (London, England: NRDC, 1976).

54

 $\{1, \dots, N_{n} \rightarrow \infty, 1\} \in \mathbb{R}^{n \times n}$

مراديني مرواه والتنابي مراجع مرواه والممراك

Although generalizations are perilous, the case of a company that had a joint venture with its one-time U.S. importing agent during the first few years in which it manufactured in the U.S. seems typical. Prior to developing its own marketing competence under its own ownership umbrells, this subsidiary was effectively cut off from new developments in its marketplace and was not able to get information about new applications for the particular product it produced. After buying out its partner's sales network, it was able to reintegrate the marketing and R&D functions in the U.S., and went from rather dismal failure to quite considerable success over the subsequent five years.

Acquisition seems to provide the quickest way to learn U.S. technology and marketing skills that are new to a European group. This was a key reason for Plessey's acquisition of the U.S. company of a small U.S. refinery had a similar motivation is but this company of a small U.S. refinery had a similar motivation is but this time for purposes of learning marketing skills rather than technological skills. The European firm's executives remarked that they felt, in order to be a viable worldwide petroleum company, they had to learn marketing in the market where most of their major competitors came from. The company did not feel that its marketing was strong enough to enter the U.S. first by setting up an exploration company and then gradually working its way into competition in refining and distribution with other U.S. petroleum companies,

A pharmaceutical company, which originally entered the U.S. shortly after World War II by forming its own subsidiary, noted that it had recently taken over 100% of a U.S. hospital supply company. The company indicated that as far as possible it preferred to avoid acquisitions "and the digestion problems that acquisitions usually cause," but that in this particular case it felt that the pharmaceutical business was changing so rapidly that it could not take the time to learn medical electronics and hospital servicing without making such an acquisition.

No. 200. ...

One experiment designed to address the problem of technological lag and insufficiency of funds is the National Research Development Corporation (NRDC) in the United Kingdom. This is an independent public corporation, financed by government loans, established in 1948 under the Development of Inventions Act whereby new high risk R&D ventures can be funded. The fields covered are the biosciences, industrial chemistry, scientific equipment, mechanical engineering, production engineering, electrical engineering, electronics, computers and automation. NRDC assists the advance

52

en en la seconda de la seco

A good many European managers admit the need to learn-by-doing in the U.S. in order to face what U.S. companies (or more daring or lucky European competitors with U.S. operations) might employ on the European market in future.

Olivetti is one company that has not hidden its desire to learn from U.S. marketing and technology. Plessey is another European group that has publicly stated its desire to learn from U.S. practice. In its proposal to shareholders for the acquisition of the U.S. firm Alloys Unlimited, Plessey stated that the acquisition would allow it to "acquire immediately a number of products and know-how which are important to our successful development." Plessey's deputy chairman notes that it "would be uneconomic for us or any other European manufacturer to learn (on his own) the skills evident in the Alloys organization."

A similar rationale underlies part of Unilever's longstanding interest in U.S. operations. And managers of one European petroleum company commented that "in order to be really successful in Europe and elsewhere, we have to compete in the market where the greatest petroleum marketing advances are being made. We have to compete in the U.S. by direct investment operations because the quota system prevents us from simply exporting to the States,"

In all, nearly 50% of the European company managers and a distribution of the study emphasized the importance of being in the U.S. in order to "feed back" technical or marketing skills to the mother company.

In one of the most notable cases of a significant product breakthrough by a European firm in its U.S. subsidiary - Sandvik Steel's development of "throwaway" carbide cutting edges - perhaps the most significant factor was the fact that the Sandvik group's development director at headquarters had himself worked for two years in the U.S. and was receptive to new product improvements. He was able to convince group management of the usefulness of transferring this innovation from the U.S. to European operations. A development team from headquarters was sent to the U.S. to work with the U.S. R&D group and further develop the new product. These improvements have accounted for a great deal of Sandvik's impressive growth during the last decade and now account for no less than 40% of the group's worldwide cales.

a el equébrica el construction de la construction de la construcción de la construcción de la construcción de l

网络小麦瓜属 新教育 网络小教学 电子

50

in a second s

buted most of the significant technological advances

an the field. Although 22% of the ideas for advances decay to the originated in Europe, less than 5% were implemented by
 European countries first. Clearly, the U. S. is very the back of the ficient at taking a working prototype and incorpor-

ating it into an actual flying component for military a second funcand commercial use. It is in making the transition from a model to a successful in-service system that it will be the the U. S. is particularly capable.

In order for a country to adapt a technology developed elsewhere, the

process of technology transfer is of infinite importance. It is e well-known fact that the acceptance, production and utilization of an advancement is often delayed for long periods of time after the initial development of that advancement. The effects of the U. S. ability rapidly to apply these technical advances has contributed significantly to increases in performance capability of U. S. aircraft. In the past this has resulted in an increasingly advantageous market position for the United States.

The cancellations of both the SST and B-1 efforts have contributed to an erosion of our previous position. The recent sale of the French A-300's (AIRBUS) to Eastern Airlines indicates that the American aircraft industry may be on the verge of losing its monopoly here in the States in the medium haul aircraft area.

U.S. aerospace firms are forming joint ventures with foreign countries. Boeing will join with Japan on a \$600 million venture to build a small (150-200 passenger) widebodied, low-noise, short takeoff airbus for use on domestic Japanese routes. The General Electric Co. has joined forces with SNECMA, owned by the French government, to produce the CFM 56 aircraft engine for use in STOL aircraft. Pratt & Whitney will join forces with a German consortium, MTU, and an Italian group formed by Fiat and Alfa Romeo to produce the JTIOD, a competitive engine. These engines will compete to power the next generation of commercial aircraft replacing the Boeing 727 and 737 and the McDonnell-Douglas.

8. Problem Summary sease of the later of the state of the

Let us examine the problem from a different standpoint -- what are seen at the effects of the lack of adequate funding? Several examples and some the quotations from competitive nations may help to place in proper focus the several examples and some the several examples are several as a several example.

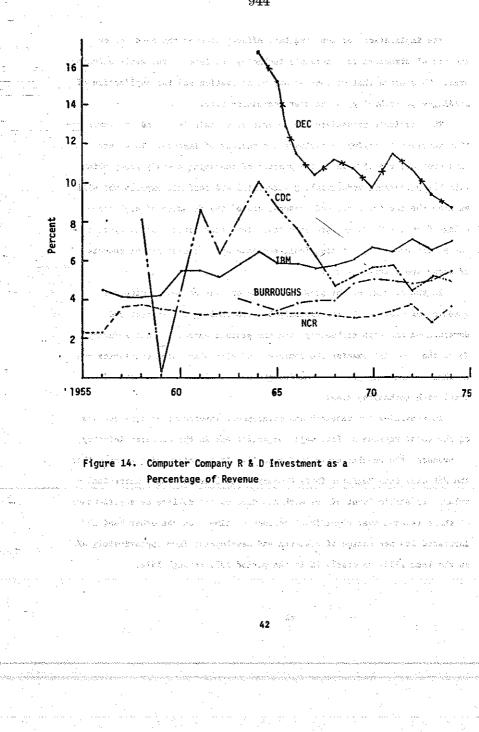
Some consequences of the lack of available research funds within the U. S. will serve as typical case-studies. The first of these involved Dr. Amdahl, a computer research scientist who worked for IBM, having design responsibilities for IBM models 704, 709 and 7030, and who managed the architectural planning of IBM System 360. Amdahl left IBM in order to pursue a proposed design of a future large scale system, which would have involved a radical change from IBM's then "present generation" computers.

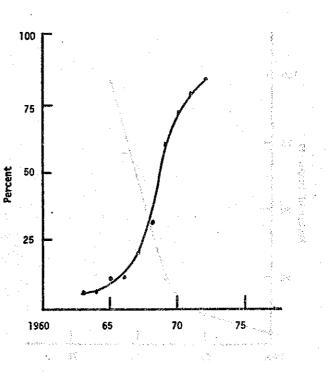
Since Dr. Amdahl believed he had a technological idea whose time had come, he established his own firm in 1970 and when sufficient financing was not available from American firms, or venture capital sources, he proceeded to negotiate financing from a Japanese Company, Fujitsu, which now owns 28% of the stock. Some domestic support was provided by a Chicago business development firm, Heizer Corporation, which owns 23%. The Board of Directors controls 8%. First revenues were recorded in late 1975 for the 470 V/6 computer which competes with the larger, faster IBM System 370's. By 1977, Amdahl announced a net income after taxes of \$27 million, on a turnover of \$189 million -- a better profit rate than that shown by the industry as a whole.^{*} The need for foreign financing effectively transferred

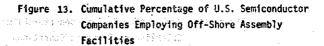
"Europe's Chance of a Computer Revolution", Business International, The Economist, April 22, 1979, pp. 105, 106.

948

(Percenage) 50 LANDERS WHEN STREET 40 Sut American Rate 30 \sim Growth ല്ല 20 v. (c. na kastas A 40 44 10 51.811.1 s saide a st promotive states of the state of Timovative'. Young sales for of management take Non-Companies Companies High Technology States - States standing a subserver a Companies A state of the sta a bal bergener i der dit seite Exemply and the construction of APAC in Algeria (Balany) and a second providence of the second providence of the eventado eta enteñere la especimiente en la conserva presentado en sub-Figure 15. Comparison of Several Typical Companies - Annual Average Growth ÷., $x_{i,j}(0,0)$ Versus Technological Classification sore as lyor From 1969 through 1977 and come of spaces one. Contrar Care and the contract produces and a sign and a state of the second second second second second second eran eff 计关键 化酸钙果菜 网络新闻家族 建合物合金 化合物分配 网络人名法法德人姓氏 法法法法 化氨基乙基 建过 古拉达 电间路运输 An and a star for the second a program and the sec weather an the constraint the states and the restaure ·新学校的《安静教史·哈尔·哈哈·哈萨·哈卡·哈哈·哈哈· March Street Factory 1 1. โดยได้ และประเทศสาหายกละ al and the second with many a dagaan ku ku ahiin hadda







companies begin to establish overseas operations. This is shown in Figure 12 which shows the number of firms who established overseas operations. Note that this number moved very rapidly from approximately 15 or 20 in 1966, to almost 100 in 1971. Further, we can examine the actual investment in overseas assembly facilities by the same semi-conductor industry. In Figure 13 we see the number of firms as a percentage of the total who established overseas assembly facilities. Starting in 1963 a very rapid development began of new overseas assembly plants by the semi-conductor industry, which reached a level of approximately 80% in 1972. Thus, most assembly or a significant portion of the assembly of semi-conductor products is currently being performed overseas by subsidiaries and joint ventures of U. S. semi-conductor organizations,

Several counterbalancing consequences of this action can be identified. On the positive side, the establishment of overseas production facilities has in several cases preempted the establishment of Japanese semi-conductor companies of production facilities in the area, and has also given the U.S. semi-conductor industry a local sales advantage. A second positive effect - resulting from one of the probable primary reasons for the overseas movement, the availability of a large, semi-skilled labor force -- was the containment of total costs, resulting in consumer prices lower than could be achieved with U.S. production.

On the other side of the ledger, we must note the loss of employment opportunities here in the U.S. (at least in the short run) and the loss of national income (in the longer run) due to:

a. diversion of profits and tax income, and a second

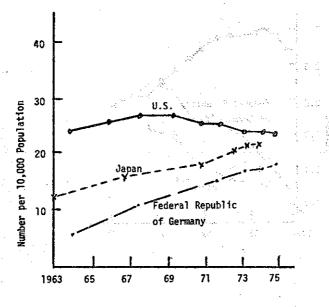
 establishment of potential competitive capability (through the transfer of the technology).

38

the best of the second s

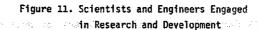
atoman shiw has shift he w Contribution in Billions of Current Dollars a 1967 kulanta ya kaswi muhafu. Prompi kuli tabu **1960** 1965 1970 1971 +8.3 High technology manufactured goods------ +6.6 +9.1 +9.6 Agricultural products--------- +1.0 +2.1 +1.9 +1.5 Low technology manufactured goods------ -0.9 -2.9 -6.2 -8.3 ..-4.1- xxxx -2.5 gender land og folgande om en skipen, peda er har omsådet er er af sko-229 2010-00 and through the specie administration of the second of the statement of the state of a second statements an an an an Construction of the state of the second state of the second state of the second states where the proceeding of the second state of the state of the second state of the second state of the second state Table 3. Contribution to the U.S. Balance of Payments by Industrial the Segments of the Children of Deck over sea year and all and the search projection of the projection of the second halesennes of Analyse plannesses of a science of constant and yr losider has been the same strength of these planes are registered to say a loss and the constant of the constants the presence of the provident of the second construction of the second at Higher weigt gesch wirkeren bereichen erstendent meigenbegenberen all ohnen vielereichen g the property control of the set of the control of the property control descent to attend of al electrone grande este a structure and final bossia and all attants สมพระพุธไลของ โอนสพระ สมไป กันหยัง อมี สูกในระสัง เป็นหมอกซี () และมะ กันไม่ระวงกฎ จะไป 36 วน ระบาทแน่งประวัติ บริษฐน ออกจนโลก เวลสุดภาพี่ประมาสนี้ 5 เอเลี้ 1 สมสะ หรือ 104 เป็น หรือไปประวัติ เป็นจะมนตร terrissense finne sente jaarste verse wind en die trait trait is and twe start and the second states of the to the second sea association and a province second and the second second second second second second second se The second s

y fil (kil 1999 - Sesan I 1



936

an an an an Arthur State an Arthur an Art



trade balance. The significance of this closing of the gap confirms the data in Horn's article, and indicates that we will shortly be faced with a competitor who is technologically on a par with the United States.

This raises the question of where are specific U. S. industries in relation to high technology development or the generation of high technology products?

As previously noted, because of the area of interest of the IEEE, we are restricting our examination to three major segments of the U.S. industrial base in which we currently maintain a lead. These are electronics and electrical equipment in general, the computer field specifically, as well as the aircraft industry.

In the broadest sense we must examine the inputs to the high technology segment of industry, by looking at the research and development expenditures as a percentage of the GNF (see Figure 10) as well as the number of scientists and engineers employed in the research and development areas, which is portrayed in Figure 11. Note that both of these Figures include the area of defense-related R&D, and this fact must be borne in mind in their interpretation. Half the total government outlay for R&D in the U. S. is related to defense, whereas the comparable figures for FRG and Japan are 11% and 2% respectively. The commercial emphasis in both Japan and Germany is paying off. These countries have led a huge increase in the number of foreign inventions being patented in the U. S., and by the addition of

Technology Assessment and Forecast, 7th Report (Washington, D. C.: U. S. Department of Commerce Patent and Trademark Office, March 1977),

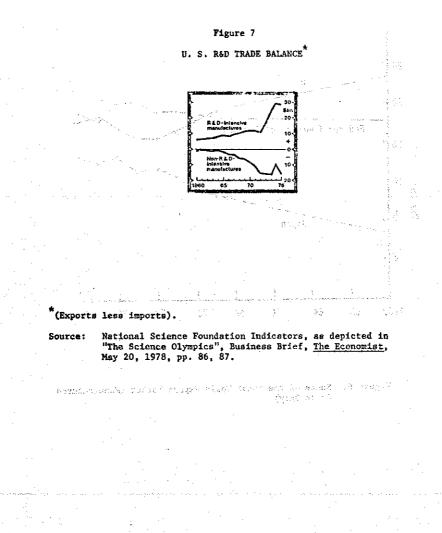
1.00 1 1943 W 14 i eyesti. And the second second 11 1 2 A.C. 31.545 1006-5009-80 60²⁰⁰60 -<-: 1277 194.1514 121 , 8--40 Not all the 50.5.42 Federal Republic 20 of Germany Sec. Sec. Advantage . 0 61.02 10.2000000 1970 ×1973 1963 Revealed Comparative 631-32 -20 ~40 -60 13 we get a compare to the constraint of the 1. 1. 1. 1. 1. 1. 1. 1.

> Figure 8. Revealed Comparative Advantage^{*} Versus Time, for the U.S., Federal Republic Of Germany and Japan

This indicator measures the extent to which foreign trade surpluses (deficits) in one product group diverge from the trade position of this country in total manufactured goods. The measure has been normed so that it can assume values between + 100 and -100. High positive values of the measure indicate a high international competitiveness. For method of calculation the reader is referred to:

Horn, Ernst-Jurgen, "International Trade and Technological Innovation: The German Position Vis-a-Vis Other Developed Market Economies", in Karl A. Stroetmann (Ed.) Innovation, Economic Change and Technology Policics, Bonn, Germany, 1976, page 144 et seq.





goods, we see in Figure 6 that the United States' position in the world market has improved only slowly during the past five years. The position of the Federal Republic of Germany has remained relatively stable over this total period. On the other hand the Japanese have increased their portion of this export market from 6.5% in 1960 to 15% in 1978. The steady increase in Japan's export of manufactured products is significant and appears to be far more important than the previous penetration by Japan of the total export market. In particular, Japan's production of consumer electronics has increased by a factor of five over the past 10 years, and 62% of the 1976 output was exported (\$4.8 billion), * 30% to the U. S:

Data become more difficult to obtain when we focus upon high technology and its impact upon exports and world trade. As shown in Figure 7, this is the only area in which the U. S. has not only maintained but increased its trade balance. A recent symposium ^{%%} on "Innovation, Economic Change and Technology Policies" provides some insights in this area. This symposium, sponsored in part by the National Bureau of Standards, contains several presentations which provide some insights into the problem and possible solutions to that problem. Of particular note is a paper presented by Ernst-Jurgen Horn (pages 129-147), which was cited earlier.

Norn has developed a measure of the significance of high technology products upon the international competitiveness of nations. This measure,

"Japan's New Electronics Goodies", Business Brief, The Economist, April 22, 1978, pp. 84, 85.

** Stroetmann, Karl A. (Ed.) <u>Innovation, Economic Change and Technology</u> <u>Policies</u> (Bonn, Germany, 1976).

from 3.3% GNP to 2.6%, and by 1976 was down to 2.2%. The U. S. figure also includes about 50% for defense-related R&D, which has limited "spill-over" to the commercial sector.

Gross expenditure on research and development (as a percentage of GNP) and gross research and development expenditure per capita also correlate highly with relative market share for research intensive products. Thus we can use research and development expenditures as a rough measure of performance in trade in research intensive products. In general, such studies as Horn's have shown research and development activity to be the most important determinant of the structural pattern of international competitiveness. The influence of the research and development variable in the U. S. appeared to be even stronger than in the case of Germany, with which it was compared.*

At the broadest level the relative position of the U. S. in the world export market between 1960 and 1976 is shown in Figure 5. During this period we can see that, in round terms, the U. S. share has dropped from 18% in 1960 to 12% in 1976, while that of the Federal Republic of Germany has moved slightly upward from 10% to 11% of the total world market. On the other hand we find that the Japanese have improved their position from 4% of the total market in 1960 to 7.5% in 1976, approximately doubling their total export share.

This figure includes not only products based upon high technology and mature technology but also the exporting of raw materials, etc. It is useful only for presenting a broad overview. Focusing upon menufactured

U. S. Tariff Commission figures, and Horn, Ernst-Jurgen, op. cit.

7. The Current U. S. Status

There is no standard equation nor set of tables that can be employed में के सिंह के सिंह के कि to determine our current achievements in the application of technology to improving either the national well-being or the U.S. position in the export trade arena. Further, and probably of even greater importance, statistics that could be applied to examine this question are scattered and in some cases imperfect. However, we can begin to develop a feeling and in some cases gain both insights and indications by examining the information and data that are available. According to the product cycle hypothesis discussed in Section 5, innovative activities of countries depend on per capita income as a measure of the stage of the country in the development process. A study of 19 OECD member countries showed a significant correlation between expenditure on research and development as a percentage of GNP, and per capita income. (At the level of the corporation, Mansfield ** has demonstrated that a high level of research and development expenditure leads to increased productivity, and thence to improved gross profits, which permits and again tends to increase research and development funds. This relationship is depicted in Figure 4.) In response to this perceived relationship, both the U. S. and U. K. since 1945 have consistently spent over 2% of GNP on R&D. *** However, German expenditures increased from 1.4% of GNP in 1963 to 2.1% in 1971, whereas U.S. expenditure dropped

Horn, Ernst-Jurgen, op.cit.

**Mansfield, E., "Research and Development and Economic Growth/Productivity", National Science Foundation Colloquium (Mashington, D. C.: GPO, 1971).
*** "The Science Olympics", loc. cit.

. - 13

Nerve N.S. States re-

. The United States Posture character and the state of a line of the state

Whatever the relative economic advantages and disadvantages, it appears to be the consensus of both government and industry opinion that the U. S. should strive to retain technological leadership, and both interests are concerned that the U. S. is unduly eroding its position by exporting technology without adequate safeguards/recompense. The concern of governmental policy-makers is manifested by such meetings as this present hearing, under the joint auspices of the Senate Science, Technology and Space Subcommittee and the International Finance Subcommittee. Other aspects of the problem are being examined by a House Subcommittee, the Congressional Office of Technology Assessment, the National Security Council, the Office of Science and Technology Policy, the International Trade Commission, the National Science Foundation, and the departments of State, Defense, Treasury, Commerce and Labor. In view of the widespread interest, we are hopeful that the outcome will be a systematic program designed to establish U. S. priorities and to define a responsive approach for achieving identified objectives.

Industrial representatives are also very much aware that a review of our policies and practices regarding the creation and transfer of high technology is an urgent requirement. Foreign products incorporating technology acquired from the U. S. are beating out American productions in markets around the world --- including the U. S. itself. Because of this, U. S. manufacturers are harvesting too little of the return from their own

of new technologies, e.g. in R&D, and in the production of goods during the early phases of the cycle. On the one hand, these countries are relatively abundantly endowed with skilled manpower which is intensively used in the above mentioned activities and whose availability determines whether these activities can or cannot take place. Furthermore, and a same of risk capital to finance R&D activities is relatively abundant. On the other hand, a high per capita income provides domestic markets capable of absorbing new products, e.g. new consumer goods, labour-saving household devices and new laboursaving investment goods. When products become more mature, highly qualified manpower becomes less critical and the other factors of production gain influence in determining comparative advantage. In the course of increasing maturation of products and the or processes of production the comparative advantage shifts to less advanced industrial countries which can already handle the technology in question what the and are able to compete successfully with these assessments innovating country because they enjoy the advantage of lower wages." In the late phases of the cycle when products are mature and standardized, comparative advantage shifts to the developing countries.

Even in the high technology phase, there are advantages in occupying second place, in that the high risks and inevitable "false steps" will be taken by the leader. A nation which can maintain a minimal gap can then be prepared to <u>buy</u> the products of leading edge technology, but produce and sell slightly less advanced products where the margins are less, but the volume is much greater. For example, Japan buys avionics and sells color

television.

 *Haitani, K., "Low Wages, Productive Efficiency, and Comparative Advantage". In: <u>Kyklos</u>, Vol. 24 (1971).
 *See for example Bufbauer, G.C., <u>Synthetic Materials and the Theory of International</u>

agent of the second second

Trade (Cambridge, Mass.: Harvard University Press, 1966) and

Vernon, Raymond (Ed.); <u>Big Business and the State</u> (Cambridge, Mass.: Harvard University Press, 1974)

The second s

ំសែងទោះ ដែលសារ ស្មេចសេស ហិសារណ៍ សាក់ ដែលស្រុកសារ សេស ដែលដែលមួយ សារសាក់ សំដែលសាស និសាសសារ នេះស្លាំ សេក សំដាយនេះ សំផងវិសាសសាសីវិសារភាគន៍ដែល សេស សេស សេស សេស សេក សេថា សេស សេស សេរ និសាសសាស្តា ស្តេ ស្ត្រីអ្វីដែលមាន សេសស្ថារវាងដែល សំដែល ស្ត្រ ស្តេស្តាស់សេស ស្រែកសាយ ដោយសែសអ្នកសារអន្តរំរូវអនុវត្តអន្តរំអ្នកស្តែ ស្ត្រីអ្វីដែលអ្នកស្តេ**ងស**ាសស្តាសែស សេរីទី សេទ

The need to provide acceptable technical service requires that the data a ba local market supplier must understand the operation of the product, its a standard virtues and limitations, and extends beyond this to require knowledge of the design and fabrication of the product as well as its mode of functioning the such that one is able to diagnose field difficulties and make the requisite 22 ab repairs or modifications." and a constant prover The second s

The transfer of technology and of intellectual property is perhaps accomplished most readily through the mobility of people. This process a occurs not only through hiring practices deliberately designed to acquire above the advance technological information, but through the routine day-to-day mobility of the work force within and between companies, industries and nations/ where the are block is the lifer of pression with the second 11,000,000

It is of course underiable that technology transfer is facilitated by $\mathbb{R}^{n} \rightarrow \mathbb{R}$ foreign assembly, foreign manufacture of components, and complete foreign assessed manufacture....Butait is essential to understand that the absence of these invitors may have other negative effects for the industry involved (Ancluding both as a subthe loss of foreign markets and the creation of new spurces of foreign and competition, and even so will not result in protection of the basic technology. The dissemination of technology cannot be stopped: it can a white only be controlled and slowed down. The pass , which will there it is and the start of a the de

14 20 2 2

The startes

Steele, Lowell W., The Economics of International Technology Transfer, in Karl A. Stroetmann (Ed.) Innovation, Economic Change and Technology Policies, Bonn, Germany, 1976. ให้เรียงของของการเข้าสะเสียงสาวจะการเป็น

. ให้เป็นหนึ่ง การหรือ ของไปการห้างหรือสะเกณีย์ ก็จัด และไก้ จากส่วนกฎห้อ แม้กระการต่ำก็ได้รักกระ menten blever og mene ogsåderk som årsånderse i en som det alls 🕅 👘

CLARBERT FRANK FRANCE RATE REVENUES AND MALE AND REPORTED AND A SAME AND

How Technology Transfer Affects the Competitive Position of the U.S. in the World Aviation Market (Arlington, Va.: Forecasting International, Ltd., March 3, 1972). March 3, 1972). ม. กรรณ คลัก เมษ. ชัญหรักษณาหลุ มีพรร มาก (400) มมไว้จากข้างหมือ 🎰 and the stand and a substantian a substance of the standard and the substance of the substance of the substance

แม่มีของและ การจังระการเห็นของการเหตุสัตวิตรรณ เหมือจะการทำงาดที่การได้การและ (และกำจะสุมุณต

16

ANTER ANTER STATE STATE

Mature (profitable) $\sim 10^{-1}$ Lonneoulo szervez dene sen and the of Technology and the concert but there is 1. 1112 1 2 Ro Charles and the 444 Truth 1 Growing (requiring heavier capitalization) git were a later . ว พรก อรู้พระบบ โจย **Development** Sector Land Parts 1.210/00/06/06 1986-11 and the second second <u>.</u>, 1.500.0 1411 18 Leading in the second Edge (reguiring venture capital) The second se I TIME and the second a en la franzistatenna u 28 10-13 12 Plan passa kan mantanakar 不完全了你。你们,你们要把我们要把你的,你还不能不知道,你不能让你们的你的。" 化化合物磷酸的 Page 1924 - More and production descents Found wear relay there to special and the collars and the matching internetti zarotitili bazina hazoning ku vessa and Figure 3. Technology Growth Curve wa ninita washingan shekkara akin ni ulah, yikandara wayoo da shekara wak tious is Vierra 3. In Charlison printed of could patencie (chick charmer - strates which is not over a to leave a for show or compared and the second second A typical measure is the percentage of firms in a particular product area which adopt the new technology. 医后周周周的 医结晶的现在分词 化化合物 网络医同门子 医小脑炎 地名法国尔德 gen in the offensive states for a second water of a reading of the end of the second se all and gradel tool and the N LVOIDK in and incorrection of 14 化合同分析 化乙基基合合 建磷酸钙 -----

However, the direct economic gains on the international scene resulting from the sale of technology-based products have been declining rapidly. In the area of semi-conductor electronics, where U. S. corporations have made nearly every technological breakthrough, the U. S. trade balance has been negative since 1968, and now stands at minus \$2 billion, excluding only one category -- that of computers -- in which the U. S. retains a favorable balance.^{*} Further comments concerning this particular situation will be made below, in section 6. An OECD report^{**} cites the computer industry as one of only three areas in which the U. S. retains its technological lead, in terms of net export of the technology base. (The other two are serospace and heavy electronics.)

Other studies have confirmed that the competitive strength of U. S. manufacturing industries in world markets is closely correlated with the performance in technological innovation. *** However, with regard to particular products, technological leads only temporarily provide comparative advantages, for the duration of the so-called imitation lag.

In the following section, therefore, we will examine the characteristics of technology and its evolution, to assist in determining an optimum policy in controlling and/or capitalizing upon its development, application and dissemination.

Boretsky, Michael, U. S. Department of Commerce, as quoted in Fortune, May 22, 1978, p. 0108: crossil as a cost of commerce as quoted in Fortune.

Gaps in Technology, Organization for Economic Cooperation and Development, 1970.

See for example: Vernon, R., "International Investment and International Trade in the Product Cycle". In: <u>Quarterly Journal of Economics</u>, Vol. 80 (1966); Keesing, D. B., "The Impact of Research and Development on United States Trade". In: <u>Journal of Political Economy</u>, Vol. 75 (1967); Baldwin, R. E., "Determinants of the Commodity Structure of U. S. Trade". In: <u>American Economic Review</u>, Vol. 61 (1971).

"Posner, M. V., "International Trade and Technical Change". In: Oxford Economic Papers, Vol. 13 (1961).

countries. In the four high technology industries, aerospace, heavy electronics (including computers), chemicals and pharmaceuticals, the two areas where we lead are aerospace and electronics, where significant amounts of monies are funneled through government agencies by the Department of Defense, NASA, HEW, Department of Energy, etc. In the other two industries, chemistry and pharmaceuticals, since they are mature technological industries the bulk of their money comes from internal corporate funds or the stock market. This provides some indication that when the government funnels R&D money to private firms (as in electronics and aerospace), the industry prospers and we have a technological lead.

. in

Sec. 2

10

.

÷.

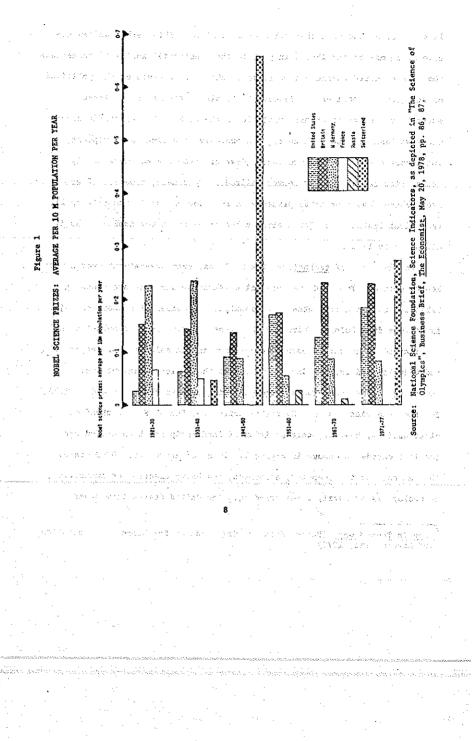


Table 1

Nobel Prize Awards, by Country, 1901-1977 ne se an se été de l'estrementence de la la la suite entre se la sécure de la seconda de la seconda de la 1901-1930 1931-1960 1961-1977 Germany United States 33 England 18 England 20 27 19.33 England 15 England 14 Germany 6 France 11 Germany 1891 Switzerland 5 France Sweden 6 United States 6.... Austria Sweden 2 Sweden 449230 Holland 6 USSR Denmark 2. Italy on Games Austria 2 Calabra 4 57.43 1.20 З USSR 2 Austria Belgium Argentina 7 tere protocon ne record a react trule such chustralia se a 1 . 1 - Frankis jame and Stransform she grantful caper and a lader in . Norway in Alexand lit could have a start that the RM and the selections and a server all Sec. 37.00 the second se Selected Invention and Patent Rates, by Country For each p , we are each of the \mathbf{A} possible part of \mathbf{A} , then use \mathbf{B} be a subserver of °c** Total Inventions Average Annual Annual Patenting Caller on Selected List Patenting Rate -1600-Present 1930-1939 Rate - 1975 No. (and provide Same 1.19 203 38,300 56,509 United States Great Britain 58 12,322 . 3 9,050 1 ang 12 an 37,733 32 14,600 Germany 29 59,5500 Av (14,500 13,386 - As (17,6 France 3,900 14 Italy 4,369 3,130 Switzerland 9,100## 1,030 Sweden nea tau Bode, H., Basic Research and National Goals, (Washington, D. C.: National Academy of Sciences, March 1965). Private Communication, U. S. Department of Commerce, Patent and Trademark Office, May 1978. 1.160136 and the second states and the second 1.1.1.1.1.1.N West Germany only (FRG). This is made up of 7,233 foreign filings, and only 1867 by Swedish nationals. elevente de la companya de relationships between research, technology, and economic growth, end assist in the definition of the appropriate role of Government in improving the international technological and economic standing of the United States.

all college in the and the main press of the construction of the connal cale internet as and more contraction with a constant of the second to a contract of a contract to the contract of the contract (c) Secure 2 and a first contact of a secure for a spin or and in the secure 2 is contacted. name a second fair a manual screep and a conservated the conservation of the second second second second second . Na naantan lag aya kata maring ali naa walituu ayan dalamata maring ta ata an ann ann a na stair ann airte a strainnean strainnean ta Marianna, ta taiste ann an in contracts many in the anti- of Brinning strategy on a subdract of Brinner. a langua di manané na ang mang na ing kanané ngané gané na nagingah na m and the max is the provided of the state of a part of the addition of the state of the state of the state of the terrelation to approach when the party of a property of the second states to the ante des constantes provins por estadou de la constante relation de la seconda de la seconda de la seconda de and the providence of the ratio of the test the test of the second states of the redre constructions and many in the second second report of the second second second second second second second ti un note a gradiu de la cuel esendares que na actuardade ella. an ara alesa ay tela yang

Mention and a characteristic sector of the product of the product of the sector of the sect

- R&D investments can be increased by direct govern-5. ment funding of long-range mission-oriented research, and by tax policies directed toward the encouragement of private-sector support. The many other obstacles to the maintenance of U. S. leaderand the first ship are addressed at length in the body of this document.
 - Foreign investment in U. S. firms, while increasing rapidly, is at present only a minor factor in the savenester: avierosion of our technological lead. The resulting transfer of technology need not be harmful if wc ourselves act promptly and positively to capture and protect potential markets. However the extent of such investment needs to be monitored and, if necessary, controlled by a central authority.
- Again, U. S. exports of technology and high technology products are not necessarily detrimental to our international stature. A two-way flow, and a coherent. national policy, are essential to our well-being. On the other hand, it should be noted that our society is becoming service/information oriented. The sale of knowledge must be placed on a business basis. Mersey to a
- 8. Licensing and joint ventures abroad can be beneficial to the U.S. if we can maintain the two-way flow of technological innovation. Potential exports are being lost due to the export of technology, but this need not be the case with careful planning at the national level. A 6 1 1 A
- Our recommendations for improving export performance in high technology goods and services are given at the end of this document. It is our contention that this needs to be considered as an intrinsic component of a total technology policy which recognizes the need for balance and negotiation at an international level.

and show the

and a second second

en weren die begen weren het weren die heren weren eine heren weren eine heren weren eine eine eine eine eine

10 and 11

in the second

2017 N

the state of the second se

LIST OF FIGURES

Figure			Page
1	Nobel Science Prizes: Average Per 10 M Population Per Year		. 8
2	Percentage of Major Technical Innovations	7 - 1	9
3	Technology Growth Curve		14
4	The R&D Cycle	Ş,	23
5	Share of the Total World Export Market (All Products and Raw Materials)		25
6) (95)	Share of the Total World Export Market (Manufactured Goods Only)	1. A	27
7	U. S. R&D Trade Balance		28
8 (14)	Revealed Comparative Advantage Versus Time, for the U.S., Federal Republic of Germany and Japan	2	30
9 ^{Dec}	The U.S Japanese Technology Lag	ć,	31
10	R&D Expenditures as a Percentage of National CNP	1	33
11 ²⁰	Scientists and Engineers Engaged in Research and Development	1.4	34
12	Number of U.S. Semiconductor Firms Establishing Overseas Operations	3	39
13	Cumulative Percentage of U.S. Semiconductor Companies Employing Off-Shore Assembly Facilities		40
14	Computer Company R&D Investment as a Percentage of Rever	ue	42
15	Comparison of Several Typical Companies - Annual Average Growth Versus Technological Classification	: • • • • •	44
	LIST OF TABLES		
Table			Page

1	Nobel Prize Awards, by Country, 1901-1977	6
2	Selected Invention and Patent Rates, by Country	6
3	Contribution to the U.S. Balance of Payments by Industrial Segments	36
4	Composition of Industrial Segments	37

Acknowledgment

This statement was developed with the assistance of various individuals both within and outside the formal organization of The Institute of Electrical and Electronics Engineers, and was approved at a meeting of its Board of Directors on May 23, 1978. I wish to acknowledge especially the contributions of:

Dr. A. Astin

Dr. M. J. Cetron

Ms. Audrey Clayton Construction of the management of the second second

< 1.1 Section of the

an in the factor of a second secon

Boll to Fight Strategic and

Maria Salara

Art Carrow A

10.11.00000

Su astars' - geotor ser 1,38 .8

R AND ST.

Bruno O. Weinschel, Vice President, Professional Activities

وفيا الأراجين أتراج

nanglas n

ે. આ પ્રાથમિક

Mr. J. Rabinow

Dr. S. Raff

900

승규는 가장 것 같다.

The GAO effort to introduce an improved classification structure for the Federal R&D budget.

As part of a planned GAO study on the impact of various Federal policies on industrial capital formation, we will review the interrelations among Federal R&D activity, private R&D activity, and industrial capital formation. This study will consider the direct impact of Federal tax, patent, and regulatory policies on private R&D expenditures. In addition, the impact of various Federal policies on the business environment and the effect of this environment on industrial R&D expenditures will be investigated. More specifically, we will analyze the effects of Federal regulatory and economic stabilization policies on how business men perceive the riskiness of their environment and how changes in these perceptions affect the level and allocation of their R&D expenditures.

We also plan to analyze the impact of the level and composition of Federal R&D expenditures on industrial R&D expenditures and industrial capital formation. In this effort, we will attempt to develop more effective methods for allo²¹

tion. In this enort, we will attempt to develop more effective methods for allo-cating Federal R&D expenditures. ೆ ಬರುತ್ತಿ ಸಾಮಿ ಸಂಕರ್ಷನಾ ಅವನಾಗಿದೆ. ಇದು ಸಂಕರ್ಷನ್ ಮಾಡಿ ಸಂಕರ್ಷನ್ ಸ್ಥಾನಿಯ ಸಂಕರ್ಷನ್ ಸಾಮಿ ಸರ್ಕಾರ ಸಂಕರ್ಷನ್ ಮುಂದು ಮಾಡಿದ ಸಿಲ್ಲಾಟಿಕೆ ಸಿಲ್ಲಿಸ್ ಪ್ರತಿ ಮಾಡಿದ ಪ್ರತಿ ಸಿಲ್ಲಿಕ್ಕೆ ಸಿಲ್ಲಿಸಿದ್ದ ಸೇವರೆ ಸಿಲ್ಲಿ ಸಿಲ್ಲಾನ್ ಸಿಲ್ಲಿಸಿ ಸಿಲ್ಲಿಸ್ ಪ್ರಾಣಿಸಿ ಸ ಪ್ರಿವರ್ತಿಸಿ ಮಾಡಿ ಸಿಲ್ಲಿಸಿಕೆ ಸಿರುಗಿಸುವ ಸಿಲ್ಲಿಕ್ ಸಿಲ್ಲಿಕ್ ಸಿಲ್ಲಿಕ್ ಸಿಲ್ಲಿಸ್ ಸಿಲ್ಲಿಸ್ ಸಿಲ್ಲಿಸ್ ಸಿಲ್ಲಿಸ್ ಸಿಲ್ಲಿಸ್ ಸ 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 - 1997 -

al fall and fall a statement of the second and a statement of the statement of the statement of the se le contestion de superior de la contesta de la c

A standard of the entropy and the entropy of the first of the first sectors, which is a standard of the entropy and the entropy of the entropy

enti negangang yekasin dalah berkere peri kananen dalah barasé di halimpi di di States, our principal foreign competitors have well-developed government-directed programs and special institutional structures for overcoming barriers to diffusion of existing manufacturing technology and for advancing the state-of-the-art through coordinated research and development programs.

In addition to improving traditional manufacturing methods, computers and numerically controlled machines are changing both the management and the engineering technology of manufacturing. There are indications that manufacturing methods are about to change—not incrementally but radically. The changes are already taking place in other countries where the productivity-improving institutions and mechanisms were created to recover from the adverse effects of war.

Such institutions exploit, develop, and diffuse the new computer-integrated manufacturing systems and are well-designed to continue development of their nations' manufacturing productive capabilities faster than that of the United States. Their success is evidenced by their increasing share of the international markets—in some cases at the expense of our own manufacturers.

But our principal concern is for the future. Short-term benefits are possible through improved diffusion of the available technology. For long-term sustained productivity increases, R&D is necessary to find new methods and to refine existing technology so that it can be economically used outside the few highly capitalized, high-technology firms.

In the most successful foreign countries, both programs and institutional models have involved joint public and private efforts. The United States has no comparable national program, although several Federal agencies are interested in this subject. A new organization has been created which could provide the central focus and leadership. This agency is the National Center for Productivity and Quality of Working Life, established by the Congress in November 1975.

We have recommended that the Center take the lead in developing a national policy and appropriate means for achieving balanced productivity growth in the industrial manufacturing base. Further, we propose that the Center, in carrying out this recommendation, seek the cooperation and assistance of the Department of Commerce and other agencies. The expertise within the Department of Commerce, particularly in the National Bureau of Standards and the National Technical Information Service, would allow that Department to play a major role in providing technological leadership and support.

The combination of expertise of the Center and of the Department of Commerce and their close coordination with other public and private organizations can provide the much-needed focal point to coordinate all the disparate Government and private work in developing, standardizing, and diffusing manufacturing technology, and assist the emerging State and regional productivity organizations to advance manufacturing technology.

A number of specific functions should be embraced by this central focus and leadership. Three of the major ones are :

Collect and evaluate manufacturing technology information from all available sources and establish means for disseminating state of the art knowledge to potential users.

Foster the development and acquisition of new technology in various ways. Analyze public policy options and formulate recommendations that will improve Government-industry cooperation in stimulating productivity improvement.

WHAT CAN WE DO?

What can we do to improve the climate for Government-industry cooperation? I have no panacea to alleviate the attitudinal constraints that continue to retard the development of a more constructive partnership between Government and industry. It behooves all of us—individually and collectively—to make extraordinary efforts to achieve better communication and mutual understanding of our respective needs and interrelated goals in the context of our total responsibilities and obligations.

Continued studies and publication of resulting reports clarifying the issues and alternatives should help improve understanding. An excellent example is the July 9, 1975, report by Robert Gilpin, "Technology Economic Growth, and International Competitiveness," report prepared for use by the Subcommittee on Economic Growth of the Joint Economic Committee. Another good example is the 1973 report, "Barriers to Innovation in Industry: Opportunities for Public Policy Changes," based on study sponsored by the National Science Foundation and performed as a joint effort by Industrial Research Institute and Arthur D. Little. be served when private industrial contractors, with a few provisos, are granted exclusive licenses for commercial development.

When developing and marketing commercial products, industry naturally prefers to exercise its own discretion independent of any Government assistance or influence unless it needs help to deal with serious threats from foreign competition or another domestic enterprise which it believes is exercising unfair competition. Industry is particularly concerned about the constraints of Government regulations which tend to divert capital from innovative R&D to R&D and other investments necessary to comply with regulatory requirements. Furthermore, some multi-national corporations may not be inclined to share strategic information with the Government and to plan and conduct their business in such a manner as to assure harmony with the international objectives of the United States.

As a final attitudinal concern, there are many in both Government and industry who are unwilling to assume responsibility for what others would judge to be reasonable and necessary risks for investment in exploratory research and development when the payoff is uncertain in terms of time or economic return.

Many factors have been identified as real or tangible constraints that tend to cause a decline in technology innovation. Among these are the uncertainty of the economy, the high cost of capital, and the slowdown during the last few years in Federal spending for research and development.

The myriad of regulations established by both Federal and State governments affect the cost of doing business and may involve conflicting requirements imposed by different agencies. For example, in Federal procurement of conventional commercial products, the public would be served better in many cases by bestbuy competition based on superior or innovative performance and life-cycle costs, rather than by the prevalent procurement practice which tends to favor the lowest bidder who offers products meeting acceptable quality or minimal specifications.

In the larger sense, criticism is levied that the Government has not established a consistent national policy and strategy for Government-industry relations to balance incentives and constraints and assure a favorable climate for technology innovation by private enterprise. This contrasts sharply with other nations, notably Japan and West Germany, that have policies and special institutional arrangements to foster industrial technology innovation and improved manufacturing productivity.

Part of this issue is the question of whether our antitrust laws, established primarily on a domestic basis, need to be reexamined in an economy which is becoming increasingly world interdependent in market relationships and competition. This question is highlighted by the increasing number and size of multinational corporations and the fact that foreign corporations are growing faster than U.S. corporations.

Most of the other industrialized nations have developed closer relationships between government and the private sector on capital formation and R&D directed to the private economy. This is an area in which we perhaps should explore new perspectives for Government-private sector interaction within the framework of American institutions.

Improved productivity and advances in science and technology cannot take place separately from other aspects of national policy; advances made in the laboratory and on the testing grounds require adequate financial support obviously. However, these advances can be similarly flawed if such support does not go hand-in-hand with policies developed which will make it possible to use and develop these innovations. The Internal Revenue Service, Securities and Exchange Commission, Justice Department, and Department of Commerce all must play a part. Too frequently, these organizations go their individual ways for their own reasons and possibly for even socially desirable purposes. This does not mean, however, that their actions will coincide with adequate accounting as to their impact and consequences for risk-taking and technological innovation. There is currently no procedure for measuring the effect of these Government decisions on science and technology. Thus, industrial risk-takers lean toward hedging and zero-risk decisions. Innovation under these conditions can be, at best, incremental. Hopefully, the new Office of Science and Technology Policy will recognize that innovation must come as the result of total Government policy-not the more frequently narrowly construed concept of science and

technology.

38W. S. Comanor, "Market Structure,"Product Differentiation and Industrial Research." Quarterly Journal of Economics, 81(4) (November 1967-1968), DD. 639-657 sectors and a sector sector and a sector ³⁹J. Jewkes, D. Sawers and R. Stillerman, The Source's of Invention (New York: St. Martin's Press, 1959). A CALL STRATES ⁴⁰Hamberg, "Invention," ap. 95-115. 41W. F. Mueller, "The Origins of the Basic Inventions Underlying DuPont's Major Product and Process Innovations, 1920-1950." The Rate and Direction of Economic Activity, NBER Conference Report (Princeton: Princeton University Press, 1962), pp. 323-346. 42Hamberg, Essays. ⁴³Hamberg, "Size of Enterprise," p. 48. 44E. F. Schumacher, Small is Beautiful (New York: Harper and Row, 1975). 45W. S. Comanor, "Research and Technical Change in the Pharmaceutical Industry," Review of Economics and Statistics, 47(2) (May 1965), pp. 182-190. Bize of Enterprise. "Size of Enterprise." HARLES BURGER BURGERS 47A. C. Cooper, "R and D Is More Efficient in Small Companies," Harvard Business Review (3) (May/June 1964), pp. 75-83. ⁴⁸Conversation with Richard O. Zerbe Sr., Patent Agent for Monsanto Chem-ical Company. 49Sctrooklar, "Bigness, Fewness and Research." S@Hamberg, "Size of Enterprise." 1.000 3.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.000 2.0 ⁵⁰Hamberg, Size of Enterprise.
⁵¹Pavjtt and Wald, "Conditions for Success."
⁵²Kamien and Schwartz, "Market Structure and Innovation: A Survey," respectfor the other p. 13. 1238 267 53F. M. Scherer, Incustrial Market Structure, Ch. 15-16. 54 Ibid., p. 3512 and a second s 55J. A. Schumpeter, Capitalism, Socialism and Democracy, Third Edition (1996) (New York: Harper and Row, 1950); Ch. VII and VIII. and () was appressed on the 56J. K. Galbraith, American Capitalism (Boston: Houghton-Mifflin, 1956, revised and edited), pp. 86-87 57Schumpeter, Capitalism, pp. 84-85. ⁵⁸Kamien and Schwartz, "Market Structure and Innovation," p. 14. - 1 -⁵⁹Comanor, "Market Structure," pp. 639-657. ⁶⁰Galbraith, American Capitalism, pp. 86-87. 61R. H. Coase, "The Nature of the Firm," Economica (November 1937), $-R^{-1}$ pp. 386-405. 62Ibid. Strate C. S. 63Scherer, Industrial larket, p. 395. an che la ⁶⁴1bid., p. 398. 65Ibid. and a sugar n an de la construit de la cons La construit de - 58... enselvende vie vie Verennerenden op in teatrier skilte uite behaving aan offisjoneren. and the same discussion of a 113 mail of the balance of the same in the solution of the second states of the second s

"Donald B. Kessing, "The Impact of Research and Development on United as section on States Trade," Journal of Political Economy (February 1967), pp. 38-48. 5K. Pavitt and S. Wald, "The Conditions for Success in Technological Innovation" (Paris: OECP, 1971). 6W. Gruber, D. Mehta and R. Vernon, "The R and D Factor in International Trade and International Investment of U.S. Industries," Journal of Political Economy (February 1967), p. 22. 7Calculated from data in a newsletter published by Economic Evaluation Associates (Chicago: 1975). With such a small sample, even if the correlation were perfect, the chi square distribution barely would be signation and nificant at the 5 percent level. ⁸The R and D figures are from U.S. National Science Foundation, National Patterns of R and D Reserves: Funds and Manpower in the United States," Reports for years 1958-1975 (Washington, D.C.). ⁹In 1965, a sample of firms in important industries showed that companies with less than 1,000 employees accounted for only 5.2 percent of industry R and D expenditures. This had fallen from 7.0 percent in 1957. ¹⁰J. M. Blair, Economic Concentration: Structure, Behavior and Public Policy (New York: Harcourt, Brace, Jovanovich, 1972). 11M. Kamien and N. Schwartz, "Market Structure and Innovation A Survey," -----Journal of Economic Literature 12 (1) (March 1975), pp. 1-37. A. Long and 12C. R. McConnell and W. C. Peterson, "Research and Development: Some Evidence for Small firms," Nebraska Journal of Economics and Business (1968), pp. 356-364. ¹³C. R. McConnell and I. N. Ross, "An Empirical Study of Research and Development in Small Manufacturing Firms," *Nebraska Journal of Economics* and Business (Spring 1954), pp. 37-46. 14D. Hamberg, Essays on the Economics of Research and Development (New York: Random House, 1966); _____, "Invention in the Industrial Re-search Laboratory," Journal of Political Economy (April 1963), pp. 95-115; _____, "Size of Enterprise and Technical Change," Antitrust Law on Economics (1) (July/August 1967), pp. 43-51. ¹⁵W. J. Smith and D. Creamer, "R and D and Small Company Growth A Statistical Review and Company Case Studies," *The Conference Board, Studies in Business Economics*, No. 102 (New York: National Industrial Conference Board, 1968). 16D. C. Dearborn, R. W. Kneznek and R. N. Anthony, Spending for Industrial and Research 1951-52 (Boston, Mass.: Harvard University, 1953). 17McConnell and Peterson, "Research and Development." These percentages refer actually to those firms responding to the questionnaire. My feeling is that firms with formal R and D programs would be more likely to respond. If this is correct, the true percentage of small firms engaging in formal R and D would be lower than the 38 percent reported, but those with informal R and D could be either higher or lower. 18Smith and Creamer, "R and D and Small Company," from combining USF and one Census data, found that only 4 percent of firms with less than 1,000 em- 🔬 ployees had R and D programs compared with about 57 percent for firms with between 1,000 and 4,999 employees and about 91 percent for companies. with more than 5,000 employees. Their figures for the smallest class of firms are almost certainly too low. Possibly the combining of NSF and Census data introduced inconsistency into the sample in the lowest size class; they themselves recognize the possibility of inconsistency.

expected value of a patent would be greater; reflecting greater immunity in the form legal attack and from "patenting around." The courts should not be reverted called upon to so often make the distinction between weak and strong and the distinction are the distinction of inventions into categories for sep-the distinction are treatment on the basis of their importance as in Germany. States and patent distinctions would require a greater Patent Office budget as well as more ex-core distinction period period period personnel.

Another approach might be to allow suit for treble damages in patent infringement cases. This clearly would increase the bargaining power of patent holders and times of an assmaller firms have a comparative advantage in patenting, would increase their bargaining position. A final proposal for patent reform is considerably more radical. This destructs is that the patent system, and/on the proposed direct award system, distribucriminate between firms on the basis on size. The patent mights of smaller firms could be defined more broadly and the life of its patents could be greater.

Honorana an astronomic an addated and the strong of the state of the strong strong strong strong strong strong

Larger firms undoubtedly will react with indignation to proposals alongeneity as a such linest offer they have a considerable appeals even on the basis of standard basis of standard be equity. Mostigovernmental regulations are disproportionately expensive give in a for smaller firms. Except for possibilities of not getting caught, there are over are clear economies of scale in dealing with government regulations and gate even of other regulations. Moreover, this country has always put a premium on the state of smallness. Large concentration of power in any areas are quite rightly and date mistrusted. Policies calculated to recognize this set of values command.

Firms on their own can effect reform. Firms themselves can, and do, make purely internal arrangements that promote an efficient allocation of R and D by size. Research units can attempt to duplicate those conditions associated with the smaller firm that are most productive. In fact, larger firms sometimes fund research efforts and have a minority stockholder position in relatively small firms headed by a highly creative inventor. Such an arrangement may create a better work atmosphere, but it

109

and share and a second seco

يوابع وأوجاب بالمتحج المحجات والكروج محدود

Presumably, barriers should be low enough to present threat of competition, but high enough so that immediate entry would not eliminate the rewards of invention too quickly. Such monopoly power would presumably deteriorate over time in accord with Schumpeter's notion of creative destruction.

size (2 all size below a second constrained of the wave event of the second second size of Schumpeter's thesis regarding firm size (as distinguished from monopoly). A grave was taken up by Galbraith: constrained of a second se

"There is no more pleasant fiction than that technical change is the product of the matchless ingenuity of a small man forced by competition to employ his wits to better his neighbor: Unhappily, it is a fiction. Technical development has long since become the preserve of the scientist and engineer. Most of the cheap and simple have, to put it bluntly and unpersuasively, been made---. Because development is costly, it follows that it can be carried on only by a firm that has the resources which are associated with considerable size."⁶⁰

Galbraith's statement about the demise of cheap and simple inventions is reminiscent of the late nineteenth century patent commissioner who resigned on the grounds that all the important inventions had been made Every year thousands of simple and important inventions are made by small firms or by individuals. Penicillin, the Polaroid camera and electrostatic duplicating were perhaps not simple inventions, or discoveries, but even these were the product of the single invention or small firm. What Galbraith is doing is confusing the inventive function with the development function. <u>Galbraith's confusion would result in a failure to</u> seek means to combine more effectively the inventive efficiency of the smaller firms with the development efficiency of the larger firms. To this subject we now turn.

na anti-static contra da tra da ser estratura e est

The direction in which solutions lie can be seen by considering a perfectly efficient patent system, the absence of uncertainty, a perfect capital market and sufficiently low transactions costs. In this situation, one would find an optimal allocation of R and D tasks among firms. Activities leading to original invention would tend to be concentrated in smaller firms, and developmental activities would be concentrated among medium-size or larger firms. Smaller firms could sell or contract, original inventions to larger firms in an efficient market setting and the allocation of resources devoted to the various aspects of R and D

107 - 107 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100 - 100

small firms, which is also a view held by Pavitt and Wald. In an examination of empirical evidence from the 1960's, they concluded that larger and smaller firms play complementary roles in innovation. Smaller firms concentrated on smaller-scale, specialized and sophisticated equipment and made major innovations after larger firms had let the opportunity slip away.⁵¹ Pavitt and Wald also found that "opportunities for small firms tend to be greatest in the earliest stages of the product cycle, when economies of scale are relatively unimportant; market shares volatile, and rates of entry and failure high."⁵²

This view of the complementary tasks of the large and small firm is also suggested by the detailed examination of the development of important set the state inventions by dewkes, Sawyers, Stillerman, and by the investigation of Nueller and by other studies. These investigations show (implicitly, as the point is sometimes overlooked by the authors) that the initial patentable idea, which is of course an essential step, is one much less expensive than the steps transforming the original idea into a form that the idea is commercially useful and marketable. The expenses involved in these examples stages of development after the original invention are, more often than the not, prohibitive for the smaller firm. ⁵³

The patentable concept of electrostatic machine copying was developed by one man, Carlson. Since this was a new process substantially differ-bail ent from existing processes, a relatively small company (Haloid) could develop the process successfully and become the leading producer (Xerox) in the new field.⁵⁴ This is to be contrasted with, say, an innovation that improves the performance of existing copiers. Discovery of such an improvement by a laboratory becomes somewhat more probable, but it is much more likely that the development of work necessary to convert the invention into a useful final product will be performed by a larger firm. Even the expense of certain types of initial inventions are beyond the means of smaller firms. What is uncertain is the extent to which capital constraints, inherent riskings of invention and the large costs of development discourage inventiveness by smaller firms. Chances are that this invent is a problem of considerable magnitude.

Just recognizing the problem is an important step since current mythology and the second seco

ha a na mban yaka kani bila da shekiliki na na na yaka sa sheka ka na katikiki kan se shquudak

en hande son ander ander an a

This general pattern is borne out by the questionnaire survey of Cooper⁴⁷ who interviewed twenty-five people with experience in research and development, primarily in chemicals and electronics, most of whom had managed development in both large and small companies. The estimates derived from these interviews indicated that large companies must spend from three to ten times as much as small ones to develop a particular product. The reasons for this are presented below.

First, the average competence of technical people in smaller firms is a second higher than in large firms. Greater freedom of a smaller company apparently is attractive; research personnel may own significant amounts of the stock of small companies so that the incentives for successful invention or innovation may be significantly greater; and small companies are less likely both to tolerate unproductive personnel and to hire unseasoned people. Although Conner does not comment on this, apparently greater productivity of R and D personnel in smaller plants derives in part from their higher salaries--either because they are more experienced or more competent, or because of their direct ownership which acts as an incentive to produce. Nevertheless, if Connor estimates are correct, it would seem that the additional expenses are more than offset by the increased productivity. In so far as the increased financial incentive increases productivity, one may wonder why large companies do not adopt some incentive system. An experienced patent agent with a large chemicalcompany suggests that this is true because in a large R and D organization sucha system would restrict information flow within the company and create difficult rivalries and jealousies.48

Second, technical people are much more cost conscious. Somehow the small firm is better able to achieve an atmosphere in which technical personnel are left alone to pursue work and, because of the closer identification of the personnel with the company, the personnel place a high priority on the way their efforts contribute to the company's success.

Call down

Third, in the small company there is greater ease of communication and reduced problems of coordination. In smaller companies, technical personnel are more likely to be sensitive to the needs of the market because of closer contact with people concerned with this area. To be sure, these various advantages must be weighted against disadvantages of breadth of experience and specialization, but Connor's study indicates that the advantage lies with small companies.

And the second second

Support for the thesis that large firms in concentrated industries show a support for greater evidence of technical change is furnished by A. Phillips.³⁴ In general, Phillips found that those industries, "which had large-scale of the second second producing units in 1904 had significantly greater rates of decrease in the number of wage earners persunit of output between 1899 and 1939 than did the other industries." Phillips' results are too facile because they probably do not measure the effects of large size and concentration assure any on invention or development. . Greater technological opportunities probably exist for capital-intensive firms so that their capital/labor ratio naturally would tend to grow more quickly over time. Thus, the casual influence probably runs from technology to concentration rather than the start start reverse, and is shown by Phillips' own subsequent work³⁵ and by studies by Scherer³⁶, Philips³⁷ and Comanor ³⁶ Scherenand Philips found that the second differences in the scientific knowledge base accounted for as much of the science of total variance in corporate R and D as did interfirm differences in corporate states and porate sales; Comanor's results were supportive of Scherer and Philips' conclusions.

INVENTIVENESS AND THE SMALLER FIRM A DAMA SALE AND

An important and cogent argumentican be made that; from the social boint is with a c of view, smaller firms should invest more than they do in R and D and Control and that they should invest more than larger firms in proportion to their statements size. This argument rests on the rather substantial amount of evidence which indicates that smaller firms have a greater efficiency in inven-10 585 . .

1 St. Augels

service and a service of the service and the second second states of the

161

a alternation that is not the

and the second

tion than larger ones.

n in the second seco

Some evidence of this from works by McConnell and Peterson and Schmookler (1997) and Scherer already has been offered. However, none of these separates invention from development or invention or development from innovation. Scherer's results mainly concern patents and, therefore, relate to invention, but these are not only unweighted as measures of the importance of the importance of invention, but also are only for Fortune 500 firms and a part of the second state of the second second 1997年1月1日,1997年日,1996年月1日,1997年月1日,1997年(1988年日)) 1997年(1997年日) 1997年日

1993 - 1983 -

The work most relevant for the present argument deals with the origins and the second states of invention. Jewkes, Sawers and Stillerman³⁹⁵ in their analysis of the Study Strate case histories of sixty-one important tweatieth-century inventions found attained at that less than one-third of these came from research laboratories. For any statement a more restricted period, 1946~1955, Hamberg⁴⁰ found that only about a construction of the second state one-fourth of a sample of major inventions were conceived in large where is sample

There is a second of the second s

However, McConnell and Peterson's results are not duplicated in studies of larger firms, Typical results for larger firms are either that there as formation is no relationship between firm size and R and D intensity or that R and a S formation D intensity increases up to a point and then diminishes. Some studies show a negative relationship between firm size and R and D intensity. Increases with

Smith and Creamer's results are somewhat typical.²⁷ One of the industries (scientific and measuring instruments) in Smith and Creamer's, twelve-industry sample also shows a negative relationship for research intensity and firm size. For two additional industries (other chemicals and communication and electronic equipment), the intensity of the small, est firms (under 1,000 employees) was greater than for any other class when federal funds were excluded. In the categories of other chemicals drugs and other medicine, and scientific instruments, the peak intensity occurred at less than the largest size class. Finally, in seven of the twelve industries, the peak intensity of the smallest size class was greater than that of the next largest class.

the particular with the factor and a 2155 A. 265 had out they for Schmookler's results for larger firms are fairly consistent with the relationships shown by Smith and Creamer.²⁸ For a six-industry sample, Schmookler found across four industries no relationship between firm to the set size and R and D intensity. However, for two of the six industries, Schmookler data show that the R and D intensity of the smallest firms and have been stored (49-499 employees in one case, 500-999 in another) was greater than that 2011 No. of any other size class. It is worth noting that these two industries (fabricated metal products and ordinance, and electrical equipment) are among those in the McConnell and Peterson sample. In two other industries, peak R and D intensity occurred at less than the largest size of 1.0000.00 more than 5,000 employees; for the professional and scientific instruments industry, peak intensity occurred at the second smallest size class (500-999 employees), in the food and kindred products industry, the peak intensity occurred at the next to largest size class (1,000-4,999 employees).29

Even for the chemical industry, the R and D intensity for the smallest size class (firms with less than 500 employees) was greater than for any size class, except for the largest. Strikingly, two of the industries found by Schmookler to exhibit peak research intensity at sizes of less than 1,000 employees (electrical equipment and professional instruments)

small firm to capital problems, especially in view of the inherent risks of R and D. As R and D is spread among a larger number of projects, as is more likely the larger the firm, the risks of failure of any one project are reduced. Related to the question of small firm survival is the greater life expectancy of larger firms which allows them to assume R and D investments whose payoff period is longer. The greater diversity of large firms in increasing the likelihood of being able to use an invention, and the greater market concentration of large firms are also elements, though quite minor ones, in explaining the greater propensity for R and D programs among larger firms.

R and D expenditures by small companies are distributed among approximately the same industries as for large companies. Smith and Creamer¹⁹ show for 1965 that four of the top five industries in absorbing R and D spending by small firms were also among the top five for large firms. It would appear that the more capital-intensive industries have the higher percentages of firms engaging in R and D.²⁰ This probably reflects the greater potential for R and D in these industries and the fact that capital-intensive industries tend to have larger firms. It would be interesting to see what the regression of both firm size and capital intensity against the percentage of firms engaged in R and D would show.

Given the skewed distribution of R and D spending among small firms by industry and by size, it is not surprising that Smith and Creamer find the distribution of R and D spending among small firms also highly skewed.²¹ Thirteen percent of manufacturing firms with less than 1,000 employees spent about 55 percent of total R and D spending by manufacturing turing in this size class. What is perhaps more interesting is that this 13 percent also showed a more continuous record of R and D spending.

Research Activity, Intensity and Firm Size

Firm size strongly influences the probability of an firm having a formal distance when the program, but does firm size influence the size of the R and D program? One would expect a positive relationship as long as there were the strongly decreasing returns to scale in R and D. One also would exact there were there were the strongly decreasing returns to scale in R and D. One also would exact there were there were there were the strongly decreasing returns to scale in R and D. One also would exact there were there were there were there were the strongly decrease there were the strongly decrease there were there were there were the strongly decrease ther

11 - 13 - O MA

advances may come from departments other than those for R and D. Changes in tax treatment of R and D can result in new, arbitrary classifications of personnel or activities into the category of research 10 If these problems exist in attempts to study R and D for larger firms, how much more difficult is it to analyze R and D by smaller firms in which the data are less satisfactory or do not exist? lik ile en∉n i barbin

Aside from basic problems of data availability, current research suffers from two interrelated and important shortcomings. The first is that data are not examined on a sufficiently disaggregated basis. The second deficiency is that too few factors have been introduced that might help explain the structure of R and D. Kamien and Schwartz¹¹ observe "much of the evidence on the effect of size has not controlled for other factors that may be helpful in explaining innovational effort." The same may be said of evidence concerning innovational outcome. Few studies really have attempted to explain the structure of R and D, undoubtedly because to do this requires that the data and information be generated by narrowly focused studies working to build up a data base sufficiently rich to understand R and D structure. ers no on units indus withers

In this regard, problems of R and D are reminiscent of problems of developing a general theory of oligopoly. The necessary basic research is tedious and perhaps less rewarding in the short run. Perhaps economists are less willing than researchers in the natural sciences to undertake the tedious and narrowly focused research upon which the advancement of the set of the set from science ultimately rests.

15 3 1 15 10 13 H

and the second second

R AND D CHARACTERISTICS OF SMALL FIRMS

-4.

10.000

The most important studies of R and D in small firms are those of, McConnell and Peterson, 12 McConnell and Ross, 13 Hamberg, 14 Smith and Creamer¹⁵ and Dearborn, Kneznek and Anthony.¹⁶ From these and other investigations, a number of limited and tentative, though important, conclusions emerge. Réduien l'and la company de la factoria de

the constant set as independent The Incidence of R and D Programs Probably about 20 to 40 percent of small firms engage in B and D in a relatively formal way. Among the more reliable estimates are those from the detailed and disaggregated questionnaire results of McConnell and

(1) A set of the se

between the investment-to-GNP ratio and real growth rates for seven OECD countries as measured by the Kendall coefficient of concordance is .92, with a chi square of 11:2. This is just significant at the 10 percent level, which is impressive for such a small sample.⁹ Similarly for the 1967-1971 period, the United States ranked last in its growth of R and D expenditures, followed by the United Kingdom, France, West Germany and Japan. This matches the respective growth rates of these countries, except for the reversal of the United States and the United Kingdom.

For the United States, the fall in the investment-to-GHP ratio has occurred in large part because of the failure of the traditional sources of investment funds, retained earnings, debt and equity. Retained earnings in constant dollars have declined enormously during most of the 1960's and the 1970's. The "crowding out effect" has limited severely bond debt as a means of financing, and, until recently, the stock market has not been a very attractive place to go for financing. Financing problems of small businesses have been especially difficult.

One set of measures that undoubtedly are cailed for are policies that encourage greater capital formation. With such policies, R and D for both small and large firms undoubtedly would expand. However, the response of small firms probably would be greater because of their greater sensitivity to credit conditions. The phenomena is similar to the unemployment rate of minorities which increases proportionately more than for other groups during periods of contraction and which decreases more than proportionately during periods of expansion.

Economic growth is a matter of the efficiency as well as the magnitude of investment. In this regard, the distribution of R and D expenditures between large and small firms becomes especially relevant. After considering the relationship of R and D to smaller firms in the next section, the third section of this paper argues that efficiency requires a greater portion of R and D spending by smaller firms. The final section suggests conditions under which the improvements in efficiency might be brought about.

DATA LIMITATIONS FOR THE ANALYSIS OF SMALL FIRM R AND D

Small firms are those with less than 500 employees and probably account for less than 3 percent of total R and D expenditures.⁹ Yet in terms of

93

872

- P ?

Appendix XV

ABTICLE, "RESEARCH AND DEVELOPMENT BY SMALLER FIRMS," BY RICHARD O. ZEEBE, JR., NORTHWESTERN UNIVERSITY AND UNIVERSITY OF WASHINGTON, JOURNAL OF CONTEMPORARY BUSINESS, 1976, PAGES 91-113

, nor are Journal of Contemporary Business Spring 1975 chigan State sed to de--a-Firm: RESEARCH AND DEVELOPMENT BY SMALLER FIRMS iness Permen ailer surse. na Aren <u>Else</u> Richard O. Zerbe, Jr. Northwestern University and University of Washington 901 (S ÷2÷ THE IMPORTANCE OF RESEARCH AND DEVELOPMENT 190 $\overline{\mathcal{T}}$ Technical change arising from research and development (R and D) expenditures is exceedingly important. Solow,¹ in his pioneering work, found that between 1909 and 1949 about 81 percent of economic growth was attributable to technical change and changes in production practice. Dennison,² in a more disaggregated study, found that 36 percent of them rise in output per worker was attributable to advances in technical knowledge, and 42 percent was attributable to improved worker education. Only 9 percent of the rise was due to increases in the capital stock. Research and development is also of major importance in determining comparative advantage, the balance of payments and the magnitude of U.S. exports.³ Donald Kessing⁴ found that there was a powerful correlation between the intensity of R and D activity in American industries and their export performance. Pavitt and Wald⁵ found a high correlation be-5.8 tween national industrial R and D expenditures and national technological performance across a sample of ten industrialized countries. In a sample of fourteen industries, Gruber, Mehta and Vernon⁶ found that U.S. export. strength was concentrated in the five industries with the greatest R and D effort, i.e., transportation, electrical machinery, instruments, chemicals and nonelectrical machinery. The remaining industries exhibited a of a second a weak can annet importabalance for 1962, the year investigated. 7 From these and fina other studies there is little doubt that R and D and technical change play a major role both in economic growth and in determining relative and economic position. A crude comparison suggests that the fall in the U.S. growth rate of recent years and the concomitant absolute and relative decline in the ratio

A crude comparison suggests that the fall in the U.S. growth rate of recent years and the concomitant absolute and relative decline in the ratio of R and D to GNP are not unrelated phenomena. The decline in R and D has been part of this decline in the United States in the investment-to-GNP ratio. See Figure J. For the 1960-1973 period, the rank correlation

<u>n]</u> .

A DATA AND A STREAM WAS A MARKED AND A DATA AND AND AND A DATA

Table 5-10. Distribution of employed doctoral scientists and engineers by employment sector, 1975

	scie	ocloral entists ngineers		toral htists1	Doctoral engineers	
Employment sector	Number	Percent?	Number	Percent?	Number	Percent ^a
Total	262.411	100	219,055	100	43,356	100
Business and industry	65,876	25	43.341	20	22,535	52
Educational Institutions	153,249	58	137,943	63	15,306	35
and universities	147.633	56	132,504	61	15,129	35
Two-year colleges	3.674		132,504 3,497	2	177	(3)
secondary schools	1,942	1	1,942	1		_
lospitals and clinics	7,586	3	7,562	3	24	(°)
Ionprofit organizations	8,510	. 3.	7,277	3	1,233	3
Sovernment	26,755	10	22,538	10	4,217	10
Federal ²	21,634	8	17,855	8 -	3,779	9
State	3,110	1 1 C	2,883	1 - E	227	i 1
Other	2,011	· . 1	1,800	1	211	(P)
Other employment sector	86 349		86 308	. <u>(9</u>		

1 Includes 94 scientists or engineers whose field is unknown.

Excluding thuse whose employer was unreported.
 Excluding thuse whose employer was unreported.
 Includes the military and the Commissioned Corps of the Public Health Service.
 Los them 05 pages.

4 Less than 0.5 percent.

NOTE: Detail may not add to totals because of rounding.

-7470 SOURCE: National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States, 1975 (NSF 77-309), pp. 38-41.

See Figure 5-17 In text.

Table 5-11, Doctoral scientists and engineers by age and type of employer, 1975

		ndustry	Four-yea and un	ar colleges Feder niversities Governm		
Age	Number	Percent	Number	Percent	Number	Percent
Total	65,876	100	147,633	100	21,634	:100
Jnder 30	2,129	3	5,772	4	773	4
80-34	15,117		30,862	21	- 4,121	19
85-39	14,113	21	30,903		4,734	
0-44	10,274	16	23.687	16	3,646	17
5-49	8,090	12	19,833	13	3.081	14
0-54	7.476	11	16,146	11	2.398	11
5-59	4,610	7	10,774	7	1,533	7
0-64	2,734	4	6.461	4.	953	4
5 or over	1.224	2	3.094	2	382	2
Vo report	109	(2)	101	(²)	13	(2)

Includes the military and the Commissioned Corps.
Less than 0.5 percent.

NOTE: Detail may not add to totals because of rounding.

SOURCE: National Science Foundation, Characteristics of Doctoral Scientists and Engineers in the United States, 1975 (NSF 77-309), pp. 38-41.

See Figure 5-19 in text.

110 2.52

2 - 2 - 2 - 2 - 2

Sauce.

1.30

1420

9.5

APPENDIX D

							÷.,			ience Board
		· · · · ·	$\mathcal{T} = \mathcal{T} = \mathcal{T}$	1 			Ĉ.	At		
	• • •									
· ·		· · · ·					5 B			
							22	· •	N .	- A.
	· ·						는 11년 12년 - 1	21		
							5 (A)			
			. •		· · .					in the second
· · · · · · · · · · · · · · · · · · ·				S.,				14	· ·	2
										10 ·
······································										- 1
							tar le tar U-246ne			. 4
									•	i la E
			÷				1.15	· -		401 2 1 - 1 - 1
		•								
	1									
								· .	1	
	1.	:						1.3 19		
1				· ·				-		
					1. ¹	e di Girina			i .	· . · · .
	N.	÷ .				· · ·	, 19 m. 19 feb			
and the second	1 A.			1				202 202		
				1.1			್ ಕಲ್ಲಿಗಿಸುವ ಪ್ರಶಸ್ತಿ ಸಂಭಾ	Y V		1.1
							8.0	5	· .	
			1	· · · · · · · · · · · · · · · · · · ·						a ng ang an ang
			· · · ·				1		1	
							67			
										· ·
					2.1					
		•			•					
New York Annual Section 2010 Section 2010			mark Outrache au is	Constant and and a		s baraha zama	atalana di sebat	antelessa eta	talaan di karaana	e e november of the state of the
	ntentantesen stan	anna an	n na tatunta ana Na Seconda ana	terretaria Sector de la composition	annin sinn a Thurse Sta	ebastis men S ying A s	ana an	antoine ann 1940 - Station Anna 1977 - Station Anna Anna Anna Anna Anna Anna Anna An	ana ana ana ang ang ang ang ang ang ang	
maran mutamata di marana muna dan seria da seri Seria da terte de Sector de Constructiva da seria da seri	n ning kan	anna an	na an a	seeseeneen Sprigt of S		alaan ahaan ahaan ahaan ahaan ahaa ahaan ahaan ahaa	ana ana ana ang Tang tang tang tang tang tang tang tang t	antonikaan ama ali ali ali ali ta ta ali ali ali ali a	antan di Sarran Martin di Sarran Martin di Sarran	anne fersken ner under Griefen Griefen
na an an an an Bhaile An Ann an A Star Ann an A Star Ann an A		ataronataroko anarazarea 1999 - Angel I. J. angel I. Angel		sensor and	Anna airsean Tha an thi	abandon manan Daga yang si sa T	antarana an anana 'n an ang Nalao Anang		an a	alanti nina ana ana ana
na an an a mart a Martin a dha an	n niemienienie dien niemienienie dien niemienie die niemienie dien n	utmentineta tura con constante a su de dominio constante a su de dominio	n matatanan Kataranan N	en e		adantin manan Sayang Saya S	ostronom investori - Nort Verice Interne		antanan disaratan Tari tari tari tari tari	anartikonomia tarta dalartik Mantaka kata dalartik

78.

OFFICE OF PLANNING AND RESOURCES MANAGEMENT

DATE OF AWARD	FIRM NAME		PROJECT TITLE		WARD IUMBER	PROGRAM AREA	AMOUNT
10/76	Computer Horizons Inc. Cherry Hill, N.J.		An Evaluation of University Research Productivity	o ` 7	681724	Evaluation	\$ 42,495
11/76	Computer Horizons Inc. Cherry Hill, N.J.	• • • • •	Review and Analysis of Importance and Utilization Measures Contained i Evaluative Bibliometrics		682854	Evaluation	\$ 18,318
9/77	Institute for Scientifi tion	c Informa-	A Citation and Publication Analysis U.S. Industrial Organizations	of 7	710048	Evaluation	\$ 64,851
	Philadelphia, Pa.						
				23			
	· :		· .				·
				1	•		
· .	- · ·	* •					
	e trapaca de			1			
	Age with the second		andro 1. provinski androgađa atorija	80	5 . · ·	u so Aggéria. Do as vij	対応によ
					en e	el DELVA	(veca-7
· •							
			Rent est est service and the service				ŝ

SCIENCE EDUCATION DIRECTORATE

DATE OF AWARD		FIRM NAME	net an earlier of PROJECT of LILE	AWARD Number	PROGRAM AREA	AMOUNT
	///	Camarillo, Ca.		7716196	Public S Understanding of Science	\$203,100]
9/77		Exotech Inc. Gaithersburg, Md.	Data Processing Support to the Science Education Directorate	7726461	Special Studies	\$124,854
9/77 N	14 .4	Westat Inc. Rockville, Md	Program Evaluation in Science Educa- tion: CAUSE	7723940	and the second	9,900
2/77	A.	Courseware Inc. Provo, Utah	Learner-Controlled Instructional Strategies: An Empirical Investiga- tion	7601650	Technologi- (cal Innova- tions in Ed- ucation	\$207,750
		Development & Evaluation Associates Synacuse, N.Y.	Evaluation of CAUSE	7723982	Systems Approach	\$ 9,990
		yourdenane. Stansen nymet i synne de	n oligi yana da kuta shekara shekara 1974 ni 198	1949) na Ruga jana	"sijest, Provi	e'n Dr
-	an an	an na cui igi Tur - Cuint Igi (gandalana Kanala dalam angan mula ngatika	XAC ^{ONE} T Contractor	a a tutki t	1.990
r The s		n an	se de Real (Real de Carlos de C Notas de Carlos de Car	<u>9</u> 7. г. у. у. 1914 - 275	la pontessar	1. 24
		н. Н ^а танда Н		anga, s Yuyua		74.

DATE OF AWARD	nas de Bantos Pertantes de <mark>FIRM NAME</mark> r	nami para jini ngamangkan kangan Katabut. Nganang paratara na namin namarakan jingan kanamatang k nami akto pananan <mark>PROJECT.TITLE</mark> kalagangkan	AWARD NUMBER	PROGRAM	AMOUNT
5/77	Technology Associates of Southern California, Inc. Monterey Park, CA	investigation of the Design and Performance of a Simple Liquid Piston Heat Engine	77-07489	Exploratory Research	53,600
8/77	CONSAD Research Corp. Pittsburgh, PA	A Prototype Evaluation of the Program Output of the Research Applied to National Needs (RANN) Program	76-11438 A04	Research Evaluation	1 999 57,107 21030
9/77	Operations Research, İnc. Silver Spring, MD	Research on Methods for Assessing the Utilization and Impact of RANN Projects	77-22190	Research Evaluation	63,500
9/77	Kappa Systems Arlington, VA	RFP 77-110: External Product Evaluation Management	77-26721	Research Applications	261,480
		1999年1998年,1999年1997年,1998年1998年(1999年),1999年1998年 1999年—————————————————————————————————	Subtot	al: \$7	,599,535
	made via a purchase order:	المراجع والمراجع والم	alia Danat dari	Stream cections	1.00
10.55		an a		Constant of Chinase	2.1
	Belt, Beranek & Newman Cambridge, MA	Evaluation of Basic Research Progress and Future Research Opportunities in Human a Factors and Ergonomics	RN-1473 7SP0920	Productivity	3,609 40 °C
6/77	Clinical Systems Associates, Inc. Washington, D.C.	Technological Needs of the Physically Handicapped	RN-1039 7SP0842	<pre>Productivity</pre>	SC 9 °,8 50
e 9/77	Clinical Systems Associates, Inc. Washington, DC	Research Priorities to Aid the Productivity of the Physically Handicapped	RN-6096 7SP1121	⊖Productivity	<u>)</u> 6, 250
8/77	Dames & Moore San Francisco, CA	Implementation Measures to Reduce Earthquake Hazards of Dams	RN-6874 7SP1045	- Environment	7,000
		8 E -	· .	· · ·	

- 10

DATE OF AWARD	e avoer <mark>FIRM NAME</mark> we are the graduate of		er a Margada Waran e Guerra Ranga Margada <mark>PROJECT TITLE</mark> Vicinese yesa mar Na Marda Sisa per Terra Vicinese Vicinese a	AWARD NUMBER	PROGRAM AREA	AMOUNT
8/77	Oneida Materials Corp. Cucamonga, CA		Development and Testing CSMRI "A" Metal Process for Recycling Steelmaking Dust and Scale Waste for Industrial Adoption	76-84256	Indus. Prog./ Resounces edr	
2/77	Amber Laboratories Juneau, WI	Velett	Natural Red Food Colorant from Beets		Resources	•
12/76	Anver Bioscience Design Sierra Madre, CA		Jojoba Seed Meal, as an Animal Feed	76-23895	Resources	77,300
8/77	Roger Blobaum & Associate Creston, IA	ŝ	An Assessment of the Potential for Applying Urban Wastes to Agricultural Lands	77-08280		92,100
9/77	Charles River Associates Cambridge, MA		An Analysis of Major Policy Issues Raised by the Commercial Development of Ocean Manganese Nodules	77-14453	Resources	191,900 (30,000 fro
7/77	Collaborative Research, I Waltham, MA	Inc.	Synthesis and Applications of Nucleic and Applications of Nucleic	77-10195	Resources	209,100
9/77	Collaborative Research, I Waltham, MA	Inc.	Enhancement of Animal Protein Production by Novel Genetic Technology	*77-19654	Resources	24,997
8/77	DASI Industries, Inc. Chevy Chase, MD		Evaluation of Free-Falling Film Ultra- High Temperature Processed Milk	77-04162	Resources	168,700
9/77	EIC Corporation Newton, MA		Recovery of Chromium from Nickeliferous Laterites	*77-19538	Resources	24,740
2/77	Experienced Resource Group, Inc. Baton Rouge, LA		Alternative Food Delivery Systems - An Exploratory Assessment	77-07184	Resources	25 , 000
26 A						2

	EIRM NAME	en neue date general de la company de la Company de la company de la PROJECT TITLE	AWARD NUMBER	PROGRAM	AMOUNT
	Maurer Engineering, Inc. Houston, TX	Conference on Research in Excavation Technology	75-14405 A03	Productivity	36,900
	Maynard Research Council Pittsburgh, PA	Study of a Mechanism to Foster University/ Small Business Interaction	77-14151	Productivity	100,000
	Multisystems, Inc. Cambridge, MA	Remote Employment of the Physically. Handicapped	*77-19497	Productivity	24,948
	Precision Instrument Co. Santa Clara, CA	Slidestore: Large Capacity Information Storage	*77~19528	Productivity	24,995
	Radiation Monitoring Devices, Inc. Watertown, MA	Résearch on Uncooled Cadmium Telluride Gamma Detectors às Substitutes for Ultra- pure Germanium	77-10434	Productivity	198,100
	Scientific Process and Research, Inc. Highland Park, NJ	Consequences (Consequences) of the second se	angi ing	Productivity	25,000
	Scientific Systems, Inc. Cambridge, MA	Microprocessor-Based Prosthetic Control	*77÷19672 _ \19672	Productivity	23,670
	Spectrum Research Denver, CO	Evaluating the Organization of Service Delivery: Public Health	74-08798 A01	Productivity	8,648 133 1000
	Stearns, Connad, & Schmidt Consulting Engineers Long Beach, CA		77-04424	Productivity	40,272
r	Stearns, Conrad, & Schmidt Consulting Engineers Long Beach, CA	Research on Equipment Technology Utilized by Local Government: Refuse Collection	74-20560 A03	Productivity Second	13,800

DATE OF AWARD

4/77

8/77

9/77

9/77

9/77

6/77

856

68.

1	and the second and	22.0201 (free lighters for Kerstekker in a	ΥK.	
	la fered for many and	1、自己,这自己的ANAA 我的话他们都能够不可能。如果是 ————————————————————————————————————	AWARD PROGRAM	1 601
AWARD	FIRM NAME	¹ data segura politika en la <u>PROJECTA TITLE</u> , program politika en la statuna en la statuna en la statuna de la st Interna de la statuna de Interna de la statuna de	NUMBER AREA	AMOUNT
	and the second			1997 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 - 1998 -
9/77	Woodward-Clyde Consultant	S Analysis of the Adoption and Implementation of Community Land Use Regulations for Flood Plains	1 77-13908 Environment	208,300
- <u>√</u> 5/77	Advanced Research Resourc Organization Silver Spring, MD	A Conference to Formulate Priorities for Research on Human Performance and Productivity	77-07886 Productivity	74,900
9/77	Agbabian Associates El Segundo, CA	Improved Design Procedures for Underground Structural Support Systems in Rock	76-80044 Productivity	179,900
9/77	Amtech, Inc. Newton, MA	Micro-Isotope Tool Wear Detection	*77-19517 Productivity	25,000
9/77	Block Engineering, Inc. Cambridge, MA	Single Ended Photoelectric Hazard Warning	*77-19478 Productivity	24,495
9/77	Ceramic Finishing Co. State College, PA	Control of Fragment Size Distribution and Darage Penetration During Machining of Ceramics	*77-19818 Productivity	24,942
4/77	Energy Research and Generation, Inc. Oakland, CA	Thermocorer for Rapid Excavation	73-03322 Productivity A06	131,200
7/77	Springfield, VA	Remote Sensing with Ground-Probing Radar	A02 Productivity	10,700
3/77	Exotech, Inc. Gaithersburg, MD	Shaped-Rulse Rotary Percussion Drilling	75-16367 Productivity AOI	18,700
1 (21 7/77 2111 (22	Exotech, Inc. Gaithersburg, MD	Shaped-Pulse Rotary Percussion Drilling	AD3	12,900

- 4

66.

DATE OF	dra log ' FIRM NAME	PROJECT TITLE	AWARD NUMBER	PROGRAM	AMOUNT
2001 7/77	Building Systems	Building Configuration and Seismic Design	76-81821	gangasan Environment	199 ,4 00
2011	Development, Inc. San Francisco, CA		12.22	<u>1</u> 00.91 (116.88)	<u>9</u> .439
4/77 ≷∿∿∖	Clement Associates, Inc. Washington, D.C.	An Evaluation of Toxicological Information Relevant to Future Testing Requirements for Hazardous Chemical Substances and Mixtures	# 77-15417	Environment	142,793
8/7 7	<pre>> Clement Associates, Inc. Washingtong D.C.V (2001) >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>></pre>	An Evaluation of Toxicological Information Relevant to Future Testing Requirements for Hazardous Chemical Substances and Mixtures	77-15417 A022200	Environment	173,444
8/77	Collier Worm Ranch and Santa Clara, CA	Conversion of Municipal Wastewater Treatment Plant Residual Sludges Into Earthworm Castin for Use as Topsol	gs	Environment	00 9,700 2001 00 0
5/7 7	Gurnham & Associates, Inc. Chicago, IL	Control of Heavy Metal Content of Municipal Wastewater Sludges		Environment	110,900
⊙ 3/7 7	Human Ecology Research Services, Inc. Boulder, CO	A Comparative Analysis of Public Response to Weather Modification	- 74-18613 A03	Environment	569600
1.7.5	网络拉拉卡拉克斯利拉卡拉马利尔	the former service and the service of the service of the	Net 26222	and the second	20 ° C (4
3/77	Human Ecology Research	Metromex: Social Impacts of Inadvertent	76-22041	Environment	60,300
5.5.5	Services, Inc. Boulder, CO	Weather Modification: A Comparative Study	as no tore	167 N 191948	a de Cale
9/77	Laser Analytics, Inc.	Improved Sensitivity of Laser Absorption	77-02124	Environment	211,500
	Lexington, MA	Techniques for Atmospheric Pollutant Monitoring	ALERAN Manada		V.2017
6/77	Media Four Productions Hollywood, CA	Synthesis of a Municipal Wastewater Sludge Management System	76-82708 A01	Environment	49,640

ASTRONOMICAL, ATMOSPHERIC, EARTH, AND OCEAN SCIENCES DIRECTORATE

化复度化合物进行工作 建磷酸化的分子

AWARD

2/77

9/77

8/77

5.35

62.52

1.11 De

我的学校的时候,被称 DATE OF THE GAS AND THE a said a star of the same share AWARD PROGRAM AREA FIRM NAME NUMBER PROJECT TITLE AMOUNT 11166 644 Scripta Technica Inc. Publication of Polar Geography 7681106 Polar \$ 21,000 Washington, D.C. Compass Systems Inc. Assembly and Analysis of Oceano-7724040 Atmospheric \$ 30,000 San Diego, Ca. graphic Data on the Surface Laver (0-150 M) in the Southern Hemisphere as the Albert Bills and Preparation of the Results for しょういち ないしょうさ じょうえんさいもない Publication in an Atlas Compass Systems Inc. "Assembly and Analysis of Oceano-7709201 Atmospheric \$158,800 Compass System San Diego, Ca. graphic Data of the Surface Layer (0-150 M) in the Southern Hemisphere and Preparation of the Results for y uniperate a grant Publication in an Atlas a standard set t fi fi sha a sh 5 1 26 1 3 ちょう とうしょうかい かいない かい 香めた A the state of the state of the second state of the second state of the second state of the second state of the Approximate constraint the end to be added to be a set of the set o 建筑的复数过度的 人名法法马尔姓氏 2 1 8 G 1986 C sector and the stations see of the statement of Hade provider of the definition of the provide 计同时的复数形式 化合金 the a paper and a presented in the second of the second second 1. 1846.0 法法认为 拉

Sector Contractor Manager and Contractor Contractor

5 . **1** 2 - 3 .

SCIENTIFIC, TECHNOLOGICAL, AND INTERNATIONAL AFFAIRS DIRECTORATE

DATE OF AWARD	FIRM NAME	PROJECT TITLE	AWARD <u>NUMBE</u> R	PROGRAM AREA	AMOUNT
1/77	Courtesy Travel Service Washington, D.C.	Travel and Administrative Services in Support of Intern'l Science Acti- vities Sponsored by the NSF	7708322	Internat'l	\$ 500,000
	Computer Horizons Inc. Cherry Hill, N.J.	Implementation of Evaluation Metho- dology for International Programs	7708484	Internat'l	\$ 24,915
	Metrics Inc. Atlanta, Ga.	The Economics of the Unique Functions Associated with Information Analysis Center (1AC) Services of the services	7718035	Science Information	\$ 83,800
35.9 <u>2</u>	Charles River Associates, Inc. Cambridge, Ma.	Development of a Discrete Choice Model for the Demand of Scientific and Technical Information	7718020	Science Information	\$ 101,764
41.91	Innovative Systems Research Pennsauken, N.J.	Electronic Information Exchange in Re- search on Devices for the Disabled	∆ 771792 4	Sections Science Information	\$51,143
2/77	Capital Systems Group Inc. Rockville, Md.	A Planning Guide on Innovation in the Dissemination of Scientific Information		Science Information	\$92,586
9/177	Capital Systems Group Inc. Rockville, Md.	A Planning Guide on Innovation in the Dissemination of Scientific Information	7720489	Science Information	\$ 219,500
3/77	Westat Inc. Rockville, Md.	Relationship of Organization Climate to the Transfer of Scientific and Technical Information in Industrial Settings	.7681946	Science Information	∴\$10 , 017

60.

58. APPENDIX C

Section and the sector sector and the sector of the sector

teentrest.∳ v. or o γá 1.200 ġ, undrage-k.cc anona Long R Production of Enges Alvestander P antar kita menyeri. 2018 18-14 1273 FY 1977 GRANT AND CONTRACT AWARDS TO SMALL BUSINESS ł esseine y and and 2 should be the set her shoel as we had washi u tanake alimat LISTED BY INDIVIDUAL AWARD BY 697.1273 RV 172600 orb and freedom to be booken to the sector sector be booken to be NSF DIRECTORATE 1/Includes programmatic grant and contract awards only. Excludes awards primarily for NSF logistics support and purchase orders except where noted in the Research Applications list. Paratical (Revision of the second 10 / 10 × 869.03 88 (b) () alle to and the つかからす内 1200 na de ale: and the second second

÷...

785.03

FY 77 AWARDS TO INDUSTRY--BY NSF PROGRAM ELEMENT

MPE Other Math Sciences Engineering/Heat Transfer Engineering Energetics Engineering/Fluid Mechanics Metallurgy Ceramics Materials Research Chemical Analysis Engineering Other TOTAL: STI Policy Research & Analysis Cooperative Science Program		n develande Leimenen Profes	Amount 3, 0000 27,700 27,700 27,700 137,500 186,700 60,000 66,500 24,535 718,335 718,335 217,847 500,000	sestA March Documents States S
Scientific Organization & Resou Economics: of Information Access Improvement User: Requirement Program Studies of Science Resources TOTAL:	urces 1 2 3 3 <u>6</u> 2 1*	Januari Januari	24,915 29:185,564,20- 21:363,229-91 146,186 534,269 1,972,010*	
AEO				
Aeronomy Solar-Terrestrial Atmospheric Chemistry Solar Terrestrial Physics Information Services USARP Contract Support USARP Climate Dynamics Research Ship Support TOTAL:	2 2 1 5 3 <u>3</u> 19*		136,500 148,800 119,900 67,500 21,000 7,059,825 288,800 295,047 8,137,372*	*
BBS				
Regulatory Biology Metabolic Bio. Economics History & Philosophy of Sci. TOTAL:	3 1 1 <u>1</u> 6		164,856 80,500 12,500 82,700 340,556	

er galagra

RA	<u>No.</u>	Amount
Resources concerns Concerns Concerns Renewable Resources Societal Response to Natural Hazard Instrumentation Technology	1	2,122,800 35,000 920,000 198,600
Excavation Technology Earthquake Engineering	19 12	1,732,800 2,013,100
Environment Weather Modification Regional Environmental Management	2 94	2,293,600 101,900 2,760,300
Chemical Threats to the Environment Productivity	134	3,269,600
Regulation Technology Assessment	2 25 1	929.000 1,115,675 5,000
Public Sector Productivity Service Delivery Technology & Syste National Productivity Measure.		664,025 192,000
Service Productivity & Intergovern Relations	ž 1	59,500
Public Sector Productivity Public Policy Distribution & Equity	1	121,600 260,400 5,760
Systems Analysis Biomass Utilization		24,942 280,000
Mineral Market Behavior & Shortages Resources Development & Conservation Advanced Processing Technology	17	190,000 708,300 89,700
Industrial Program International Travel TOTAL:	8 <u>1</u> 431	89,700 142,819 978 \$23,829,799
		Sector Andreas Sector Anterna
BBS Genetic Biology	r skiner ^{In l} 2	548,200
Ecosystem Studies Regulatory Biology	1 2	198,000 112,100
Metabolic Biology Biophysics Memory & Cognitive Processes	s i francúski stal k stali stali zakovateľka	319,200 72,600 .63,100 112,500
Anthropology Economics	fer all a second s	16,200
History & Philosophy of Science TOTAL:		82,700 1,524,600
		in electrical contractors and the second s Second second
nder Byd €1: 1:1:	2 2	i Bernigen (1997) 1999 - Steffen J., (1999) 1993 - Steffen J., (1997)
	1	Mary Contractor Contractor
	1 A.	· · ·

Berlige Actual and With Agine Advances, parameters in

Benergy, reencorded and a second consistent with control of the ended of the second of the second of the second seco

Bie Construction of a set of the title of the title of the set of the title of the set of the se

(c) Anteres (and directions of entries of enclosed cases). Repairs direction is reacted with the contract of the and the entries of the anteres of the a

We want was a first of the second state ng might bo which is in marked. NASA patent policies appear not to be a serious deterrent to industry participation in NASA basic research activities. Patent rights start with NASA but companies often are assigned development rights if the government does not plan to use the patent: NASA's congressional supporters have emphasized that NASA supported research is beneficial to U.S. industry and the national economy. Moving research results to utilization is important in meeting those objectives. refren franz ella fui en insuent des estas ella cuerda i apega -

NASA's publication policies in the basic research area generally resemble those of NSF. NASA encourages publication in refereed journals and staff spoke of an increasing emphasis on that mechanism as one of the evaluations of quality to be weighed when considering further research support. In Stranger addition, for NASA contracts, particularly those let in response to specific research needs, NASA requires a technical report addressed to NASA. In one of the research areas it was noted that research findings by private firms in the natural resources area sometimes are not published readily; some companies with large research programs and labs participate readily in certain of the basic research activities, and publish results in the open literature. His sect of the contract who will be the sector of the contract of 1.2

AIR FORCE OFFICE OF SCIENTIFIC RESEARCH

501 35 E 30/6 100

. 1993 - Maria Maria, ang Kabupatèn Ang Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Kabupatèn Ka 1995 - Kabupatèn Kabu

The Air Force Office of Scientific Research relies mainly on unsolicited proposals for initiation of new work through grants and contracts. Proposals are supported based on their originality, significance to science, the scientific competence of the investigator; the reasonableness of the researchbudget, and the appropriateness to the Air Force. Grants are limited to support of research at universities and not-for-profits. Contracts are used to support research in industry.

Research awards to industry vary according to the industry expertise and interest as these relate to the Air Force's research programs, and the interest of the Air Force in the industry expertise or the questions that a researcher may want to investigate. The AFOSR indicates that about 15% of its extramural basic research outlays go to industry, and estimates that about 10% of these awards are to small businesses. 网络白色的白色的 医白白

Industry performance of basic research for AFOSR is more likely in high technology areas such as electromagnetic materials research and device concepts. In the microwave tube area, AFOSR has seven industrial research 1.01 performers and because of a scarcity of trained researchers in this area Stanford University is training researchers in the field.

The AFOSR reports no special patent problems that appear to deter industrial basic researchers from Air Force work.

nate av2 n° (nadot age i entere

and the state many of a

ONR does not have data permitting comparisons with NSF on proposal pressure. ONR interests are known generally and preliminary contact serves as a screen. Only proposals of some interest to ONR are submitted in most cases. There are few unsolicited proposals and their relative likelihood of support is not high.

In the nature of ONR relationships, contracts and negotiations, there are no serious administrative problems of a continuing sort involved with patents or publications. There are no cost-sharing requirements.

NATIONAL INSTITUTES OF HEALTH

NIH does not make grants to industry. Its awards to industry are in the form of contracts. Most of the contracts with industry are in response to requests for proposals. Within specific contracts it is sometimes necessary to perform some basic research, but such basic research is neither the major portion nor the primary purpose of the contract. This accounts for the fact that no industry basic research is reported by NIH in the annual Federal Funds report, since traditionally NIH has not split its awards for reporting purposes. Rather, the entire amount of any award has been allocated to the major research or development thrust.

There are relatively few unsolicited research proposals per year from industry. In FY 77, there were fewer than 10 active R&D contracts with industry resulting from unsolicited proposals, some new and some carryover from prior years.

In FY 76 there were about 300 R&D contracts awarded to for-profit organizations.

The determinations for awards to industry are made on the basis of competitive evaluation, with a very few awarded on the basis of "singular technical competency." NIH-supported research in industry is primarily in the life sciences.

NIH policies concerning both publications and patents resemble closely those of NSF. Researchers are encouraged to publish in the open literature and patent rights are dealt with on a deferred determination basis as with NSF. Cost-sharing is based on individual contract negotiations based on possible commercial advantage to the research performer.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

Discussions were held with NASA Headquarters research management staff in three areas - engineering, life sciences, and space and terrestrial sciences. NASA's policies on the support of basic research are completely open. Anyone can apply. From one area to another, practices vary. Project announcements and knowledge of program thrusts in each field have a major influence on the support sought by research performers.

1.1-1.1.6

de trabal careta

121 46. 8-10 offet Astronomic Lovations and Lovation Ad-Malakeson (Med He $\leq x_{2}$ 17 M 100 C 2004 and 160 Anna Chua (1950) - - -Transa Abrows A 3.31.000000 "这些"招手"的话题中的感。 1 383, 84 F ومرووب الموقول التواج . J. . fellens door disserver Fellens ferstens der s 1911 - N. C. C. PART IV at all the All and All lana iyon eenta lak beedi k 75 k0 Support of Basic Research in 过程 化氯化物 建橡胶纸 化分裂管 用具 Industry by Five Other in webserde sametai Federal Agencies Tank Island - Etc. Byefin A Q. 203 ser er stander i $\{g_i\}_{i\in \mathbb{N}} \in \{g_i\}, i\in \{0\}$ answerster 1 Antonia (alternation) Antonia (alternation) 25412333433 . 34761 1.1.1.5 马轮 建立分子器 化化合合式 经管理编码 化合金 化合金化合金合金 nanco kaliota isala koʻ^{ra} a partementar and 1937 at 19 anno and material and the static memory and the static state of the state of the A static term of 1938 at 19 and 19 (構成) かんしょう しんしょう of (no set). The terms of the experiment of the theory of the states of the second second second second second a (see 12), an as made a fair a first share had been a set and she have been a set of the The first search of sound could be contain the

	1889	·		44.
		-2	⊨ a (stat	
	Directorate/Field/Pro	ogram Area	No.	Amount
	Science Education		a sé grande raje y	4.
	Science & Society Science Education Science Education	Development Research	-	203,100 484,648 <u>19,890</u> \$707,638
	Administration		. 5 6	1,115,744
·.	Office of Planning &	Resources Manageme	ntrà Class6ero8 ext	295 ,999
	Office of Government	& Public Programs	2	anto?
				antropala 1960 - Station 1960 - Station 1960 - Station
		· 《合本》的代表:	iati Ante Ante	geloetorol - or e aveleg
	1/Appendix <u>B</u> provides 2/Includes Antarctic	1. Star 12	1712	i 11 i turun versioneta Automotipi usaata
		t Marshall (* 19	n 1918 - Statler States	ture (Allocite) - Merceles
	 A Constraints A Constraints A Constraints A Constraints A Constraints 	e Di Stational Anna		กระโปลม (11) (สายสม. 1940) 26 สาขาฐมาณี (1955) (19
		· · · · · · · · · · · · · · · · · · ·	stribu Baséla Pr	nna va fes , en galats
				ารแปนใน ก็สารกรุงไฟฟร์ เป็นสินสารคริสม ก็สารแห่งการการการกา
	i i detelar stre			· .
·			8	e de la Bracilia de Cardelanda. E
			en de la companya de La companya de la comp La companya de la comp	<pre>Part Durk Reserve Acade a</pre>
			una anna an taoinn a Taoinn an taoinn an ta	ennen etter som ander etter som att so Som att som att
•				

22.555

ww.

830

Table III-4

FY 1977 GRANT AND CONTRACT

AWARDS TO INDUSTRY1/

Directorate	No. Awards	Amount	% of FY 77 Obligations	FY 77 Obligations
Mathematical & Physical Sciences & Engineering	25. 9 12	\$ 718,335	.32%	\$224.4
Scientific, Technological & International Affairs	21	1,972,010	no f. 10, <u>15</u>	19.42/
Astronomical,Atmospheric, Earth & Ocean Sciences	19 19	8,137,372	3.48	233.5 ³ /
Research Applications	110	9,714,070	15.2	63.7 <u>2</u> /
Science Education	7		1 19	59.0 <u>4</u> /
Biological, Behavioral & Social Sciences	6 6	340,556	ന്നത്. .27	126.6
Planning & Resources Management	6	4 295,999	este : sire	ಿ ಕೆ. ಆಚಿತ್ರದ್ದ ನಿಜ್ಞಾನ ಬೆ ರ. ಕೇರೆಕ
Administration	6	1,115,744		tintes estatio
Government & Public Programs TOTAL:	<u>2</u> 189		3.2%	\$726.65/

Excludes purchase orders

23803 M

1 - 1646 X., Services

²/These figures shown without \$1.3 million transfer from RA to STIA for technology assessment as shown for FY 77 for consistency in the FY 1979 Budget request.

3/Includes U.S. Antarctic Program

 $\frac{4}{\text{Science Education total less Fellowships and Traineeships ($15.3m)}$

 $\frac{5}{FY}$ 1977 Total NSF obligations (\$791.8) less Special Foreign Currency (\$4.4m), PD&M (\$45.5m), and Fellowships and Traineeships (\$15.3m).

GENERAL NOTE

During a fiscal year some awards will be to support proposals received in the prior fiscal year. Some proposals received during the current fiscal year will not be acted on finally until the following fiscal year. In categories of small numbers, particularly where contracts are included, it is possible that for a single fiscal year awards may exceed proposals.

alitika kundora jeti

Table III-3

FY 1977 PROPOSALS RECEIVED FROM INDUSTRY

50

BY DIRECTORATE AND FIELD OF

SCIENCE OR PROGRAM AREA WITHIN DIRECTORATE

-	12.1	5	21	÷	÷	12
	•			-		

é se écolos

Directorate/Field	<u>No.</u>	Amount
Mathematical & Physical Sciences & Engineering		Anton of Lengue Process of Autobach Confection, Presidence of Autobach
Math & Computer Sciences Engineering Materials Research Physics	25.8	\$ 53,000 769,316 926,600
Physics Chemistry Other	$\frac{1}{22}$	212,500 509,750 10,535 501 (\$2,481,701) 502 (\$2,481,701)
Scientific, Technological & International	N.	
Policy Research & Analysis International Science Science Information Science Resources Studies TOTAL:	8 6 24 7 45	701,039 1,623,600 2,162,686 <u>488,613</u> \$4,975,938
Astronomical, Atmospheric, Earth & Ocean Sciences	<u>f</u>	s de la set de la main de séc. Deserver en la defini
Atmospheric Sciences Astronomy Polar Programs Ocean Sciences TOTAL:	9 1 <u>42</u> / <u>1</u> 2- 29	1,746,600 398,700 7,679,225 40,700 \$9,865,225
Biological, Behavioral & Social Sciences		and a second s
Biological Sciences Social Sciences Behavioral & Neural Sciences TOTAL:	7 2 2 11	1,250,100 175,600 98,900 \$1,524,600

 $\underline{L}' \text{Appendix} \ \underline{A}$ provides more detailed list by program element.

 $\frac{2}{1}$ Includes Antarctic Research Program logistics support.

. Table III-1

TOTAL PROPOSALS RECEIVED BY NS		1977
FROM ALL SOURCES AND FROM	I PRIVATE INDUSTRY	ly lin states
(Data as of Sept.	30, 1977)	Reader Nr. 1
	Total Erom	Color Alling
Directorate	ALL SOURCES	Total From Private Industry
Mathematical, Physical & Engineering	이 다른 물을 들은 문제를 다른다.	a second second second second second
Sciences and the second second second		A
 Provide the state of the state state state 	tich stranger (635)	Minal sector to Hoan
Affairs	1.027	45
Action and the state of the second state of th	mittabel weit size	व हा भाष राख्या भाषा अस्त आहे ।
Astronomical, Atmospheric, Earth & Ocean Sciences	2.988	29
しん かんし かいたいしょう しゃうち 読むがれ ない 読み とない かわれい たい	and the second frequencies of the	
Research Boolleanions	「谷谷」と「「「 」牛」か 」。 シャイ・トイ	
Biological, Behavioral & Social Sciences ad		
一般的现在分词 化磷酸盐 化硫酸钙化 化过多分的 法法法 建磷酸化物酶		n ne servize (prosperation) Miller Colombia
Science Education	7,421*	17
Other (Administration; Office of Planning & Resources Management;		
Office of Government & Public Programs)	54	13

TOTAL: 28,122

568

38.

*Excludes Fellowships and Traineeships.

The fiscal year 1977 data in Table III-3 show that more proposals were received in the materials research area than elsewhere in these three directorates, with atmospheric sciences, biological sciences, engineering, astronomy and chemistry all receiving four or more proposals. (Polar programs is considered to have received five research proposals when the nine for research support services are excluded).

The greatest number of basic research program awards were made to industry (Table III-5), in materials research, atmospheric sciences, engineering and biological sciences. (When Polar programs support awards are excluded, that program category drops to the low end of the group). Appendix B lists the grant and contract awards to industry by NSE directorate and program element.

The data for awards to small business, a subset of the data for all industry, are grouped by totals for each directorate and then are individually listed by award by Directorate in Appendix C. Review of the awards to small business made by the three basic research directorates in fiscal year 1977 shows that most of these awards are for analysis or evaluation of data on research materials.

The actual numbers of awards in these areas are too small to permit valid conclusions from statistical comparisons of these totals with the data on population characteristics and distribution of basic researchers in industry.

RESEARCH APPLICATIONS DIRECTORATE

Some 1417 proposals were received by the Research Applications Directorate in FY 1977. That directorate has accepted proposals from private firms without special criteria for qualification beyond the merit criteria used for consideration and support of proposals from other sectors. In addition, small business firms that have outstanding capabilities for scientific research or technology have been encouraged to submit proposals particularly because of special legislative provisions first added by the Congress in FY 1976. In FY 1977 the Research Applications directorate received 431 proposals from private industry, amounting to approximately 30% of the total received. Of the 431 there were 329 proposals that small businesses submitted in response to the "Small Business Innovation" solicitation. Research Application made 544 awards in FY 77, 110 awards were made to industry, nearly 20% of the RA total number of awards. Of the 110 RA awards to industry, 95 were to small business, 17.5% of the total number of RA awards.

RANN's proposals and awards are identified by field of program thrust rather than by the traditional fields of science or disciplinary area. In FY 1977 these grouped as follows (proposals from the solicitation are in the data, shown separately in parentheses): The largest NSE obligations incurred in awards to businesses other than through program directorates occurred in the Administration Directorate for support of the Foundation's data center and computer operations.

822

34

Strate Las

e-16 - 1

 $\{m_i\}_{i=1}^{M} \in \mathbb{R}^{N}$

Industrial proposal and award levels in NSF's basic research supporting directorates are discussed below. see rised as cut to she of through another sectors BASIC RESEARCH ONLY with sampair and the well that any the three second the second to be and the second to be a

This section considers proposal pressures on NSF from industry for basic research support in terms of the data for NSE's three directorates in which nearly all of the obligations are in support of basic research--the Directorate for Mathematical, Physical Sciences and Engineering (MPE), the Directorate for Biological, Behavioral and Social Sciences (BBS), and the Directorate for Astronomical, Atmospheric, Earth and Ocean Sciences (AAEO). enternet dan har

155 1 120 The Foundation's policy on the support of basic research proposals from private industry has been expressed for many years in these words:

"Private Profit Organizations: Commercial firms are infrequent recipients of awards for scientific research project support. However, in exceptional cases, unsolicited proposals for basic research will be considered from industrial organizations where: ndare her añ (a) the project is of special concern from a national point of view and shows promise of solving an important scientific 1980302 002 problem; (b) unique resources are available in industry for the work; or (c) the project proposal is outstandingly meritorious.

出版的 品牌 This policy has been widely known. It also has been misunderstood by some who have thought that NSE never makes awards to commercial firms for inter al support of basic research; such is not the case. Awards to private firms, for basic research support have been relatively infrequent but have been -vdaeveZ made by NSF for many years. . Shekasi kasi

Concerned that the long-standing wording of the basic research support policy may have been unduly negative in tone, the National Science Board lasi terej lato on January 19, 1978, took the following action:

ารกรณ์ - และหมวาสมี ธอ สุเวซ์ โรว สุขภารีที่รับได้ พระ หรุ่ง จระ ครั้งส่วนสุขภารสมัยว่าสายสมุณหลุ่มไปได้ is reveau by the average of internal from on sec of scientific interestion for the Division of Science Telecaucies.

excently of white date bearingers contin start which himses percented formed? eribosi kes estraiugai mesareni one bisilasiok

32

E.aB Corea of confirm of the defaultation population of solar devices and corea of confirm and the default of and the poyed by indicating which was dock and "ending of the first contact default of addient "in indicating shows the off indicating and "ending of the first contact addient "in indicating shows the off indicating and "ending of the first contact.

Birth US Lister of Beresel of Berelou and

fal count ver thus a constant active studies of the second studies of the second br>second second br>second second br>second second br>second second	1 21 20 21313	202 (Annorod) George (Constant Net you (Chail Bonaile: Me
isso PART III	1.1.1	ិភ ភ្ ពន៍
i i i i i i i i i i i i i i i i i i i		Superior install.
Science Founda		Солтанется Самонскатально вобо
Teneratoria de la Proposalis^a from a lindust Préferencies		2721238855889999 272239899835
Awards to Industry,	2.013 \sim	
Fiscal Year 1977		Colleter sciencists Solid Sciencists

(2) encourse for externances extremized in Darb RV ⁽²⁾ Sais encourse, daes not backet the list back of extrement, deary or equilater or encourse, they private listes as meaning the shoer volume of propriate view support of courtly accousted to all processors. For discrete this approximation (1) where the second course of the discrete the approximation of any second volume of a second to accoust or a second rest approximation of any second to restore this where a course data accoust of a provide the approximation of any second to the restore of this where a course data conduction the approximation of a second to the restore of the rest of the second restored any and a provide the approximation of a second to the restore of the rest of the second restored any and a provide the approximation of the approximation of the second restore of the rest of the second restored and any second restored to the restore of the rest of the second restored account of the approximation of the approximation of the second restored to the second restored account of the second restored to the restore of the restored at the second restored to the second restored to the second restored to the restore of the restored at the second restored to
Table II-11: Funds for Basic Research by Selected Industry for Firms With Less Than 1000 Employees, 1976

(Includes Company and Federal Funds)

818

Dollars in Millions

	ю	21 C	. 1	1976 Pre	imi	nary	%	of Total
TOTAL	•			68	÷.	1412		100%
Food and kindred products				2		G+		3
Chemicals and allied products Industrial chemicals Drugs and medicines Other chemicals			- 249 - 211 - 211	18 3 5 10			·	27 4 7 15
Petroleum refining and extracti	on			1			، محمود بر الم الج رائم الم الم	_2
Stone, clay, and glass products	· ·	. ~ `	1	4		2 44	1. 	-6
Primary metals Nonferrous metals and product	s			1 1	•		N 2. 53	2 2
Machinery Office, computing, and accoum machines	ntin	g		4				6 3
Electrical equipment and commun Communication equipment and communication Other electrical equipment	icat	ions		14 4 10				21 6 15
Transportation equipment other motor vehicles and eqpt.	thàn .2			ୁ 2	214 - 114 - 115		·	3
Other manufacturing industries				1		* · · · ·		2
Nonmanufacturing industries				21*				31

*Including commercial research and development firms.

Source: National Science Foundation Preliminary Data

Table II-9: Funds for Basic Research by Selected Industry {Includes Company and Federal Funds} 1971 and 1976

(Dollars in millions)

esta historia esta de la compañía de

angla di Quidenta (para kang

Total: Total: Chemicals and Allied	200 <u>22</u> 3013 022	<u>1971</u> \$581 216	% of Tota1 100% 37	<u>1976(</u> \$786 322	Preliminary) <u>% of Total</u> 100% 41	Percent Change 35% 49 56 Contemport
Drugs & Medicines	985	77	13	125	16	978:2-1 > 62
Petroleum refining & extraction Machinery	10. 11. 11. 21.	21 22	√3√ 4 4	45 36	6 5	114 64
Electrical equipment & communication	3	143	,25	148	19 19 10000 1000	4 (12)
Aircraft & Missiles	ê	53	9	52	aaano) 7. (2.5)	
Nonmanufacturing		. 31	્ 5	. 29	4 7,5,3%7	
All other industries	4 î.F	95	:16	154	20	63
97 - Maria I.		1. 81	12			14127778 (1977)
	123	3	12	-	lenne har de	a., (4.83)
	2		τ <u>e</u> ,		ka shinish Shiringa	Restantia (j. 19
Source: National Science 1/25/78	Founda	tion			1 2.82	an ng mgassi

ż8.

fonstikel Prijekt

Table II-7: Funds for Basic Research by Size of Company (Includes Company and Federal Funds) 1997 merels 1state3 (Dollars in millions) 1.1.1 ên k 332.52 Percent % of 1971 19<u>76(Preliminary</u>) Change Total 5 X. S $\sqrt{2}$ % of Total \$581. 100% \$786 Tota1 100% 35 $q \rightarrow q$ 36 6 69 9 Less than 1,000 employees 92 38_{8 (%} -26 51 5 1,000 - 4,999 employees 9 112 56 5,000 - 9,999 employees 72. 12 14 $-\sqrt{2}$ 10,000 or more employees 72 422 73 567₀₁₇₀ 34 ×4... 281.8 2835 1003710 958 -00 Source: National Science Foundation રક ને દ

연물수 영상의 수 있는 중이

1/25/78

23

NOTE: Since different companies comprise the specific size classes in each year, the data by size of company may not be entirely comparable.

8.S	$\Delta \widehat{g} = \{\widehat{g}\}$		14.7 <u>8</u>	
0 n	9.65	Q #*	5 (c.)	14.65
<u>.</u> .9		2.122	j,jM	. <u>N</u> NU
8. Q	- 	o si	Q.43	
3.8	1.23		1 S. M	1.50
(i ?	tanın Q.s.≯			
12.15	$\delta_{1},\delta_{1}^{(1)}$	8. ođ	C. 53	. J. Q.
1	19 (19) 19	na an transformation de la terraria	4 (A. (b)	(*35)\\?\{
19 A B	1 - 1 B	1. 1. 1.	n dina. Na sili a	(388 mill)

sereer (see ast in terms for activ). States

814

26.

Table II-5: Company Funded Basic Research as a Percent of Total Company R&D 5 anof (in the free) 1970 - 1978 1970 - 1978 4.3% 1970 a ed geograd) 4.3²⁶⁰⁰ 요구 가 공 <u>yesese</u>ĝ - 995 1971 238.5 人力教育 1972 3512 4.0 8V21 23 1973 3.893 364 <u>ε</u>ς. 1974 660 3.6 3001 ęt. 3.5 1975 rea. $\{\cdot,\cdot\}$ ete) 2.51976 0.82 3.5 (2)2725

3181	3.4	1977(est) @0	000	έλ
8V.97.	3.3	1978(est)	6 <u>7</u> 2	e7
(Ath Con	• S ^a tt	231	1078	-01 <u>-</u>
(1:5)879[1	265	10	77

sofence Plankerfold

8732776

Source: National Science Foundation

.876) (abana 1978) .859341 (b .5191-0178

15011162

24.

Table II-3

Share of Federal Basic Research Performed by Industry 1/ by Major States Support Agency, with Percent Change, FY 1971 & FY 1976

Agency	es tet see	<u>Share o</u> 1971	f Total 1976	<u>Pe</u> Vast Sevet	<u>Funding</u> rcent Chan 1971 - 76	ge
NASA		63%	43%	. 9701	-43%	
ERDA	2.2	16	28	1971	+45	÷.,
DOD	9.5	19	21		- 9	
NSF	3.5	.5	5	₹" <u>~</u> 1	+700	
OTHERS	ð š	2	3	1574	+50	
	8.1			<u>ल्</u> रभुर		

/ Includes federally funded research & development centers (FFRDC's) administered by this sector.

1979) X (est)

(0ze1879)

207

5

Ċ

90398-3

รักรหวันธ

Source: Federal Funds surveys. NSF

а.і 8.і

9

Source: <u>1225/78</u> (2) 1/25/78 (2) 1/25/78 second & development bender (2) 1/25/78 (2) 1/25/78 second & development bender (2) 1/25/78 (2) 1/25/78

22.