SECOND THEME SOURCEBOOK

VOLUME TWO:

BACKGROUND STUDIES RELATED TO COMMUNICATIONS FOR CANADA'S GROWTH

Prepared by:

Technology Policy Branch
Telecommunications and
Informatics Sector

May, 1986

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TABLE OF CONTENTS

A STATISTICAL OVERVIEW OF THE COMMUNICATIONS SECTOR IN CANADA

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TABLE OF CONTENTS

INTRODUCTION

The economic importance of the communications field has grown rapidly in recent years in Canada and worldwide, leading some to predict that the most prosperous nations in the 21st century will be those that make the greatest use of labour-saving advances in communications and information processing technologies.

Development and convergence in the telecommunciations and computer fields is dramatically changing the way voice, data and images are moved between places and stored. Distances between cities are disappearing as digital signal transmission speeds communications between people and computers. In the same way satellite technology is reducing communication barriers between continents.

Just as the Industrial Revolution improved efficiency through the mechanization of production, the 'information revolution' is improving productivity through wider access to labour-saving technology for use in industry and better information handling capabilities for the services sector. It has been suggested that the nations which quickly absorb, adapt and develop these new information processing and communications technologies will be in the most competitive positions as the world economy approaches the 21st century.
The communications sector is an important part of the Canadian economy. The activities of its four main economic subsectors - arts and culture, broadcasting, telecommunications and informatics - are quantitatively extensive and qualitatively diverse.

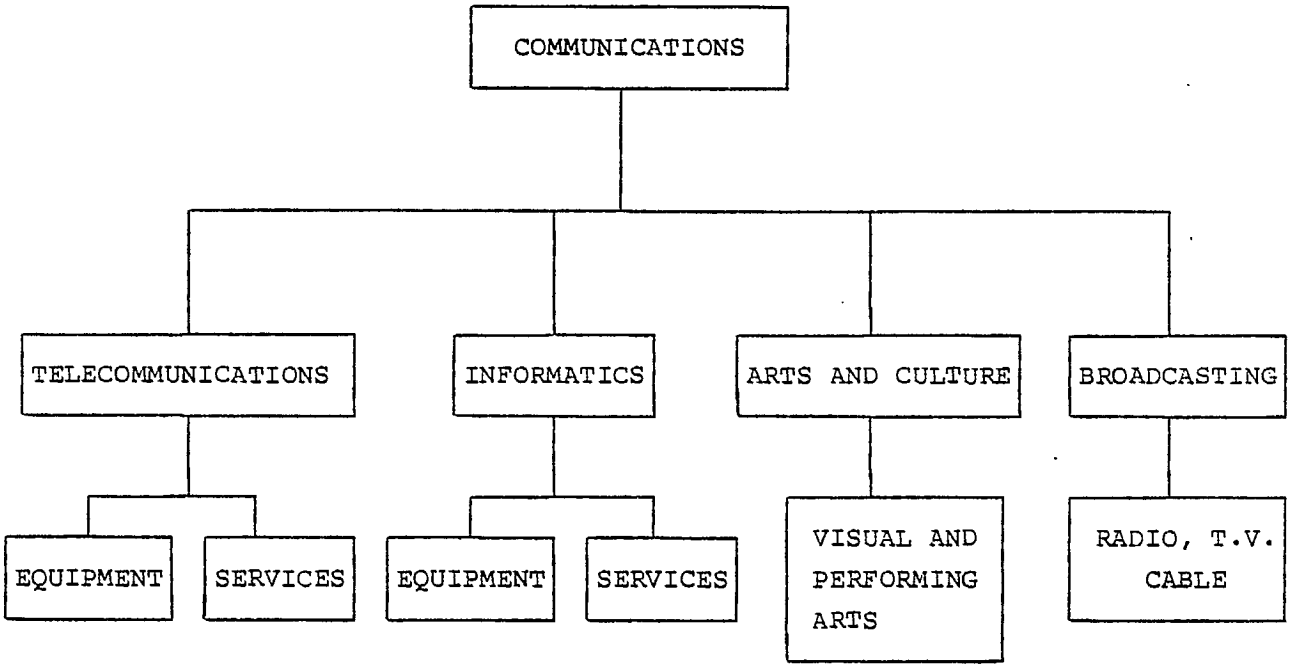
The hardware side of the telecommunications and computer sectors alone made shipments worth $5 billion in 1984 while the services side of these sectors including telephone, other telecommunications carriers, and computer services had revenues of $ 10 billion in 1983. Broadcasting revenues totalled $ 9.1 billion in 1983. The Canada Council estimates Canadians spent $ 10.3 billion on arts, culture and related activities in 1982. Taken all together these figures indicate the significant economic impact of the communcications sector in Canada.

In addition to generating significant employment, investment and export opportunities for Canada, the communications sector also provides important linkages between various sectors of the economy. They affect the way business is conducted, the nature of information design, creation, storage and communication, and the way people share knowlege. All of these influence Canada's social and economic development and indicate the importance of the communications field to Canada.

.../2

This report looks at the following communications sub-sectors: arts and culture, broadcasting, telecommunications and informatics, with particular attention to the last two of these sectors. A statistical appendix is included.

For the purposes of this report the communications field has been separated into four general areas of economic activity as indicated below:



.../3

ARTS & CULTURE

The field of arts and cultural activities is traditionally defined to include performing arts - music, dance, theatre, opera; visual arts - fine arts, photography, commercial art; crafts, literature, heritage, galleries, museums and libraries and the cultural industries - radio, television, film, video, sound recording and publishing.

The economic impact of these activities has escaped precise measurement in the past partly because no universal definition of the sector exists. This definitional problem can make certain regional studies or studies of specific activities incompatible with others. The problem of choosing an appropriate multiplier to be applied to direct expenditures also exists.

While no precise estimate has been established for the impact of arts and culture on the Canadian economy some figures are cited in the literature which indicate the order of magnitude of this impact.

A Canada Council report in 1983 suggested culture was the nation's 11th largest revenue industry, 4th largest job provider and the 6th largest paymaster[1]. A Statistics Canada report estimates the sector's labour force is growing at nearly twice the rate of the total labour force[2].

In 1981-82 federal government expenditures on arts and culture totalled $1.2 billion[3], about 1.8% of total federal spending. This included funding of wages, salaries, capital and operating budgets and grants for museums, archives, films, broadcasting, and the performing arts. Provincial expenditures in this field were $809.7 million in 1981-82. About half this figure was for libraries.

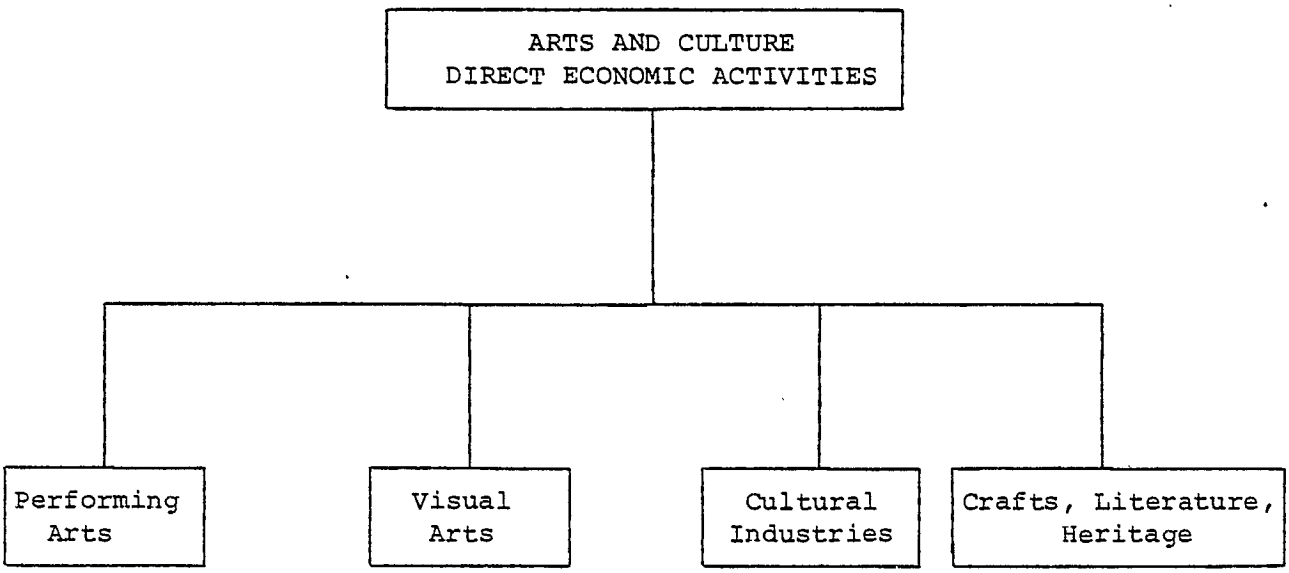
The performing arts alone - theatre, music, dance, opera - had an income of over $90 million in 1979, according to Statistics Canada figures[5] with about one third of this coming from public finances, the rest from paid attendance (8.6 million attendees in 1979) and private donations.

These revenues entered the economy through salaries to artistic personnel (48%), technical personnel (25%) and other expenditures on administration (27%).

Consumer expenditures on cultural products and services were estimated at $10.3 billion[6] by a recent Canada Council report. This figure includes expenditures for museum visits, publications, film/broadcasting, live performances and the like.

.../4

COMPONENTS OF THE ARTS AND CULTURE SECTOR



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NOTES

1. Research and Evaluation (The Canada Council), Selected Arts Research Studies, 3rd Edition, The Canada Council, 1983.

2. Graser, Gail, Manpower and The Arts: A Growth Area in Canada, Statistics Canada, 1984.

3. See: Statistics Canada catalogue 87-660.

4. See: Statistics Canada catalogue 87-610

5. Ibid.

6. Chartrand, Harry, An Economic Impact Assessment of the Canadian Fine Arts, Canada Council, 1984.

.../6

BROADCASTING

Radio and television broadcasting is an important component of the communications sector's economic impact. Radio, television and cable industry revenues totalled $1.3 billion in 1982, having more than doubled since the late 1970s. Nearly 29,000 people were employed by 510 radio and 67 television stations in 1982, not to mention those industries which are largely supported by the sale of commercial airtime - ad, promotion and public relations firms for example. Table 13 in the Appendix shows the path of industry revenue growth since the early 70's. It suggests the growing impact of broadcasting on the communications field and on the Canadian economy.

TELECOMMUNICATIONS

It has been said that Canada is fortunate to have been faced with the challenge of linking together communities from north to south and west to east, often long distances apart, because out of this grew the need to develop unique and reliable communications systems. The result has been the development of Canada's capability for designing and putting in place national communcications systems which are now in demand in many countries of the world giving Canada opportunities to export, worldwide,sophisticated information-communications technology and expertise.

TELECOMMUNICATIONS SERVICES:

Sector Description

The telecommunications services industry includes firms which emit, receive, switch or transfer, on a commercial basis, electro-magnetic or optical signals. This industry maintains Canada's local and long distance communications network via cable, microwave and satellite links. Voice telephony, public messaging (telegram), telex, electronic message, mail and text services, public data networks and private leased circuits are all part of the telecommunications services field. Traditionally a division is made between telephone services, local and long distance, and the other telecommunications services - telegraph, telex, satellite.

.../7

The Telephone Carriers

The telephone carrier component of the telecommunications services industry had revenues of $8.5 billion in 1983 representing 94 per cent of all telecommunications industry revenues in that year. The industry includes all local telephone service providers in Canada, mainly large companies serving an entire province with some of them owned by the provinces themselves. In addition there are another 110 smaller municipally owned telephone companies across Canada. The larger companies all belong to Telecom Canada, an unicorporated association responsbile for long distance telecommunications traffic crossing the territories of any of its members. Telecom Canada also negotiates rates and revenue sharing arrangements with Teleglobe Canada for overseas traffic, with U.S. carriers for telephone traffic south of the border and with CN Telecommunciations for traffic to Northern Canada and Newfoundland.

Regulation of the telephone carriers is divided in Canada among federal, provincial and municipal authorities making Telecom Canada rates subject to approval by eight regulating agencies, each acting independently. The regulatory bodies hand down decisions affecting competition, rate structure and the nature and quality of services offered by the telephone carriers.

Economic Trends

The telephone industry has enjoyed steady growth in revenues over the past ten years with total revenue more than quadroupling since 1973 growing from $2.1 billion that year to $8.5 billion in 1983. This represents a compound annual growth rate of 13.3 per cent. About half this revenue traditionally comes from long distance 'toll' services: the remainder from local services. Recent revenue growth has slowed however to 4.9 per cent over 1982-83 down from 13.4 per cent over 1981-82 and 17.7 per cent over 1980-81.

Since 1973 the number of telephone calls made in Canada has grown by 50 per cent surpassing 29 billion in 1982, up from 19 billion in 1973. Calls per capita grew from 854 per capita in 1973 to 1,173 in 1982, a 30 per cent increase. The number of installed telephones has increased 43 per cent from 11.7 million in 1973 to 16.8 million in 1982.

Employment in the telephone industry has actually increased 39.7 per cent since 1973 rising from 75,407 in that year to 105,354 in 1983.

.../8

OTHER TELECOMMUNICATIONS CARRIERS

The telecommunciations sector, excluding the telephone carriers, includes CNCP Telecommunications, Teleglobe Canada and Telesat Canada. CNCP Telecommunciations, the second national telecommuncications network, offers public message services (telegram, overseas cable, telex) and other data, voice and broadcast services through its own national microwave relay system and switching centres.

Telesat Canada, the national satellite carrier, is a member of Telecom Canada. It has the sole responsibility of providing domestic satellite services as well as transborder satellite services to the U.S., subject to regulatory requirments in both countries.

Teleglobe Canada, a federal crown corporation, offers international telecommunications services. In 1984, eighty per cent of Teleglobe's revenues were generated from telephone and telex services. The company links 70 per cent of Canadian telephones to destinations in 87 countries around the world and offers telegraph services to 250 other countries. In the course of service diversification, Teleglobe has begun offering satellite links between Canadian based multinationals and their overseas offices through its Globesat service using small dish technology.

Economic Trends

The non-telephone telecommunications carriers had revenues of $530.3 million in 1982 representing 6.4 per cent of all telecommunications industry revenues. Despite the fact this represents triple the revenue of the industry in 1973, employment has fallen over the last decade by over one thousand, from 7,047 in 1973 to 6,027 in 1982.

Telesat is responsible for 11 per cent of the non-telephone telecommunications carriers revenues; Teleglobe Canada 32.4 per cent and CNCP Telecommunications with the largest portion at 56.3 per cent of all revenues. The largest proportion of the group's revenue by type of service is from leased circuit services (26.8 %) followed by private telephone services (25.6 %), leased plant (19.4 %) and other non-transmission services (6.4%) These proportions of 1982 total revenue for the group have changed little since the mid 1970s suggesting that their traditional services remain in demand in the marketplace.

.../9

TELECOMMUNICATIONS EQUIPMENT:

Sector Description

The telecommunications equipment industry is composed of establishments primarily engaged in manufacturing telephone, telegraph, and transmission systems and equipment along with related communications products. Product and equipment areas include: telephone and telegraph carrier equipment, central office switching systems, telephone sets, private branch exchanges, satellite communication systems and components; transmission systems (cable, microwave and optical fibre); mobile radio, radio telephones and paging systems, and other terminal attachment equipment. Prior to January 1985, Statistics Canada also included security and alarm systems, TV equipment and parts and other products associated with telecommunications under their Communications Equipment Manufacturing Industry survey. The data in this study reflects Statistics Canada sector definition prior to January, 1985.

Structure and Characteristics

The Canadian telecommunications equipment industry is dominated by large firms with the capacity for adequate R&D expenditures to keep their technology internationally competitive. International marketing is also important for developing a customer base large enough to support sufficient financial and managerial resources to be a competitive firm.

The dominant Canadian telecommunications equipment manufacturer is Northern Telecom, a subsidiary of Bell Canada Enterprises which owns 50% of Northern Telecom's shares. Northern Telecom is the second largest telecommunications equipment manufacturer in North America and the seventh largest in the world. The company operates subsidiaries for manufacturing in Canada and the U.S. and international subsidiaries for marketing and equipment maintenance, based in Canada and the U.S.

Five other Canadian based companies, besides Northern Telecom, have annual sales exceeding $100 million. Microtel Ltd., Mitel Corporation, Electrohome Ltd., Canadian Marconi Ltd., and Spar Aerospace had 1984 revenues of $1.2 billion, about one third of Northern Telecom's revenue for the same year.

.../10

These firms design and manufacture a wide variety of telecommunication and satellite transmission equipment from traditional switching systems and private branch exchanges to satellite earth stations and military radar technology.

There are nine establishments with over 100 employees that account for 47% of total shipments. Fifty-nine establishments employing 100 to 1,000 represent another 41% of total shipment. The remaining 375 establishments with less than 100 employees account for 12% of shipments.

The industry is based largely in Ontario and Quebec. Ontario has 54% of the establishments with 60% of total shipments and employment. Quebec has 23% of establishments in the industry with 27% of employment and 29% of shipments.

Economic Trends

Telecommunications equipment is contained in the communciations equipment classification, SIC 335. As with the electronics sector as a whole, communications equipment experienced strong recovery in 1984 with shipments reaching $3.5 billion. If present trends continue the next few years could see a return to pre-recession growth levels in the communications equipment sector.

Throughout the 1970s shipments of communications equipment rose every year although sometimes fluctuating dramatically from year to year. The 1980-81 recession reduced shipments in 1982-83 but growth began to rebound in 1984, approaching pre-recession levels. From 1974-84 the compound annual growth rate for shipments of communications equipment was 11.1 per cent. This represents an increase from shipments of $1.2 billion in 1974 to $3.5 billion in 1984. The largest period of growth was from 1979-84, despite the recession.

Exports of communications equipment grew from 36 per cent of shipments in 1973 to 73 per cent in 1984. Annual growth of exports again was stronger in the latter half of the 1974-84 period averaging 27.3 per cent between a year from 1974 and 1979 compared to 15.0 per cent annual growth from 1974 to 1979. Exports totalling $408 million in 1974 grew to $2.7 billion by 1984. Imports declined during the recession but still maintained 17.5 per cent annual growth helping reduce the trade deficit in communications equipment from $571 million in 1981 to $444 million in 1984 although the trade deficit remains substantial compared to 1974 when it was $222 million.

.../11

The Apparent Domestic Market for communications equipment has grown more slowly than total shipments and exports by Canadian producers. The compound annual growth rate from 1974 to 1984 was 10.6 per cent. Canada's ADM was $837 million in 1974 and rose to $4.6 billion in 1984. Imports grew as a share of the ADM from 44 per cent in 1974 to 81 per cent in 1984. While domestic production increased over this period it appears to have been export rather domestically oriented.

INFORMATICS SERVICES:

Sector Description

The informatics services industry includes firms providing information processing, computer consulting, and software development services. Three sub-categories are generally used to describe this industry. First, processing services which includes input preparation and data entry, data processing and information retrieval. Second, professional or consulting services including systems development, custom programming, hardware and software maintenance, education, training and research services. Finally, software products which includes the sale, lease and rental of systems and applications software.

Two types of software traditionally identified are systems and applications. Systems software directs the fundamental operation of the computer providing instructions for hardware control, computer memory, allocation and management of computer resources. Applications software, in contrast, instructs the computer's processor as to how end-user tasks are to be performed. Applications software in packaged or custom form performs functions such as word processing and financial spread sheets.

Structure and Characteristics

The computer services industry in Canada can be divided into three general areas: processing or 'machine-based' services, provided largely by the service bureaux; custom systems development and computer consulting - the 'people based' sector; and finally, the software sector including systems and applications software.

.../12

The second largest source of computer services revenue in Canada is custom systems development and computer consulting. It accounted for 25.6 per cent of industry revenues in 1983. Some firms in the computer services field offer EDP hardware for lease or rental. According to Statistics Canada, in 1983, 12.2 per cent of total computer services revenue was from hardware lease and rental.

The fourth source of revenue for the computer services industry is software sales, lease and rental. $178.6 million in revenue was generated in the software field in 1983, according to Statistics Canada. This is about 12.3 per cent of all industry revenues.

Economic Trends

Canada's computer service industry has experienced tremendous growth in the past ten years. Revenues were $131 million in 1972. These reached $638 million by 1979 then doubled to $1.4 billion by 1983. The industry's strongest growth occurred from 1974 to 1979 when the compound annual growth rate was 24.8 per cent. This rate slowed to 17.7 per cent a year from 1979 to 1983. Revenue from outside Canada, while not substantial, has grown from 2.0 per cent of total revenues in 1973 to 5.7 per cent in 1983.

The number of firms in the industry has also grown dramatically. There were 331 computer service firms in 1971: in 1983 there were 1836. Employment has grown nearly 10 per cent a year in the industry through the 1970s increasing from 8,956 in 1974 to 21,973 in 1983.

Since the early 1970's demand for computer services as a whole has shifted somewhat, towards the services sectors of the economy. Financial institutions, health services and the service trades (doctors, lawyers) have increased their share of total computer usage while primary and manufacturing sectors now use a lower proportion of all computer services provided in Canada than they did in the early 1970s. In-house computer capabilities may partly explain the lower use of outside services by these sectors.

.../13

INFORMATICS EQUIPMENT:

Structure and Characteristics

The Canadian informatics equipment industry consists largely of subsidiaries of the major multinational computer corporations and a group of smaller, mostly Canadian-controlled firms. The multinational subsidiaries undertake development and production of hardware for the domestic market to differing degrees. Some of their activity is part of a world product mandates which may partly explain the high export orientation of Canadian production, with the domestic market supplied largely imports.

IBM dominates the informatics equipment manufacturing industry in Canada. IBM revenues from EDP equipment totalled $2.8 billion in 1984, up 29% from 1983 and accounting for 43% of the EDP revenues of Canada's top 100 hardware supply firms.

After IBM, there were 13 firms with EDP revenues exceeding $100 million in 1984. Together they accounted for 40.6 of top company EDP revenues. The remaining 10 firms ranging from $1 to $98 million in revenues. Eighty-one per cent of the top 100 firms, represent only 15.5% of total EDP revenues, according to Evans Research estimates.

Economic Trends

Informatics equipment - computers, peripherals, etc. - is contained in the Office and Store Machinery Classification, SIC 318. Shipments of office and store machinery grew more quickly than the electronics sector as a whole in both the periods 1974-79 and 1979-84. Shipments grew at an annual rate of 11.6 per cent from 1974-79 starting at a level of $346 million in 1974. By 1984 total shipments were $1.6 billion.

Exports slowed in their rate of growth during the recessionary early 1980s dropping from annual growth of 23.6% from 1974-79 to 17.4% during 1979-84. Total exports were $1.8 billion in 1984 having grown from $281 million in 1974. Canada's export performance was strong over this period. In 1974 exports were 63 per cent of shipments: by 1984, 88 per cent of shipments were exported.

.../14

Imports grew more quickly from 1979-84 than from 1974-79 despite recessionary effects on demand. Annual growth was 26.0 per cent between 1979 and 1984, and 14.7 per cent from 1974-79. The trade balance was adversely affected as import growth outpaced export growth. Imports totalled $772 million in 1974 when the trade deficit was $491 million. In 1984 total imports were $4.8 billion and the trade deficit reached $3.0 billion.

The Apparent Domestic Market for office and store machinery, including computers, grew 18.6 per cent a year from 1974 to 1984. The ADM was $837 gain million in 1974. This tripled to $2.1 billion by 1980 then doubled again to $4.6 billion by 1984.

WORLD AND CANADIAN DEVELOPMENTS

The following briefs are from current market research by A.D. Little:

- Total free world revenues from information processing products grew to $112 billion in 1984, up 16% from 1983;

- Desktop computers, software and 'general-purpose' computers experienced high growth in shipments but software is expected to be the highest growth sector doubling from 10% of worldwide information processing revenues now to 20% by 1994;

- An increased need for central 'general-purpose' computer power and file storage has been identified as interactive and office automation markets grow;

- IBM continues to outpace growth of the second largest company, Digital Equipment;

- By 1994, storage peripherals will be the largest' equipment market by far. The next largest markets in 1994 will be systems/utilities software, application software and special-purpose computers;

- U.S. industry revenue growth is expected to be 8-9% a year during 1989-1994;

.../15

- Western Europe, because of its slight lag behind the U.S. in technology use, is expected to move more quickly through the intermediate step in the evolution of integrated office systems - i.e. the desktop computer proliferation - towards multifunction workstations; and

- Western Europe's information processing product revenue grown only 7% in 1984.

Meanwhile, Evans Research Corporation reports that:

- While revenue of Canada's information processing industry is recovering from the 1981-1983 recession, the short-term industry outlook is not certain;

- Information processing equipment manufacturing is 'becoming a two horse race' between IBM and the Pacific Rim forcing other U.S. and Canadian suppliers to fight hard for market share;

- The market for computers has become saturated in recent years, with IBM leading the way leaving its competitors to find market niches or areas of the market to which IBM has not addressed itself;

- IBM is competing on price with makers of plug compatible equipment. It now has about 40 per cent of the total revenue from the fastest growing micro-market;

- By 1990 IBM could have 70 per cent of the Canadian hardware micro-market;

- The Pacific Rim suppliers of personal and home computers have posed little threat to IBM's dominance of the Canadian market but they have been successful in markets for printers, low and mid-range Direct Access Storage Devices (DASD), monitors and soon in modem and multiplexor markets;

- The market for applications software packages is expected to grow at 28 per cent a year through 1989 and 27 per cent for systems packages and related maintenance;

.../16

- Hardware manufacturers such as IBM are moving more and more into the microcomputer software packages market; and

- Some growth is expected in the processing services market to 1988-89.

LIST OF TABLES

LIST OF TABLES (CONT'D)

Table 1

SUMMARY STATISTICS

Communications Equipment and Components - SIC 335

$ million	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Compound Annual Growth Rates (%) 1974-1979	1979-1984	1974-1984
ADM[1]	1082	1453	1529	1628	1828	1967	2404	2881	3357	3280	3413	3961	10.6	10.5	10.6
SHIPMENTS	889	1225	1368	1383	1441	1532	1814	2329	2786	2947	2834	3517	8.2	14.2	11.1
TRADE BALANCE	-193	-228	-161	-245	-387	-435	-590	-552	-571	-333	-479	-444	8.5	-5.9	6.9
TOTAL EXPORTS[2]	351	408	433	468	437	572	821	1139	1467	1542	1805	2749	15.0	27.3	31.0
RE-EXPORTS	27	33	44	47	39	45	71	97	99	119	149	198	16.6	27.5	19.6
IMPORTS	544	636	594	713	824	1007	1411	1691	2038	1875	2284	3193	17.3	17.7	17.5

NOTES: [1]ADM, Apparent Domestic Market includes total shipments less export plus imports.

[2]Includes re-exports, which are goods imported to Canada and exported without Canadian value-added.

SOURCE: Shipments, Exports, Imports from Department of Regional Industrial Expansion, Sector Analysis Division, Electronics and Aerospace, Statistical Unit.

ADM, Trade Balance derived from DRIE data.

Table 2

SUMMARY STATISTICS

Office and Store Machinery and Equipment - SIC 318

$ MILLION	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Compound Annual Growth Rates (%) 1974-1979	1979-1984	1974 1984
ADM[1]	620	837	816	846	924	1216	1445	2101	2919	3203	3166	4619	11.6	26.2	18.6
SHIPMENTS	287	346	373	412	417	547	725	889	1147	1246	1170	1558	16.0	16.5	16.2
TRADE BALANCE	-333	-491	-443	-434	-507	-669	-720	-1212	-1772	-1957	-1996	-3061	8.0	33.6	20.0
TOTAL EXPORTS[2]	245	281	317	379	4414	574	810	926	1111	1187	1379	1805	23.6	17.4	20.4
RE-EXPORTS	39	64	45	48	67	99	168	187	237	1260	310	428	21.3	20.1	20.9
IMPORTS	578	772	760	813	921	1243	1530	2138	2883	3144	3375	4866	14.7	26.0	20.2

NOTES: [1]ADM, Apparent Domestic Market includes total shipments less exports plus imports.

[2]Includes re-exports, which are goods imported to Canada and exported without Canadian value-added.

SOURCE: Shipments, Exports, Imports from Department of Regional Industrial Expansion, Sector Analysis Division, Electronics and Aerospace, Statistical Unit.

ADM, Trade Balance derived from DRIE data.

Table 3

SUMMARY STATISTICS

Consumer Electronics - SIC 334

$ MILLION	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Compound Annual Growth Rates (%) 1974-1979	1979-1984	1974-1984
ADM[1]	584	588	494	606	530	588	695	815	1024	972	1276	1694	3.4	19.5	11.1
SHIPMENTS	352	315	274	254	166	172	258	352	416	405	473	492	-2.5	13.8	4.6
TRADE BALANCE	-232	-273	-220	-352	-364	-416	-437	-463	-608	-567	-803	1202	9.9	22.4	16.0
TOTAL EXPORTS[2]	33	36	32	32	57	97	107	73	90	113	145	176	24.3	10.5	17.2
RE-EXPORTS	1	3	5	1	2	1	3	5	4	5	5	5	0	10.8	5.2
IMPORTS	265	309	252	394	421	513	544	536	698	680	948	1378	12.0	20.4	16.1

NOTES: [1]ADM, Apparent Domestic Market includes total shipments less exports plus imports.

[2]Includes re-exports, which are goods imported to Canada and exported without Canadian value-added.

SOURCE: Shipments, Exports, Imports from Department of Regional Industrial Expansion Sector Analysis Division, Electronics and Aerospace, Statistical Unit.

ADM, Trade Balance derived from DRIE data.

Table 4

SUMMARY STATISTICS

Electronic Instruments and Related Products - SIC 3911

$ MILLION	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Compound Annual Growth Rates (%) 1974-1979	1979-1984	1974-1984
ADM	408	468	526	597	662	819	965	1188	1370	1422	1444	1627	15.6	17.6	13.2
SHIPMENTS	316	358	414	473	507	618	722	880	988	1013	1010	1024	15.0	7.2	11.0
TRADE BALANCE	-92	-110	-112	-124	-155	-201	-243	-308	-382	-409	-434	-603	17.1	19.9	18.5
TOTAL EXPORTS	54	56	64	73	79	102	147	180	193	178	177	204	21.3	6.8	13.8
RE-EXPORTS	1	3	5	1	2	1	3	5	4	5	5	5	0	7.6	5.2
IMPORTS	146	166	176	197	234	303	390	488	575	587	611	807	18.6	15.7	17.1

NOTES: ADM, Apparent Domestic Market includes shipments less exports plus imports.

SOURCE: Department of Regional Industrial Expansion, Sector Analysis Division, Electronics and Areopsace, Statistical Unit, 1984.

Import and export data taken from DRIE data, as noted above, which is based on Statistics Canada data.

Table 5

SUMMARY STATISTICS

Total Electronics Sector

$ MILLION	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	Compound Annual Growth Rates (%) 1974-1979	1979-1984	1974 1984
ADM[1]	2694	3346	3365	3677	3944	4590	5509	6985	8670	8877	9299	11901	10.5	16.7	13.5
SHIPMENTS	1844	2244	2429	2522	2531	2869	3519	4450	5337	5611	5587	6591	9.4	13.4	11.4
TRADE BALANCE	-850	-1102	-936	-1155	-1413	-1721	-1990	-2517	-3333	-3266	-3712	-5310	12.6	21.7	17.0
TOTAL EXPORTS	683	781	846	952	987	1345	1885	2318	2861	3020	3506	4934	19.2	21.2	20.2
RE-EXPORTS	68	103	99	97	111	146	245	294	344	1389	469	636	18.9	21.0	20.0
IMPORTS	1533	1883	1782	2107	2400	3066	3875	4835	6194	6286	7218	10244	15.5	21.5	18.5

NOTES: [1]ADM, Apparent Domestic Market includes total shipments less exports plus imports.

SOURCE: Department of Regional Industrial Expansion, Sector Analysis Division, Electronics and Aerospace, Statistical Unit, 1984.

Import and export data taken from DRIE data, as noted above, which is based on Statistics Canada figures.

Table 6

SHARE OF TOTAL ELECTRONICS ADM

By Subsector (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
COMMUNICATIONS EQUIPMENT, COMPONENTS (SIC 335)	40	43	45	44	46	43	44	41	39	37	37	33
OFFICE AND STORE MACHINERY AND COMPUTER (SIC 334)	23	25	24	23	23	27	26	30	34	36	34	39
HOUSEHOLD RADIO AND TELEVISION (SIC 334)	22	18	15	17	13	13	13	12	12	11	14	14
INSTRUMENTS AND RELATED PRODUCTS (SIC 3911)	15	14	16	16	17	18	18	17	16	16	16	14

SOURCE: Figures derived from tables 1 to 4.

Table 7

SHARE OF TOTAL ELECTRONIC SHIPMENTS

By Subsector (%)

	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	1974	1973
COMMUNICATION EQUIPMENT AND COMPONENTS	53	53	53	52	52	52	53	57	55	56	55	48
OFFICE & STORE MACHINERY	24	21	22	22	20	21	19	17	16	15	15	16
HOUSEHOLD RADIO AND TELEVISION	8	7	7	8	8	7	6	7	11	11	14	19
ELECTRONIC	16	18	18	17	20	21	22	20	19	17	16	17

SOURCE: Figures derived from Tables 1 to 4.

Table 8

SHARE OF TOTAL ELECTRONICS IMPORTS

By Subsector (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Communications Equipment	31	32	30	33	36	36	33	34	34	33	34	36
Office and Store Machinery	48	47	50	47	45	40	41	38	39	43	41	38
Consumer Electronics	14	13	11	11	11	14	17	18	18	14	16	17
Electronic Instruments	8	9	9	9	10	10	10	10	9	10	9	10

SOURCE: Percentages, derived from DRIE figures on shipments and imports as shown in tables 1 to 4.

Table 9

SHARE OF TOTAL ELECTRONICS EXPORTS

By Subsector (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Communications Equipment	48	55	56	55	57	53	52	52	52	53	53	53
Office and Store Machinery	16	15	15	16	17	19	21	20	22	22	21	24
Consumer Electronics	19	14	11	11	7	6	7	8	8	7	7	8
Electronic Instruments	17	16	17	19	20	22	21	20	17	18	18	16

SOURCE: Figures derived from tables 1 to 4.

Table 10

IMPORT PENETRATION[1]

By Subsector (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Communications Equipment	50	44	39	44	45	51	59	59	61	57	67	81
Office and Store Machinery	93	92	93	96	100	102	106	102	98	98	106	105
Consumer Electronics	45	53	51	63	79	87	78	66	68	70	74	81
Electronic Instruments	36	36	34	33	35	37	40	41	42	41	42	50

NOTES: [1]Share of ADM held by imports, in percentage.

SOURCE: Figures derived from tables 1 to 4.

Table 11

EXPORT PERFORMANCE[1]

By Subsector (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Communications Equipment	36	27	28	30	28	35	41	45	49	48	56	73
Office and Store Machinery	59	63	73	80	83	87	89	83	76	74	91	88
Electronic Consumer Products	9	11	10	12	33	55	40	19	21	26	30	35
Electronic Instruments	13	12	12	13	13	14	17	17	16	14	14	16

NOTES: [1]Share of domestic shipments exported, in percentages.

SOURCE: Derived from DRIE figures on Shipments and Exports, as shown in tables 1 to 4.

Table 12

NET DOMESTIC SHIPMENTS

By Subsector ($ million)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
Communications Equipment	565	850	979	962	1044	1004	1064	1288	2418	1523	278	966
	(64)[1]	(70)	(72)	(70)	(73)	(66)	(59)	(55)	(87)	(52)	(44)	(28)
Office and Store Machinery	82	129	101	81	70	72	83	150	273	319	102	181
	(29)	(37)	(27)	(20)	(17)	(13)	(12)	(17)	(24)	(26)	(9)	(12)
Consumer Electronics	320	282	247	223	111	77	154	284	330	298	333	321
	(91)	(90)	(90)	(88)	(67)	(45)	(60)	(81)	(79)	(74)	(70)	(65)
Electronic Instruments	274	314	363	414	442	529	598	732	830	873	872	865
	(87)	(88)	(88)	(88)	(87)	(86)	(83)	(83)	(84)	(86)	(86)	(85)
TOTAL ELECTRONICS	2333	2585	3013	3851	2454	1899	1182	1667	1680	1690	1575	1241
	(67)	(70)	(70)	(67)	(66)	(59)	(54)	(55)	(72)	(54)	(46)	(35)

NOTES: [1]number in brackets are share of total shipments shipped domestically including: total shipments less total exports (excluding re-exports).

SOURCE: Figures derived from tables 1 to 4.

Table 13

RADIO AND TELEVISION BROADCASTING

SUMMARY STATISTICS

$ MILLION	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
OPERATING REVENUE: PRIVATE RADIO	160	183	208	244	272	309	356	397	445	476	492	559
PRIVATE TELEVISION	171	194	234	282	331	404	473	562	652	746	786	899
CBC (RADIO-CANADA):	205	239	299	342	409	467	562	522	783	665	745	N/A
FEDERAL EXPENDITURE[1]												
OPERATING REVENUE	46	50	64	78	69	76	90	104	109	111	131	161
CABLE TV REVENUE	107	133	162	199	233	273	314	352	405	472	544	N/A
TOTAL REVENUE	377	427	506	605	671	788	919	1,063	1,206	1,333	1,953	-
TOTAL EMPLOYEES												
PRIVATE RADIO	6,998	7,296	7,530	7,920	8,286	8,674	9,069	9,547	9,693	9,737	9,666	10,025
PRIVATE TELEVISION	4,687	5,019	5,396	5,338	5,682	5,944	6,365	6,685	6,841	6,840	6,892	7,215
CBC (RADIO-CANADA)	9,487	9,946	10,571	11,422	11,683	12,233	12,241	12,104	12,258	12,129	12,334	12,473
TOTAL	21,172	22,261	23,497	24,680	25,651	26,851	27,675	28,336	28,792	28,706	28,892	29,713
TOTAL STATIONS:												
RADIO	348	385	392	402	419	440	476	492	496	510	475	484
TELEVISION	60	59	59	59	N/A	59	67	69	69	67	81	81

NOTES: [1]From Public Accounts, Minister of Finance, Years as Indicated.

SOURCE: Statistics Canada Catalogue 56-204, 56-205.

Table 14

FIRMS SUPPLYING COMPUTER SERVICES

Summary Statistics

	1973[1]	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	CAG 1974-1983
ESTABLISHMENTS	331	345	397	489	596	698	689	1,036	1,392	1,752	1,836	18.1
EMPLOYEES	14,173	8,965	8,737	10,288	11,879	13,196	14,400	17,599	20,596	22,317	22,191	9.5
TOTAL OPERATING REVENUE ($ MILLION)	589.7	211.0	285.7	327.5	416.0	531.8	638.0	819.8	1,102.2	1,347.0	1,441.6	21.1
TOTAL REVENUE FROM OUTSIDE CANADA ($MILLION)	11.7 (2.0)[2]	10.7 (5.0)	7.9 (2.8)	8.9 (2.7)	10.1 (2.4)	17.9 (3.4)	38.1 (6.0)	48.9 (6.0)	58.8 (5.3)	75.5 (5.6)	83.4 (5.7)	22.7

NOTES: [1]After 1973, firms engaged in sale, rental and leasing of EDP hardware were separated out of this classification.

[2]Figures in brackets show share of total revenue earned outside Canada, in percentages.

SOURCE: Statistics Canada, Catalogue 63-222

Table 15

Computer Services Industry Revenue

By Class of Customer (%)

	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
CONSTRUCTION	1.2	1.9	1.8	1.5	1.5	1.3	1.5	1.9	1.3	1.4	1.4	
EDUCATION	9.8	2.1	4.4	3.2	2.7	2.3	2.4	2.0	2.2	2.6	2.3	
FINANCIAL INSTITUTIONS (BANKS, STOCK BROKERS, ETC.	16.6	15.5	12.3	14.1	17.0	17.9	17.8	17.4	18.2	20.0	21.0	
GOVERNMENTS	16.7	18.9	20.6	20.6	21.9	19.8	19.0	18.7	18.0	18.8	16.0	
HEALTH SERVICES (HOSPITALS, ETC.)	2.2	1.6	1.8	2.0	2.5	2.7	2.7	4.3	4.3	3.5	4.6	
MANUFACTURING	13.7	20.3	14.8	11.9	8.8	8.4	9.8	9.8	8.8		8.6	
PRIMARY INDUSTRY (FISHING, MINING, LOGGING)	11.1	9.3	10.7	11.1	12.0	13.2	12.9	13.0	12.2	12.8	10.7	
SERVICES TRADES (DOCTORS, LAWYERS, HOTELS, RESTAURANTS)	4.7	3.8	7.7	11.1	11.3	12.5	11.8	12.5	10.8	10.1	12.9	
TRANSPORTATION AND COMMUNICATION	8.3	6.9	8.0	7.9	.8	7.2	7.3	6.7	7.9	5.7	7.6	
WHOLESALERS, RETAILERS	8.0	15.7	14.9	13.7	14.2	13.5	13.1	12.6	12.9	11.2	12.2	
OTHER	6.7	4.0	3.0	1.7	1.3	1.2	1.7	1.1	3.4	4.5	2.7	

SOURCE: Statistics Canada, Catalogue 63-222

Table 16 a

Firms Engaged in Sales, Lease, Rental

of EDP Hardware

	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983
ESTABLISHMENTS	35	50	27	26	32	30	29	28	56	82
EMPLOYEES	9,462	9,501	8,927	8,341	8,855	9,468	9,765	10,055	10,065	6,232
REVENUE ($000)	612.0	648.8	720.7	797.1	929.9	929,911	1,110.7	1,441.3	1,845.9	1,091.5

SOURCE: Statistics Canada, Catalogue 63-222

Table 16 b

Principal Statistics Reported by the Statistics Canada Computer Service Industry Survey, 1972-1983

Item	Group	1972 (4)	1973 (4)	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	CAG 74-79	CAG 79-83
1. Establishments	Services	309	331	345	397	489	596	698	689	1,036	1,392	1,752	1,836	14.8	21.7
	Hardware (1			35	50	47	26	32	30	29	28	56	82	-3.1	22.2
	Sec. Supp.(2)	329	405	381	284	502	454	-	-	-	-	-	-	-	-
	Total	638	736	761	731	1,038	1,076	730	719	1,065	1,420	1,808	1,918	-1.1	17.7
2. Total Operating Revenues ($ M)	Services	131.	166.6	210.9	285.7	327.5	416.0	531.8	638.0	819.8	1,102	1,348	1,442	24.8	17.7
	Hardware	403.	423.1	612.0	648.8	803.1	797.1	879.8	929.9	1,111	1,411	1,846	1,092	8.7	3.3
	Sec. Supp.	37.	60.6	100.1	97.2	116.9	148.7	-	-	-	-	-	-	11.1	10.0
	Total	572.	650.3	923.0	1,031.7	1,247.5	1,361.8	1,411.6	1,567.9	1,930.8	2,513.0	3,194	2,534	28.9	27.0
3. Revenue Generate Outside Canada ($ M)	Services	10.	11.7	10.7	7.9	8.9	10.1	17.9	38.1	48.9	58.8	75.5	83.4		
	Hardware (3)			(15.2)	(17.4)	(8.9)	-	-	-	-	-	-	-		
4. Paid Employees	Services			8,956	9,693	10,245	11,831	13,148	14,370	17,538	20,495	22,137	21,973	9.9	8.9
	Hardware			9,462	9,501	10,276	8,341	8,855	9,468	9,765	10,055	10,080	6,276	1.0	8.9
	Total	14,364	14,119	18,418	19,194	20,521	20,172	22,003	23,838	27,303	30,550	32,217	28,249	5.2	3.5
5. Salaries, Wages and Benefits ($ M)	Services			89.5	120.6	139.8	160.7	199.0	242.5	315.1	426.1	567.3	579.0	22.0	19.0
	Hardware			154.9	175.1	199.3	168.1	192.4	228.5	258.9	295.6	340.7	220.6	8.0	-0.7
	Total	165.	180.1	244.4	295.7	339.1	328.8	391.4	471.0	574.0	721.7	908.0	799.6	14.0	11.1
6. Total Operating Expenses ($ M)	Services			201.6	274.8	308.5	382.3	456.8	560.8	728.4	953.5	1,232	1,401.1	22.7	20.0
	Hardware			465.7	477.5	581.4	570.7	-	-	-	-	-	-	-	-
7. Operating Ratio	Services			0.956	0.962	0.942	0.919	0.859	0.879	0.889	0.865	0.914	0.972		
	Hardware			0.761	0.736	0.724	0.716	-	-	-	-	-	-	-	-

Source: Statistics Canada, Catalogue 63-222.

Table 17

TELECOMMUNICATIONS CARRIER REVENUE
(Excluding Telephone Carriers)

BY MAJOR FIRMS

1) TOTAL REVENUE (1974) ($)	55,304,691	(100)
CN	30,980,701	(56.0)
CP	24,317,419	(43.9)
Others	6,571	
2) TOTAL REVENUE (1979)	411,759,372	(100)
CN	153,486,434	(37.2)
CP	90,973,498	(22.0)
Teleglobe	110,370,000	(26.8)
Telesat	49,842,000	(17.2)
3) TOTAL REVENUE (1982)	536,331,796	(100)
CNCP Telecommunications	302,203,000	(56.3)
Teleglobe	173,951,000	(32.4)
Telesat	59,007,000	(11.0)
Others	1,170,796	(2.0)

SOURCE: Statistics Canada, Catalogue 56-201

Table 18

Telecommunications Carriers[1]

Sources of Revenue (%)

	1974	1979	1982
Total Operating Revenue	230,078,500	411,759,372	536,332,796
Transmission:			
Public and Gov't Messages	4.0	2.6	1.8
Telephone Service	21.1	26.1	25.6
Cable, Wireless Radio Message	8.0	6.5	5.1
Non-Transmission			
Leased Circuits	28.2	26.3	26.8
Other Leased Plant	16.9	19.6	19.4
Other Non-Transmission	15.0	14.4	14.9
Other Revenue[2]	6.8	4.5	6.4

NOTES: [1]Includes CNCP Tel, Teleglobe, Telesat.

[2]Includes broadcast, fascimile and other transmission services; money order and other non-transmission services.

SOURCE: Statistics Canada, Catalogue 56-201.

Table 19

SUMMARY STATISTICS - TELECOMMUNICATIONS SERVICES

TELEPHONE[1] INDUSTRY REVENUE ($ MILLION)	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	CAG 1973-1983 (%)
LOCAL SERVICES	1,050	1,167	1,341	1,568	1,796	2,043	2,268	2,532	2,981	3,398	3,564	11.6
TOLL SERVICES	1,013	1,195	1,435	1,689	1,930	2,285	2,667	3,083	3,701	4,140	4,497	14.4
OTHER	74	87	104	127	151	196	247	271	355	402	519	19.1
TOTAL TELEPHONE REVENUE	2,127 (91.7)[2]	2,436 (91.3)	2,861 (91.7)	3,364 (92.3)	3,854 (92.7)	4,472 (92.8)	5,151 (92.6)	5,848 (93.0)	6,987 (93.4)	7,865 (93.6)	8,533	13.3
OTHER TELECOMMUNICATIONS CARRIERS[3] REVENUE ($ MILLION)	190.7	230.0	259.0	278.3	302.0	348.3	411.8	439.1	492.0	536.3	N/A	10.9
TOTAL OPERATING REVENUE	2,318	2,666	3,120	3,642	4,156	4,820	5,563	6,287	7,479	8,401	-	13.7
EMPLOYEES - TELEPHONE	75,407	81,225	82,866	83,864	87,546	92,873	96,539	100,059	102,625	105,061	105,354	3.0
EMPLOYEES- TELECOMMUNICATIONS	7,047	7,163	7,162	6,973	6,863	7,150	7,247	6,055	6,118	6,027	N/A	-1.6

NOTES: [1]Includes all telephone companies in Canada as surveyed in Catalogue 56-201.

[2]Figures in brackets are telephone industry's share of all telecommunications revenue.

[3]Industry CNCP Tel, Teleglobe, Telesat.

SOURCE: Statistics Canada, Catalogue 56-203, 56-201.

Table 20

Telephone Statistics

	Telephones Calls[1] ($000')	Calls Per Capita	Telephones[2] ($000')	Cost of Plant ($000')
1973	19,054,890	854	11,677	8,791,434
1974	20,701,006	914	12,454	10,039,662
1975	21,194,109	922	13,165	11,426,333
1976	22,219,161	953	13,885	12,936,322
1977	23,240,844	991	14,488	14,531,598
1978	24,069,407	1,020	15,172	16,029,996
1979	25,096,523	1,054	15,839	17,754,852
1980	26,841,326	1,114	16,531	19,742,479
1981	28,639,394	1,176	16,944	22,297,544
1982	29,029,507	1,173	16,802	24,467,219

NOTES: [1]Approximately 95 per cent of all calls are local with the remainder long-distance 'toll' calls.

[2]Approximately 70 per cent of all telephones are residential: 30 per cent are business.

SOURCE: Statistics Canada Catalogue 56-203.

Table 21
Revenues of the Top Service Bureaux
In Canada

COMPANY NAME	OWNER-SHIP	EDP SERVICE REVENUES			% SAMPLE TOTAL			% ANNUAL GROWTH		SOURCE CODE
		1982	1983	1984	1982	1983	1984	82-83	83-84	
1. CANADA SYSTEMS GROUP	CAN.		127.9	132.4		16.5	16.3		4	C
2. CROWNTEK INC.	CAN.		115.4	131.6		14.9	16.2		14	A
3. BRITISH COLUMBIA SYSTEMS CORPORATION	CAN.		75.6	65.0		9.8	8.0		-14	C
4. INDUSTRIELLE-SERVICES TECHNIQUES INC.	CAN.		51.0	58.0		6.6	7.2		14	B
5. I.P. SHARP ASSOCIATES LTD.	CAN.		47.5	49.5		6.1	6.1		4	B
6. IBM CANADA LTD.	U.S.		44.0	46.0		5.7	5.7		5	C
7. CONTROL DATA CANADA, LTD.	U.S.		34.8	36.0		4.5	4.4		3	C
8. CO-OPERATORS DATA SERVICES LIMITED	CAN.		29.1	31.5		3.8	3.9		8	B
9. SASKATCHEWAN COMPUTER UTILITY CORP.	CAN.		22.2	22.1		2.9	2.7		0	A
10. MANITOBA DATA SERVICES	CAN.		18.9	19.5		2.4	2.4		3	C
11. DATALINE INC.	CAN.		13.8	17.2		1.8	2.1		25	A
12. CANADIAN GENERAL ELECTRIC CO. LTD.	U.S.		16.0	16.0		2.1	2.0		0	C
13. ADP CANADA	U.S.		17.2	15.0		2.2	1.8		-13	B
14. REAL TIME DATAPRO LTD.	CAN.		12.3	13.6		1.6	1.7		11	A
15. COMPUTER SCIENCES CANADA, LTD.	U.S.		11.3	13.1		1.5	1.6		16	C
16. REYNOLDS & REYNOLDS (CANADA) LTD.	U.S.		11.6	12.2		1.5	1.5		5	C
17. ALPHATEXT, A DIVISION OF RONALDS-FEDERATED LTD.	CAN.		10.0	11.6		1.3	1.4		16	A
18. NEWFOUNDLAND & LABRODOR COMPUTER SERVICES LTD.	CAN.		10.4	11.0		1.3	1.4		6	B
19. CABLESHARE INC.	CAN.		11.3	9.0		1.5	1.1		-20	B
20. THORNE RIDDELL	CAN.		8.9	8.9		1.1	1.1		0	C
21. COMSHARE LTD.	CAN.		9.2	8.6		1.2	1.1		-7	B
22. COMCHEQ SERVICES LTD.	CAN.		6.4	8.5		.8	1.0		33	C
23. M.I.C.R. SYSTEMS LTD.	CAN.		5.9	8.0		.8	1.0		36	A
24. NCR CANADA LTD.	U.S.		8.0	8.0		1.0	1.0		0	C
25. ACO GROUP LTD.	CAN.		6.2	7.5		.8	.9		21	B
26. ACT COMPUTER SERVICES LTD.	CAN.		7.8	7.5		1.0	.9		-4	B
27. POLYCOM SYSTEMS LTD.	CAN.		4.8	6.9		.6	.9		44	A
28. DIGITECH LTD.	CAN.		7.6	6.8		1.0	.8		-11	A
29. COMTECH GROUP INTERNATIONAL LTD.	CAN.		5.7	5.7		.7	.7		0	A
30. RILEY'S DATASHARE INTERNATIONAL LTD.	CAN.		5.2	5.7		.7	.7		8	A
31. CYBERHSARE LTD.	CAN.		4.4	4.5		.6	.6		2	B
32. ELAN DATA MAKERS LTD.	CAN.		3.3	3.4		.4	.4		3	B
33. BOEING COMPUTER SERVICES CANADA LTD.	U.S.		3.0	3.0		.4	.4		0	C
34. BUSINESS DATA PROCESSING LTD.	CAN.		2.1	2.5		.3	.3		19	B
35. NDC COMPUTER SERVICES LTD.	CAN.		1.2	2.0		.2	.2		67	B
36. COMPUTREX CENTRES LTD.	CAN.		3.0	1.7		.4	.2		-43	C
37. NOVATRON INFORMATION CORPORATION	CAN.		1.3	1.5		.2	.2		15	B
TOTAL			774.4	811.0					5	

TOTAL U.S. CONTROLLED: 21.6% Firms, 18.4% of 1984 Revenues, 18.9% of 1983 Revenues.

SOURCE CODE: A - Published by Company, B - Confirmed by Company Officer, C - Estimated by Evans Research Corporation.

SOURCE: Evans Research Corporation, August, 1985

Table 22
Revenue of Top 50 EDP Hardware
Firms in Canada[1]

COMPANY NAME	OWNER-SHIP	EDP SERVICE REVENUES			% SAMPLE TOTAL			% ANNUAL GROWTH		SOURCE CODE
		1982	1983	1984	1982	1983	1984	82-83	83-84	
1. IBM CANADA LTD.	U.S.	1846.0	2,193.0	2,821.0	41.4	42.1	43.9	15	29	C
2. DIGITAL EQUIPMENT OF CANADA LTD.	U.S.	294.9	308.5	419.7	6.6	5.9	6.5	5	36	A
3. CONTROL DATA CANADA LTD.	U.S.	206.0	205.9	224.5	4.6	4.0	3.5	5	9	C
4. BURROUGHS MEMOREX INC.	U.S.	111.7	203.3	217.0	2.5	3.9	3.4	28	7	B
5. PHILIPS INFORMATION SYSTEMS LTD.	U.S.	108.5	187.5	190.1	4.5	3.6	3.0	-6	1	B
6. NCR CANADA LTD.	U.S.	154.0	175.0	188.0	3.5	3.4	2.9	7	7	C
7. SPERRY INC.	U.S.	140.4	144.0	185.0	3.1	2.8	2.9	3	28	C
8. HEWLETT-PACKARD (CANADA) LTD.	U.S.	104.9	11.20	154.6	2.4	2.2	2.4	7	38	C
9. AES DATA INC.	CAN.	188.2	134.0	145.0	4.2	2.6	2.3	-29	8	B
10. HONEYWELL LTD.	U.S.	110.0	115.5	120.0	2.5	2.2	1.9	2	4	C
11. COMMODORE BUSINESS MACHINES LTD.		23.5	110.0	112.7	0.5	2.1	1.8	374	2	B
12. XEROX CANADA INC.	U.S.	47.7	81.4	107.5	1.1	1.6	1.7	19	32	A
13. WANG CANADA LTD.	U.S.	65.9	65.9	105.8	1.5	1.3	1.6	2	61	B
14. AMDAHL LTD.	U.S.	65.0	104.2	100.1	1.5	2.0	1.6	60	-4	B
15. APPLE CANADA INC.	U.S.	29.9	62.5	98.0	.7	1.2	1.5	100	57	B
16. RADIO SHACK	U.S.	64.3	82.4	90.0	1.4	1.6	1.4	21	9	C
17. GEAC COMPUTER CORP. LTD.	CAN.	48.0	62.4	70.0	1.1	1.2	1.1	30	12	C
18. GANDALF TECHNOLOGIES INC.	CAN.	53.3	58.6	69.1	1.2	1.1	1.1	10	18	A
19. MOTOROLA INFORMATION SYSTEMS LTD.	U.S.	43.2	48.7	61.1	1.0	.9	.9	12	25	B
20. MAI CANADA LTD.	BAH.	52.0	49.7	59.4	1.2	1.0	.9	0	20	A
21. OLIVETTI CANADA LTD.	U.S.	19.0	28.0	55.5	.4	.5	.9	-11	98	B
22. STC CANADA INC.	CAN.	73.9	56.0	54.0	1.7	1.1	.8	-23	-4	B
23. NORTHERN TELECOM LTD.	CAN.	29.0	40.4	50.0	.6	.8	.8	39	24	C
24. EPSON CANADA LTD.	CAN.	10.4	26.6	46.0	.2	.5	.7	156	73	B
25. DATA GENERAL (CANADA) INC.	U.S.	32.4	30.7	45.7	.7	.6	.7	-5	49	B
26. NATIONAL SEMICONDUCTOR CANADA LTD.	U.S.	22.0	28.0	40.0	.5	.5	.6	27	43	C
27. AMDAHL COMMUNICATIONS INC.	U.S.	-	27.0	35.0	-	.5	.5	-	30	B
28. MOHAWK DATA SCIENCES - CANADA LTD.	U.S.	34.2	37.0	35.0	.8	.7	.5	8	-5	B
29. GENERAL DATACOMM LTD.	U.S.	16.5	13.2	33.0	.4	.3	.5	-16	150	B
30. TANDEM COMPUTERS CANADA LTD.	U.S.	20.5	18.0	33.0	.5	.3	.5	-12	83	C
31. DATAPOINT CANADA INC.	U.S.	13.2	23.5	29.9	.3	.5	.5	95	27	B
32. PRIME COMPUTER OF CANADA LTD.	U.S.	16.0	19.5	26.9	.4	.4	.4	24	38	B
33. INTERGRAPH SYSTEMS LTD.	U.S.	14.4	16.8	25.5	.3	.3	.4	17	52	B
34. MATROX ELECTRONIC SYSTEMS LTD.	CAN.	11.1	15.0	24.6	.2	.3	.4	35	64	B
35. ELECTROHOME LTD.	CAN.	25.0	25.0	22.9	.6	.5	.4	0	-8	C
36. TULSA COMPUTER PRODUCTS LTD.	U.S.	13.9	17.0	20.4	.3	.3	.3	22	20	C
37. DEVELCON ELECTRONICS LTD.	CAN.	9.7	16.2	20.3	.2	.3	.3	67	25	A
38. COMTERM INC.	CAN.	-	44.4	19.2	-	.9	.3	-	-57	A
39. ICL COMPUTERS CANADA LTD.	U.S.	14.0	12.9	15.4	.3	.2	.2	0	19	A
40. COMPUTERVISION CANADA INC.	U.S.	6.9	8.7	15.1	.2	.2	.2	26	74	B
41. NCR COMTEN INC.	U.S.	10.4	12.4	13.6	.2	.2	.2	19	10	C
42. REXON BUSINESS MACHINES CANADA LTD.	CAN.	-	11.0	13.4	-	.2	.2	-	22	B
43. GRAY CANADA INC.	U.S.	-	12.0	13.0	-	.2	.2	-	8	C
44. TEXAS INSTRUMENTS CANADA	U.S.	10.0	11.3	13.0	.2	.2	.2	13	15	C
45. ITT COURIER	U.S.	12.7	12.7	12.7	.3	.2	.2	0	0	C
46. PARADYNE CANDA LTD.	U.S.		11.0	12.0		.2	.2		9	C
47. CENTRONICS CANADA INC.	U.S.	9.2	9.8	11.7	.2	.2	.2	7	19	C
48. AUTO-TROL TECHNOLOGY LTD.	CAN.	-	7.0	10.0	-	.1	.2	-	43	C
49. CYBERNEX LTD.	CAN.	7.1	7.1	10.0	.2	.1	.2	0	41	B
50. SANYO CANADA INC.	CAN.	-	5.0	10.0	-	.1	.2	-	100	C

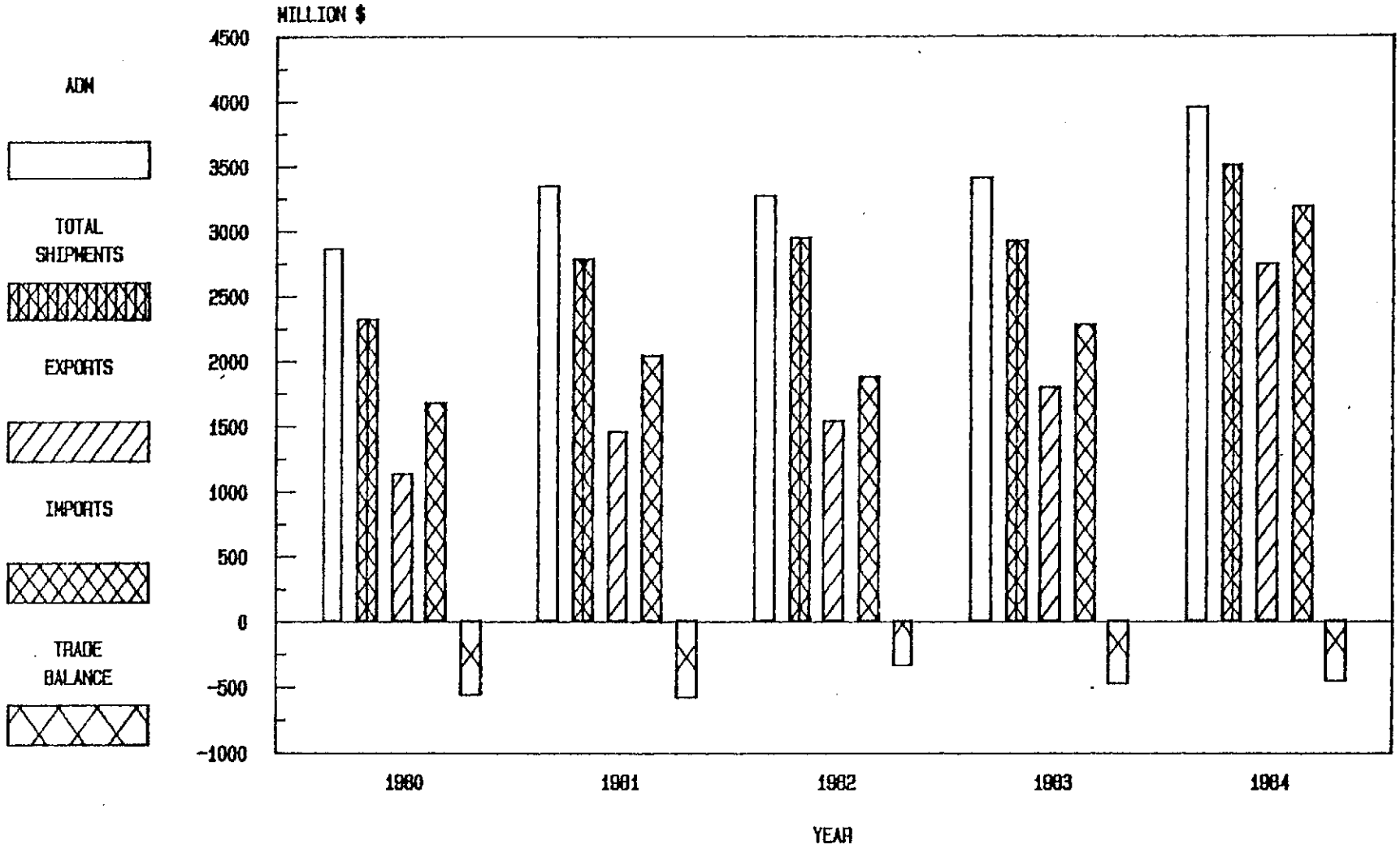
Notes: [1]Firms include those primarily engaged in selling or leasing goods of own manufacture. The Top 10 firms account for 72.9% of total sample revenues; the top 50 represent 98.5% of sample revenues.

Source Code: A - Published . . . as in Table 21.

Source: Evans Research Corporation, 1985.

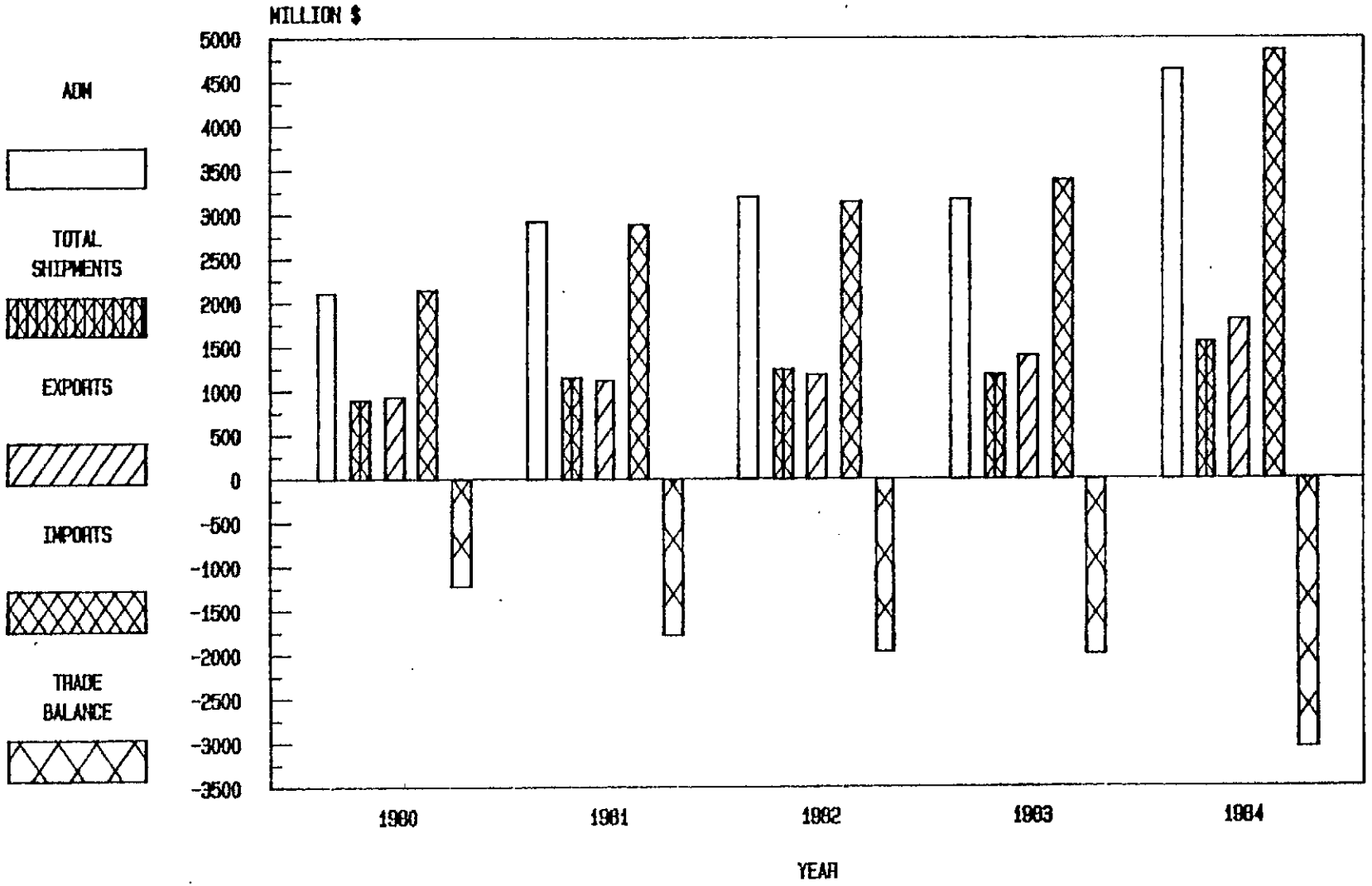
COMMUNICATIONS EQUIPMENT AND COMPONENTS

SIC 335



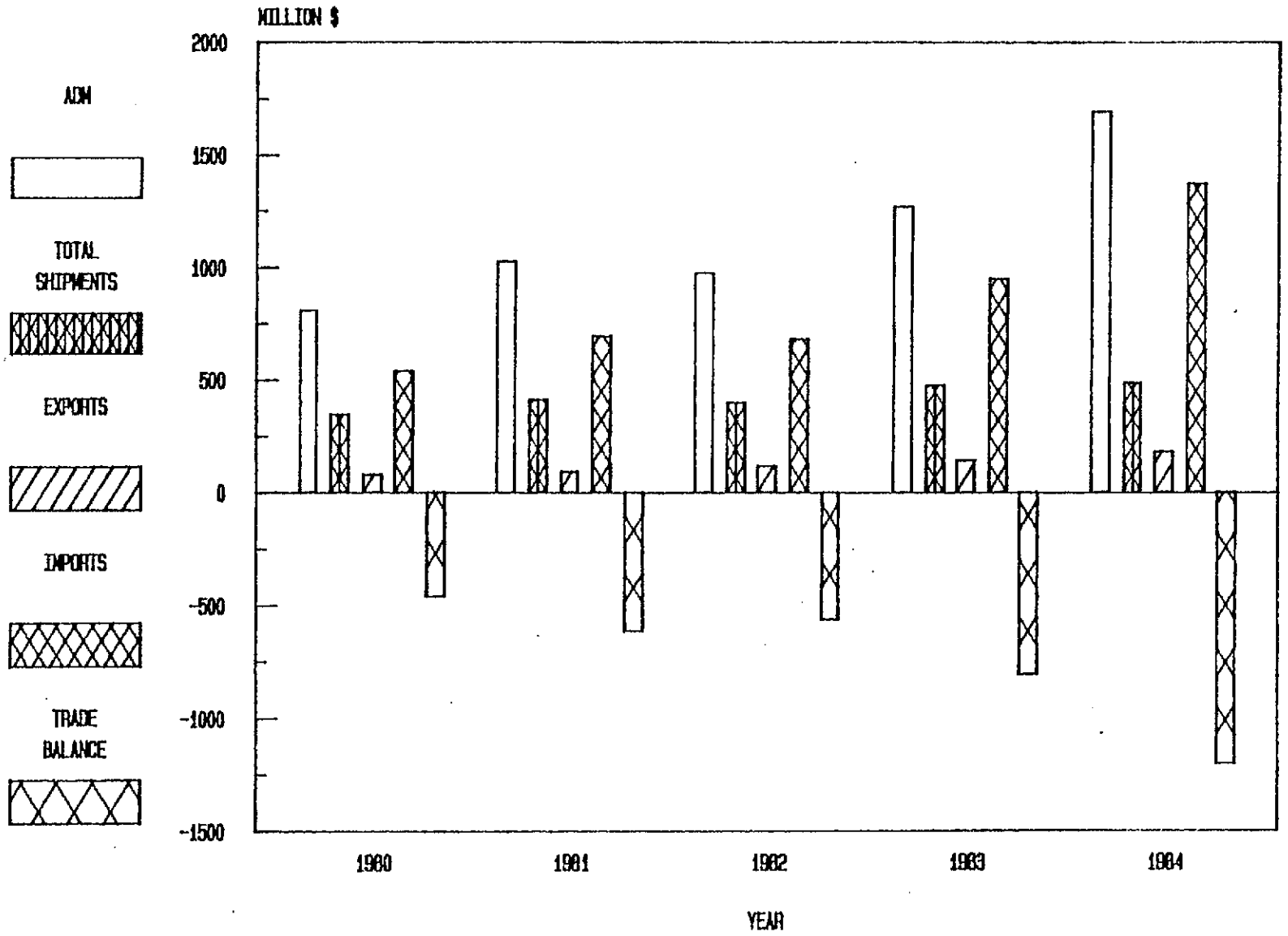
OFFICE AND STORE MACHINERY AND EQUIPMENT

SIC 318



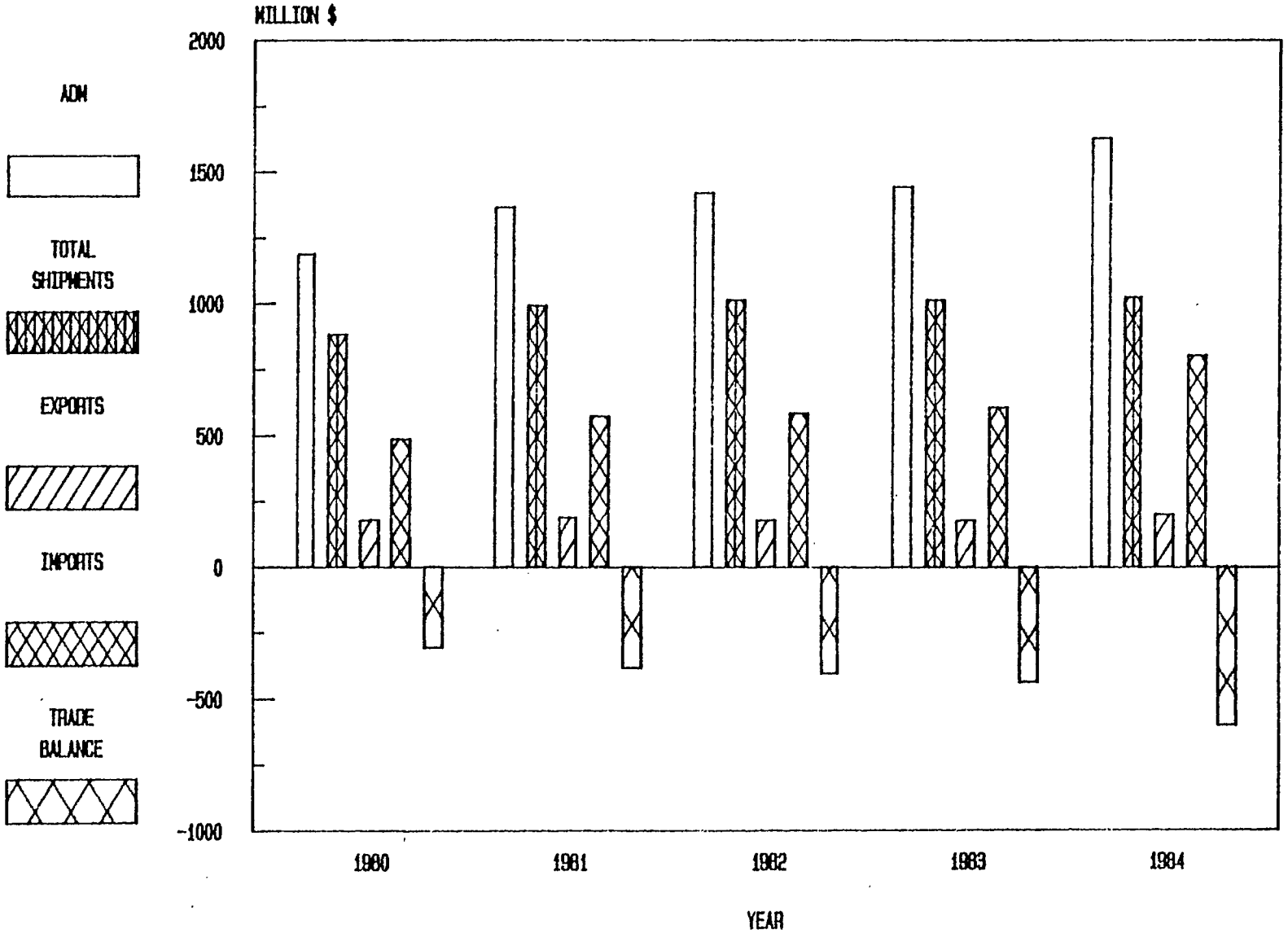
HOUSEHOLD RADIO AND TELEVISION

SIC 334

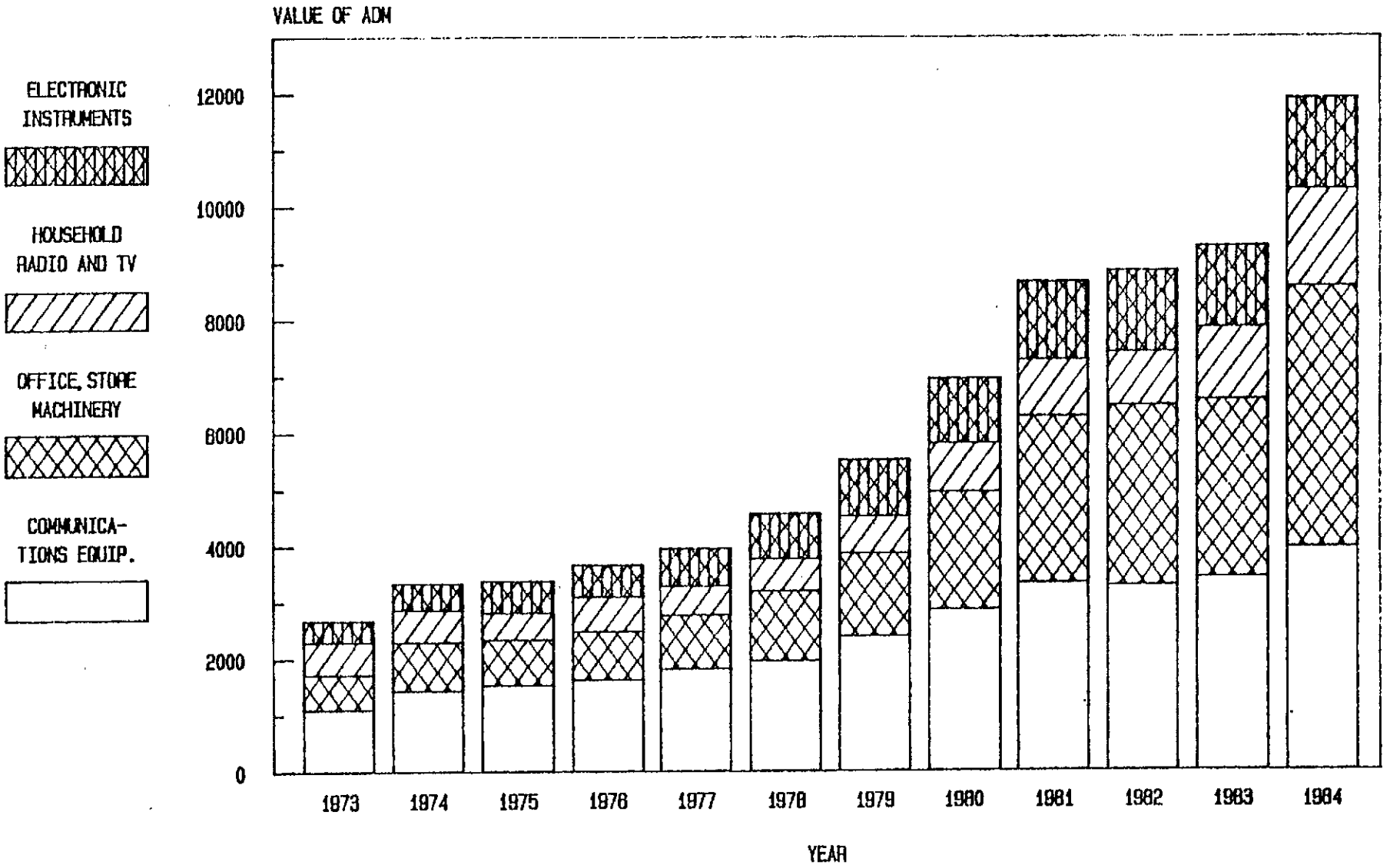


INSTRUMENTS AND RELATED PRODUCTS

SIC 3911

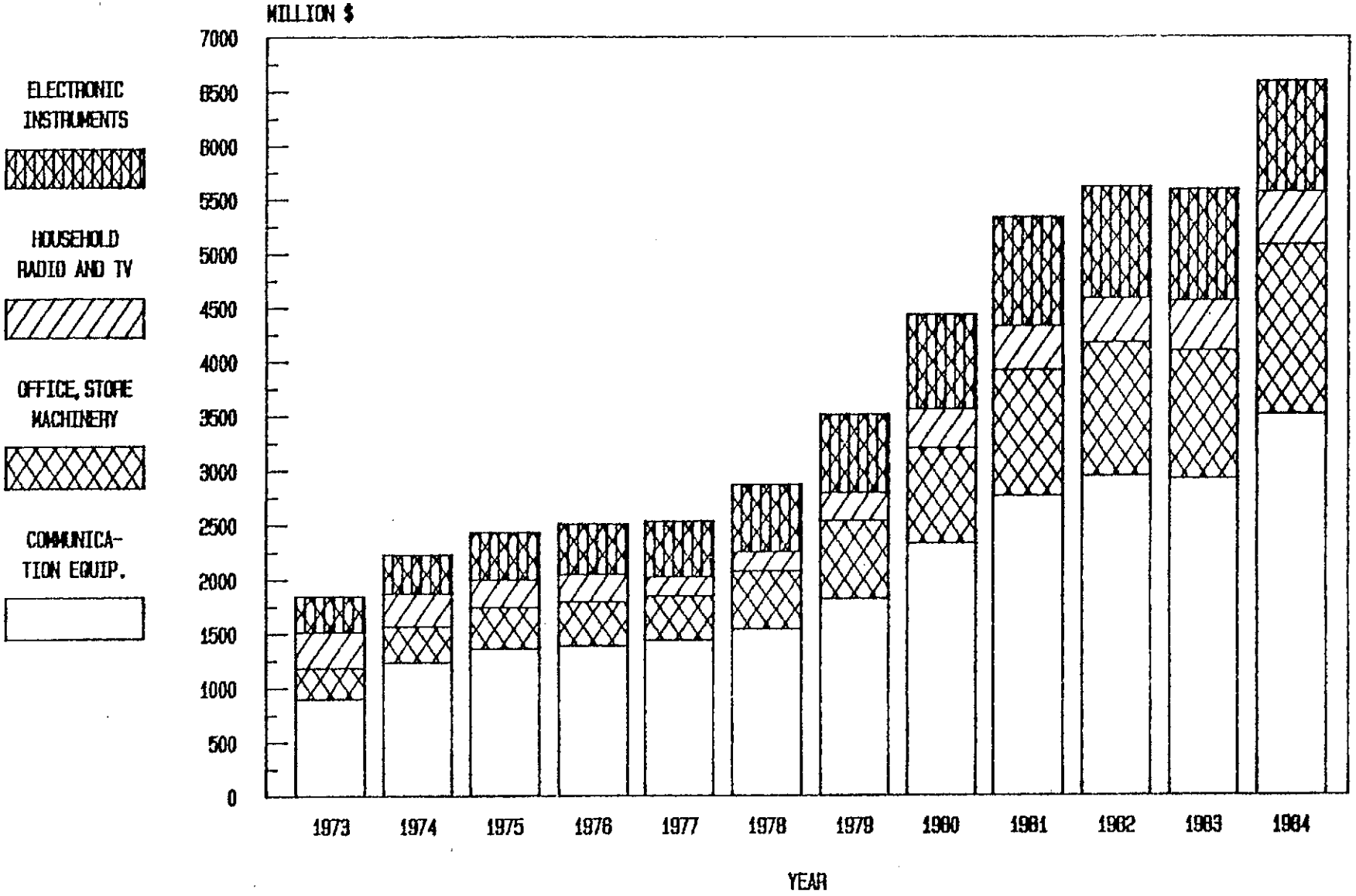


GROWTH IN ADM FOR ELECTRONICS SECTORS



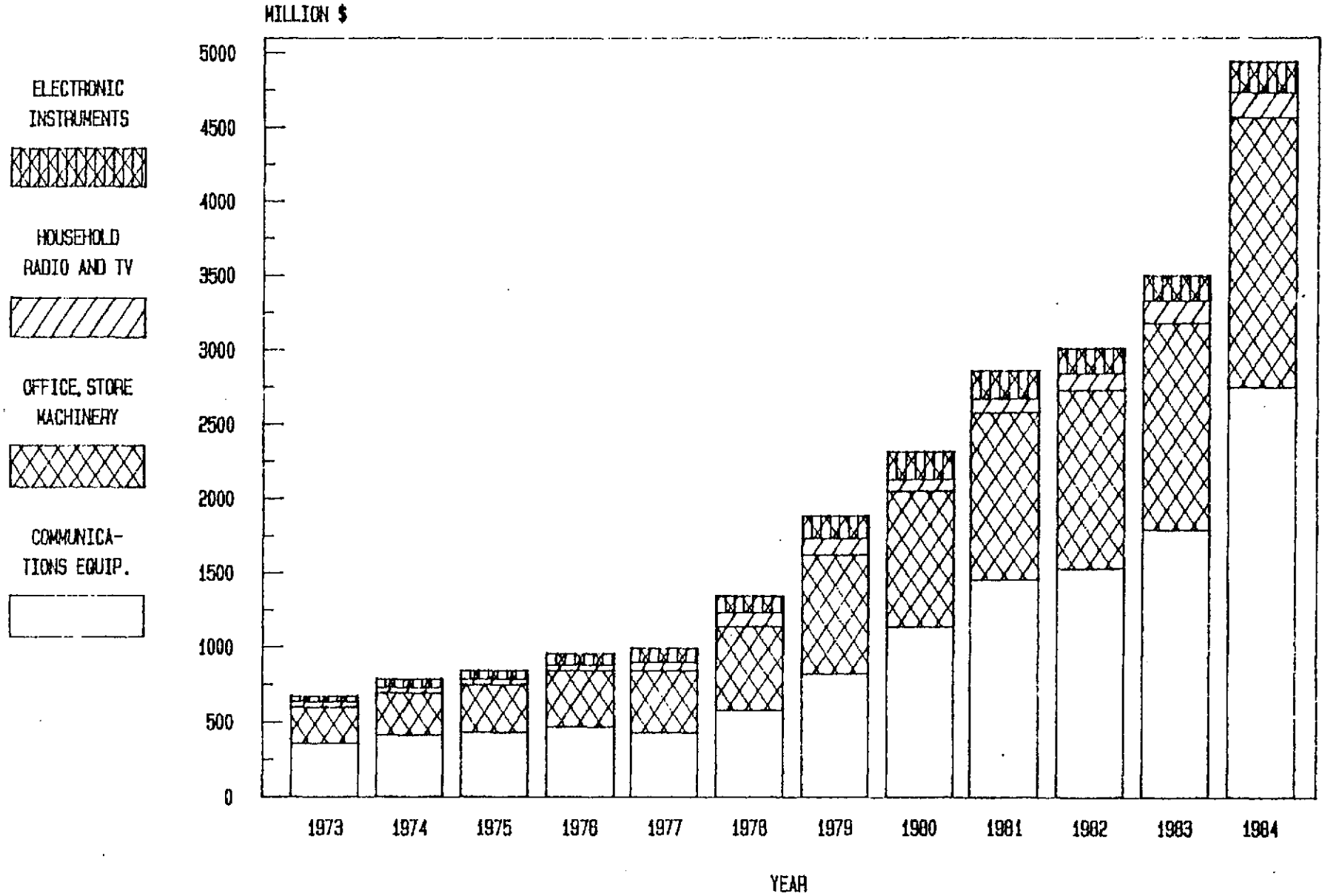
SHIPMENTS BY ELECTRONICS SECTORS

SIC 318, 334, 335, 3911

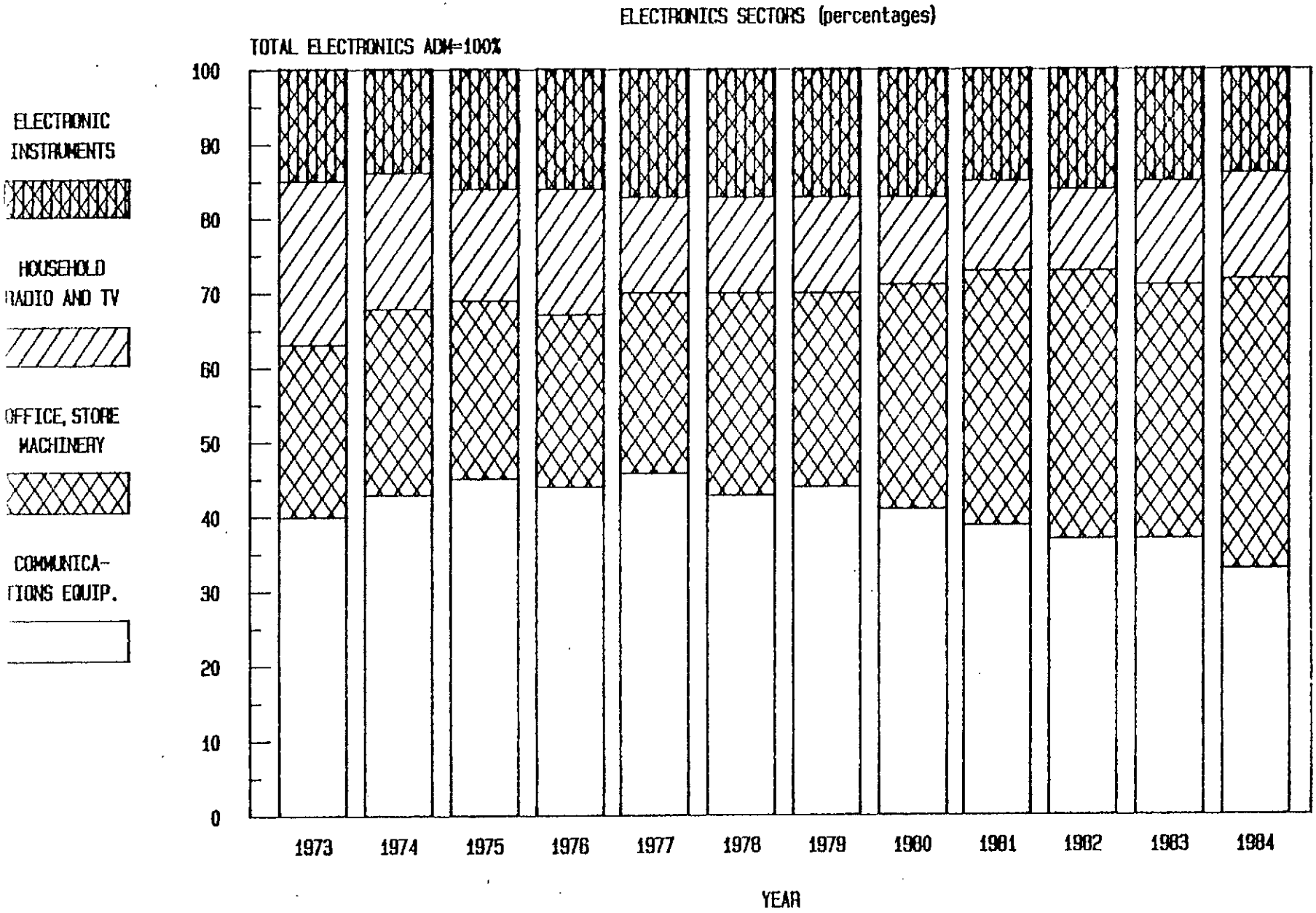


EXPORTS BY ELECTRONICS SECTORS

SIC 316, 334, 335, 3911

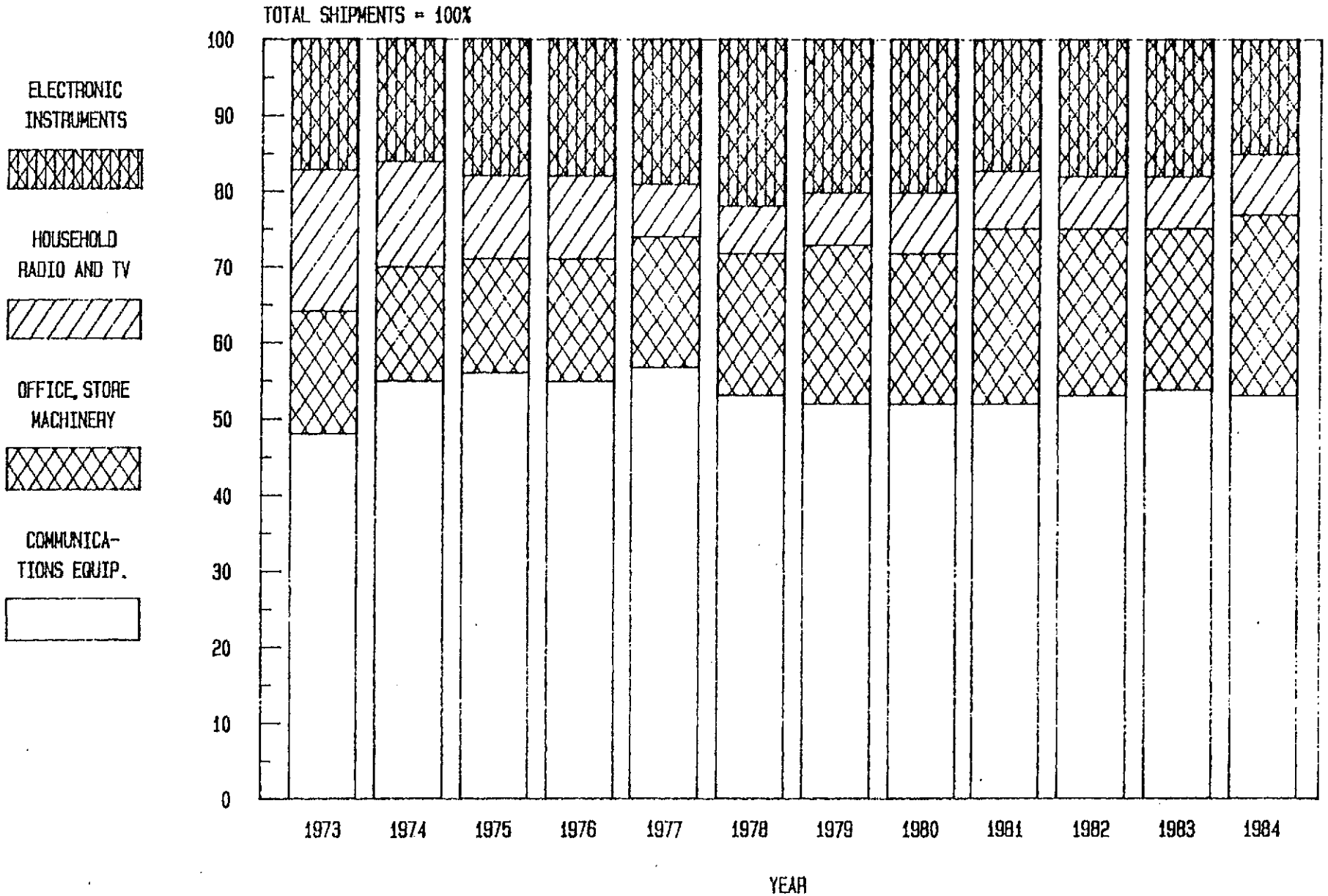


SHARE OF APPARENT DOMESTIC MARKET



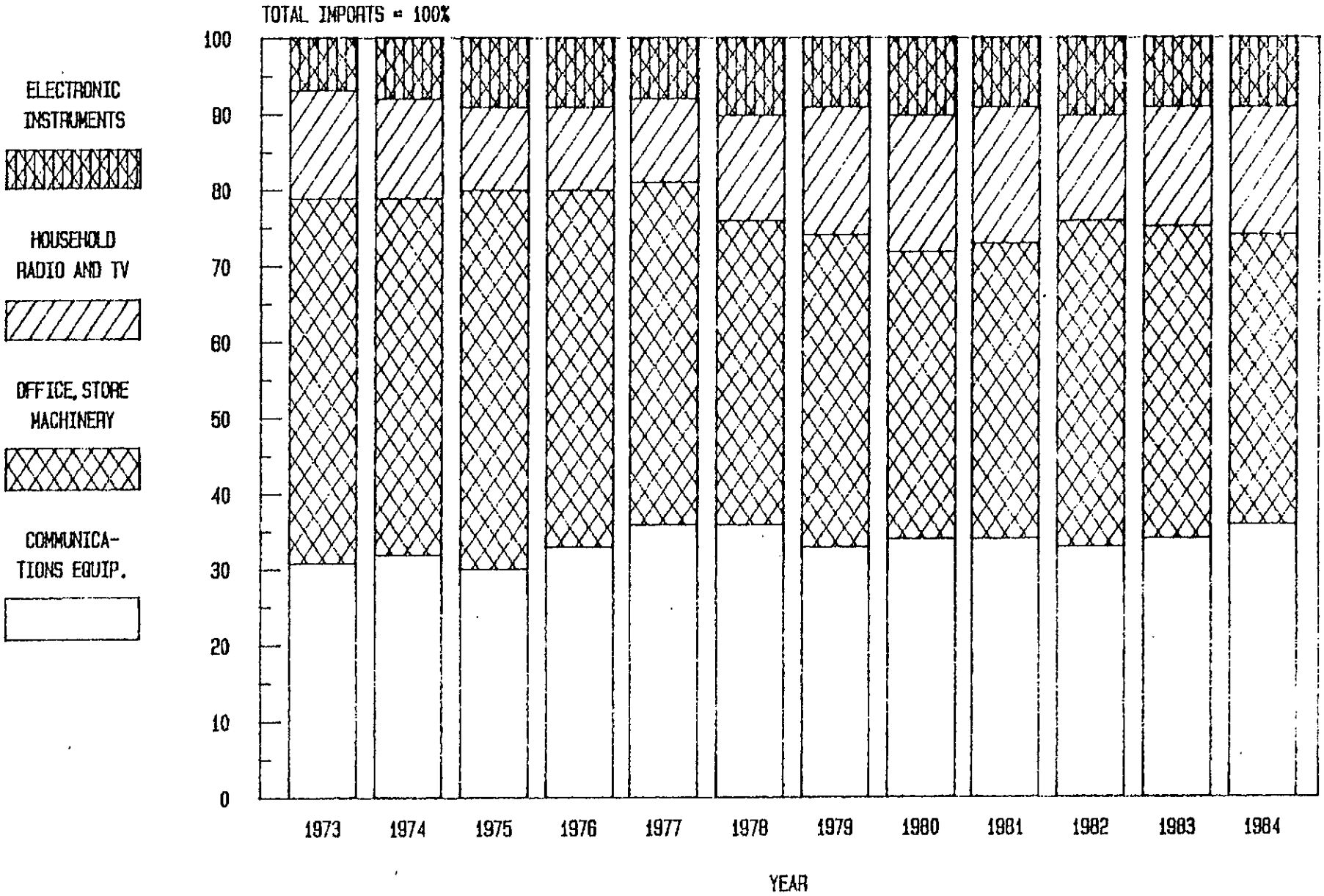
SHARE OF TOTAL ELECTRONICS SHIPMENTS

By Subsector (percentages)



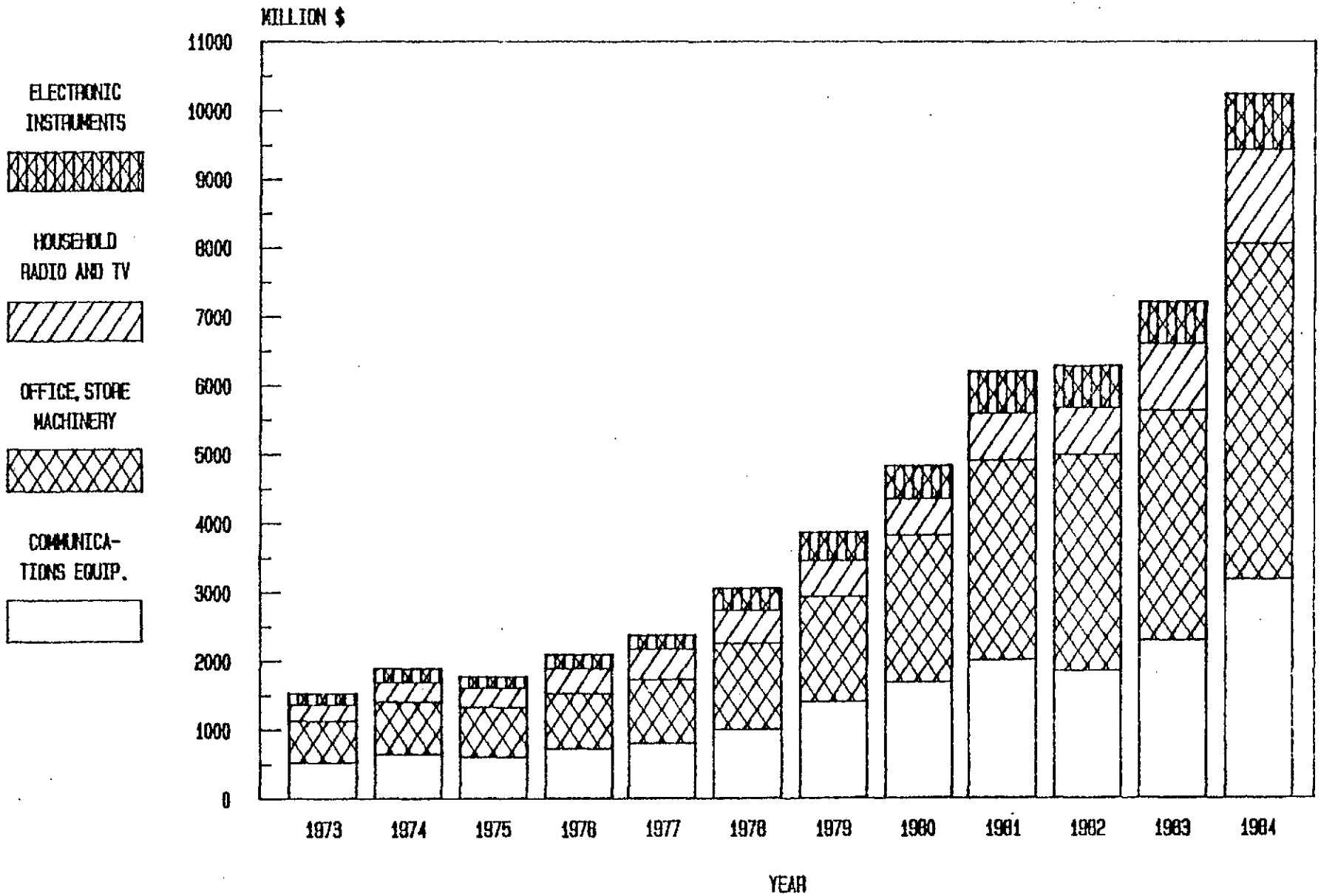
SHARE OF TOTAL ELECTRONICS IMPORTS

By Subsector (percentages)



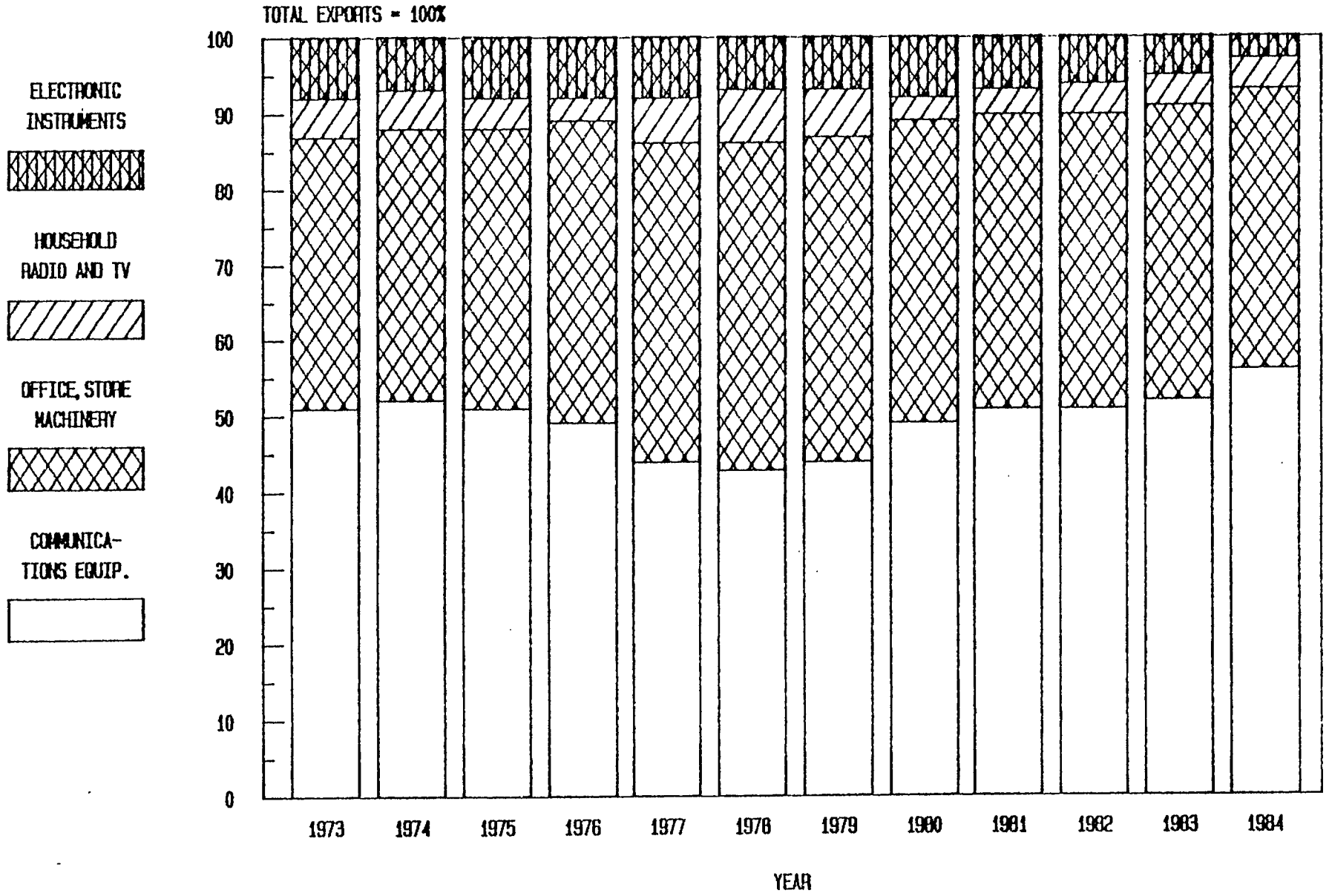
IMPORTS BY ELECTRONICS SECTORS

SIC 318, 334, 335, 3911



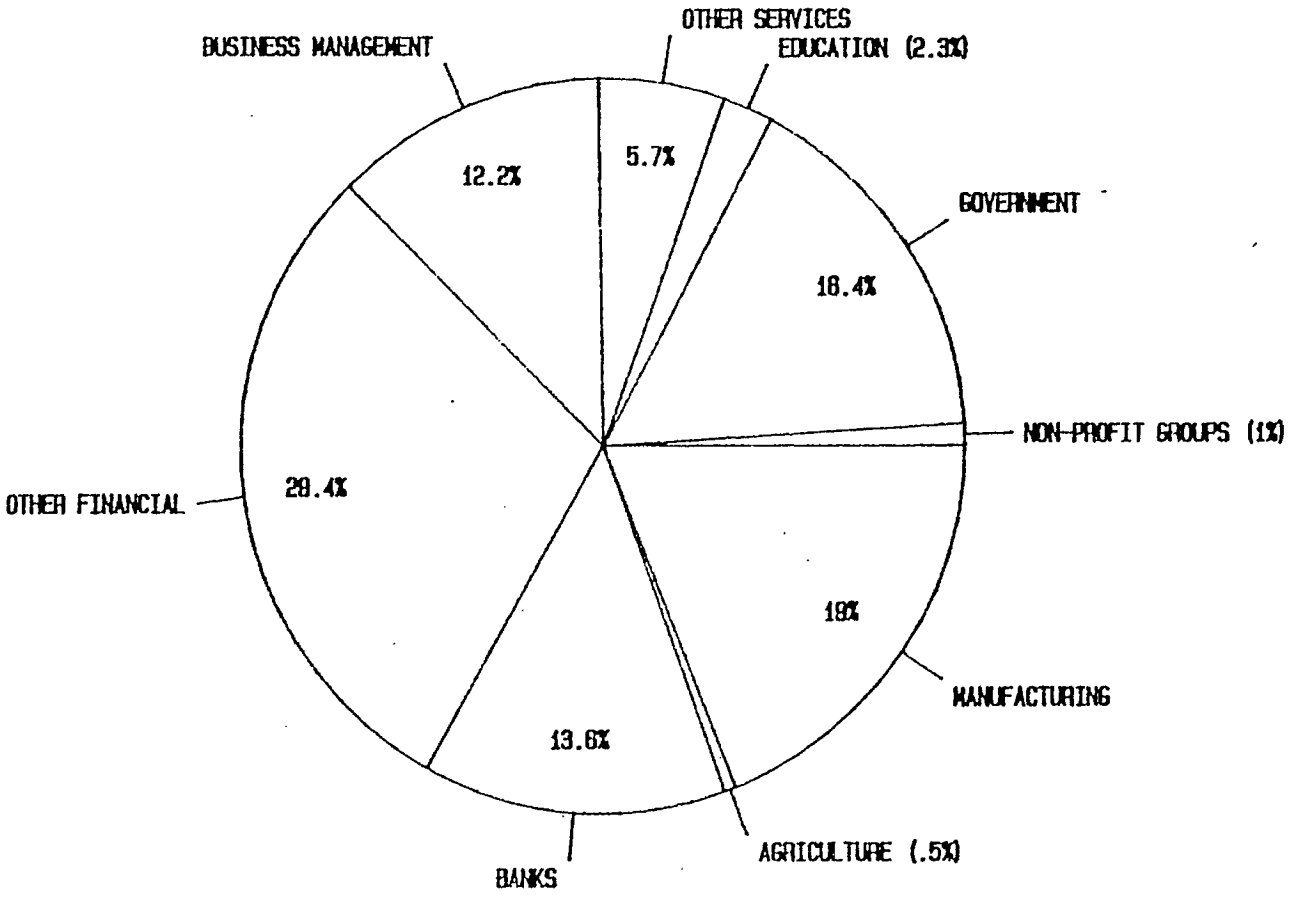
SHARE OF TOTAL ELECTRONICS EXPORTS

By Subsector (percentages)



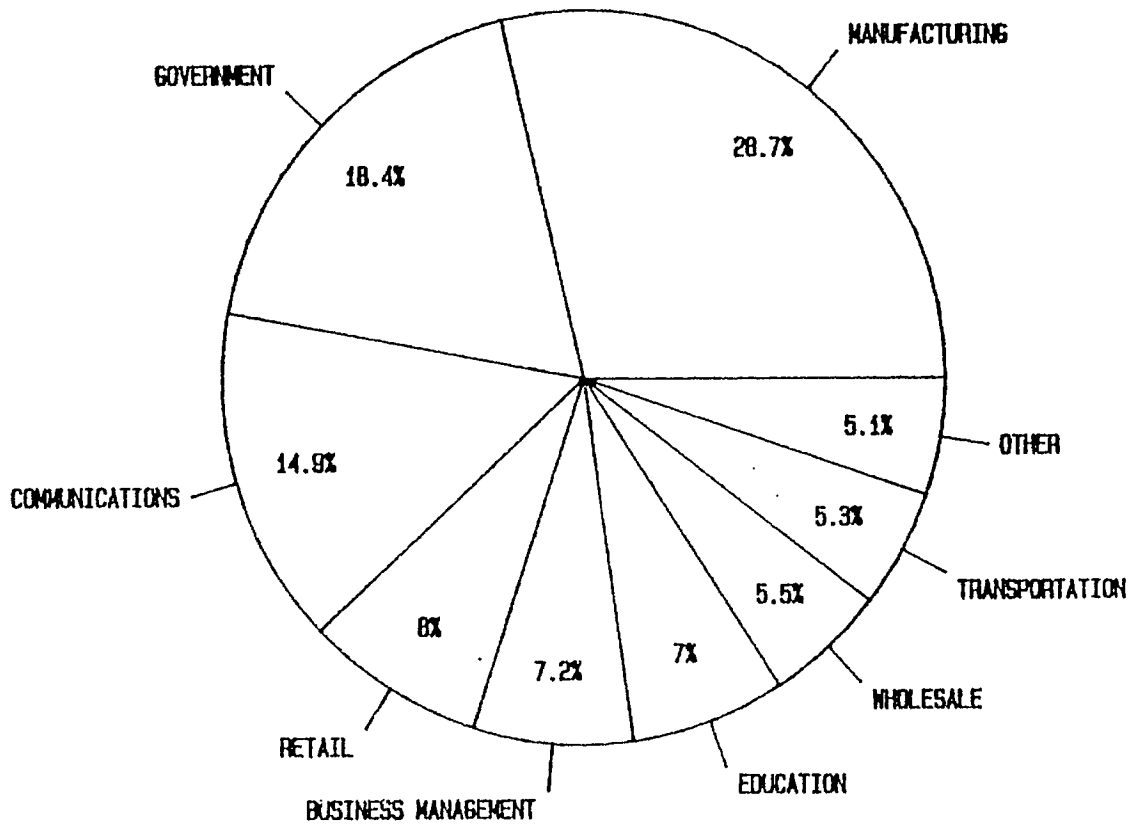
COMPUTER SERVICES REVENUE BY MAJOR USER

1983



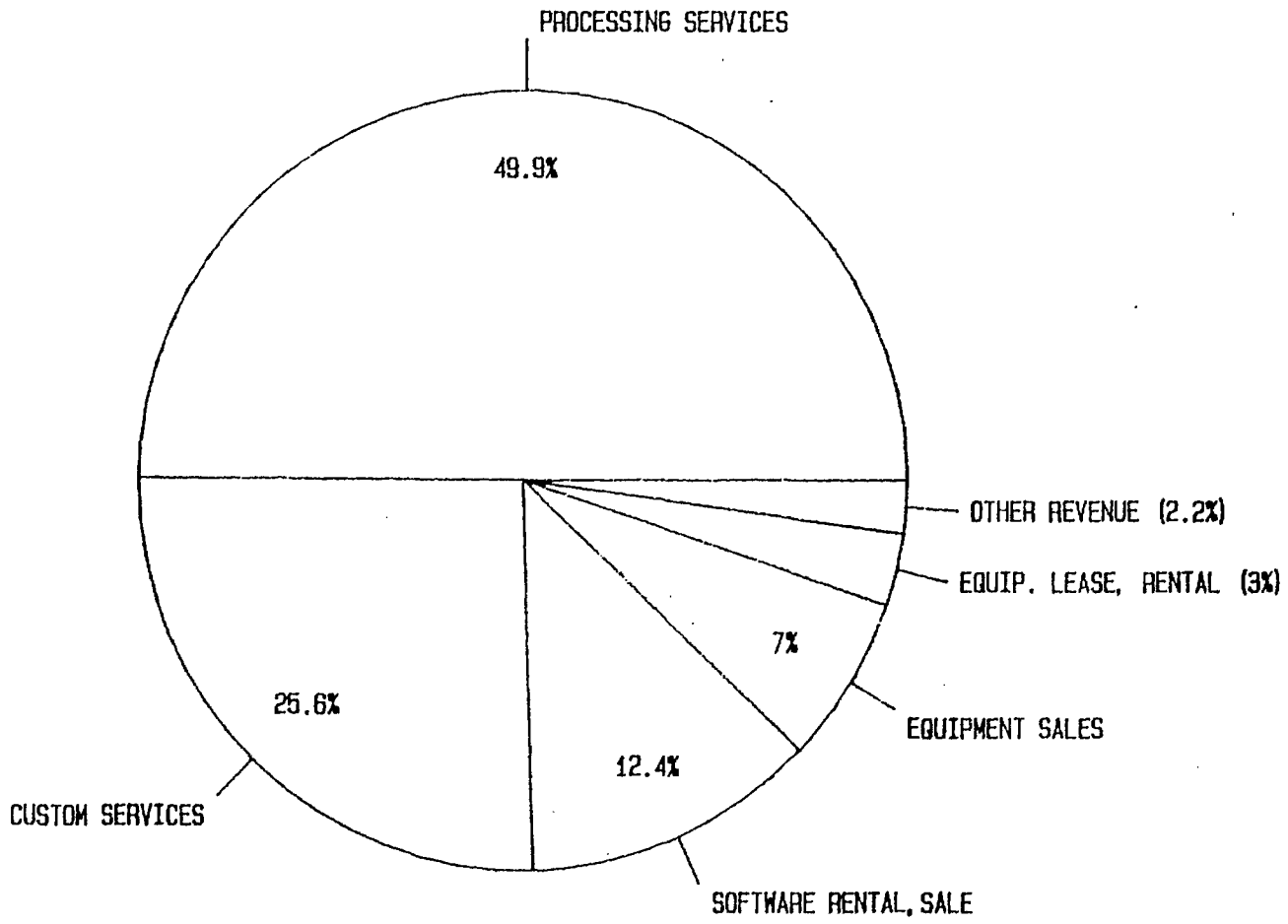
FIRMS LEASING HARDWARE- REVENUE SOURCES

1983



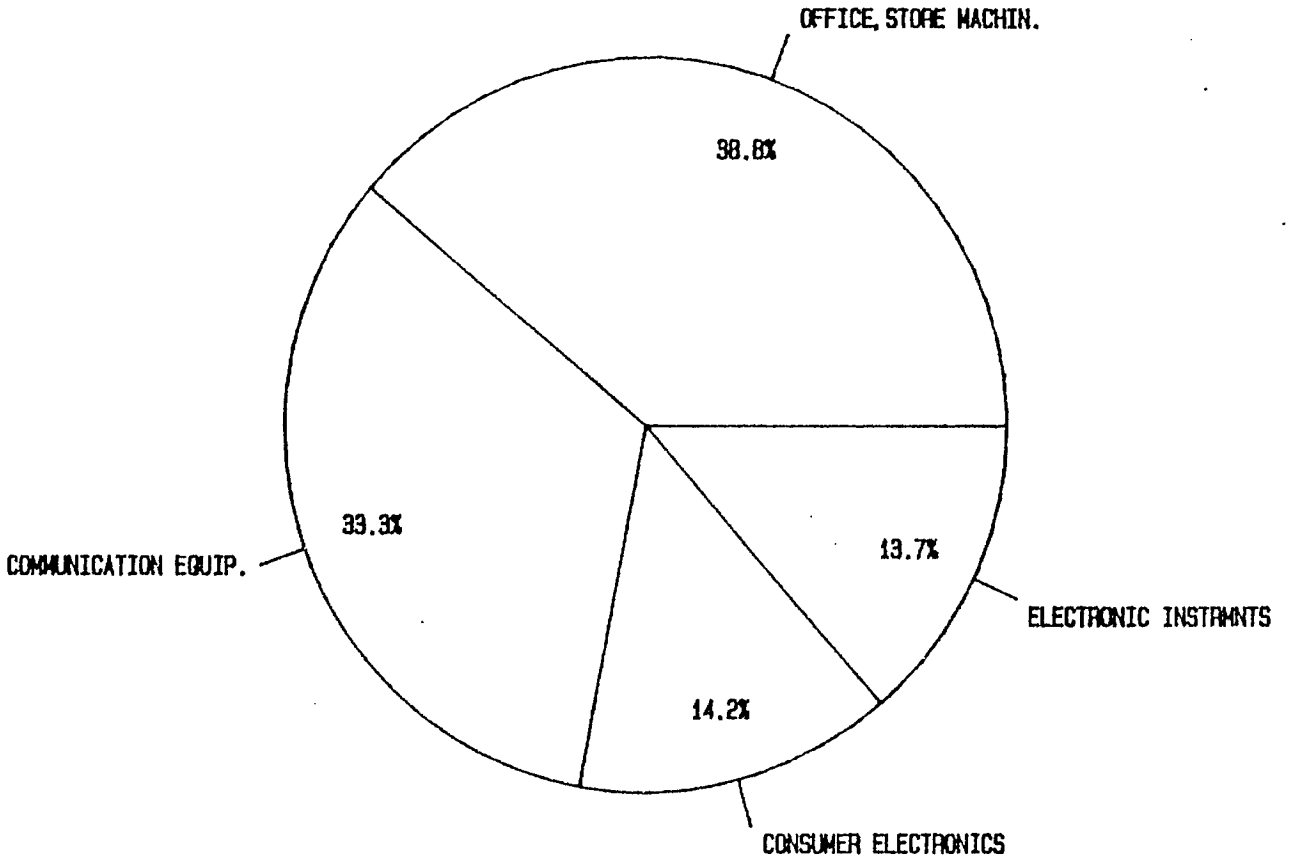
COMPUTER SERVICES REVENUE - BY CLASS

1983



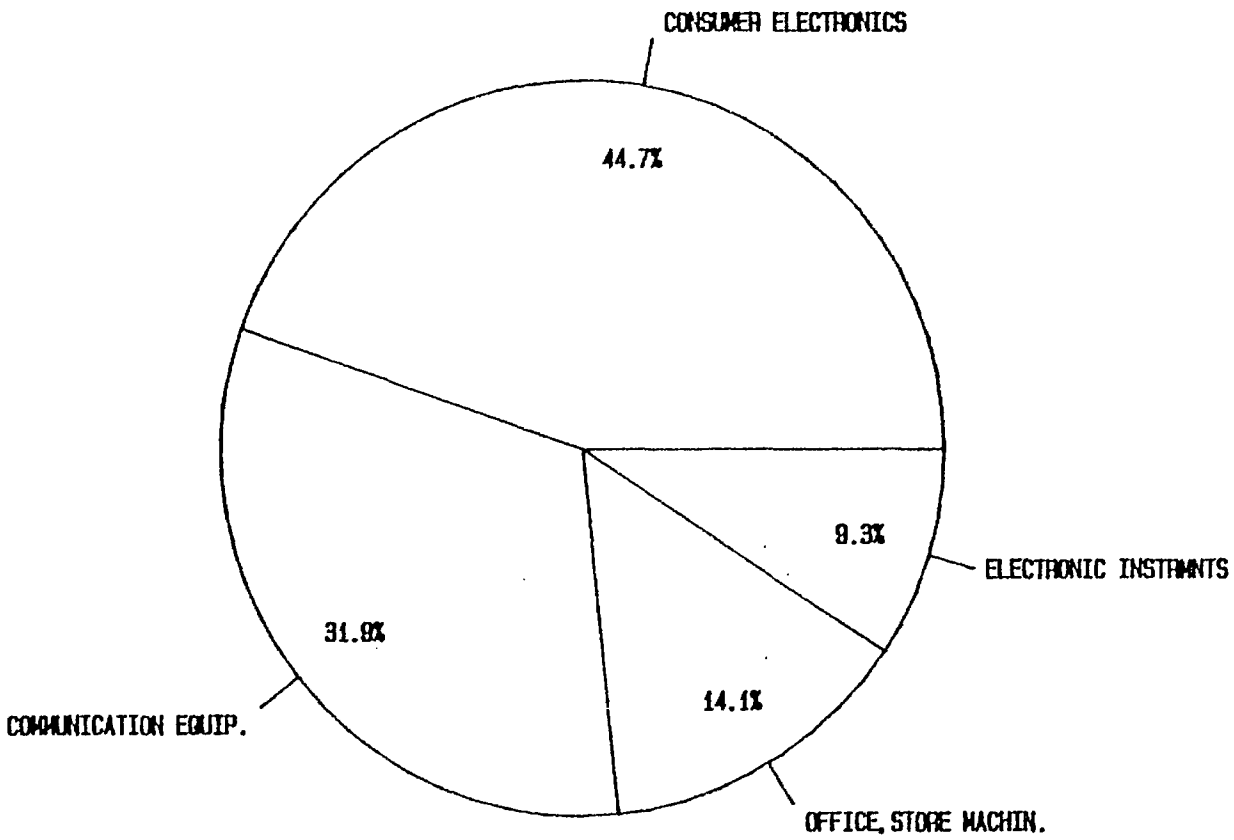
SHARE OF ADM FOR TOTAL ELECTRONICS

1984



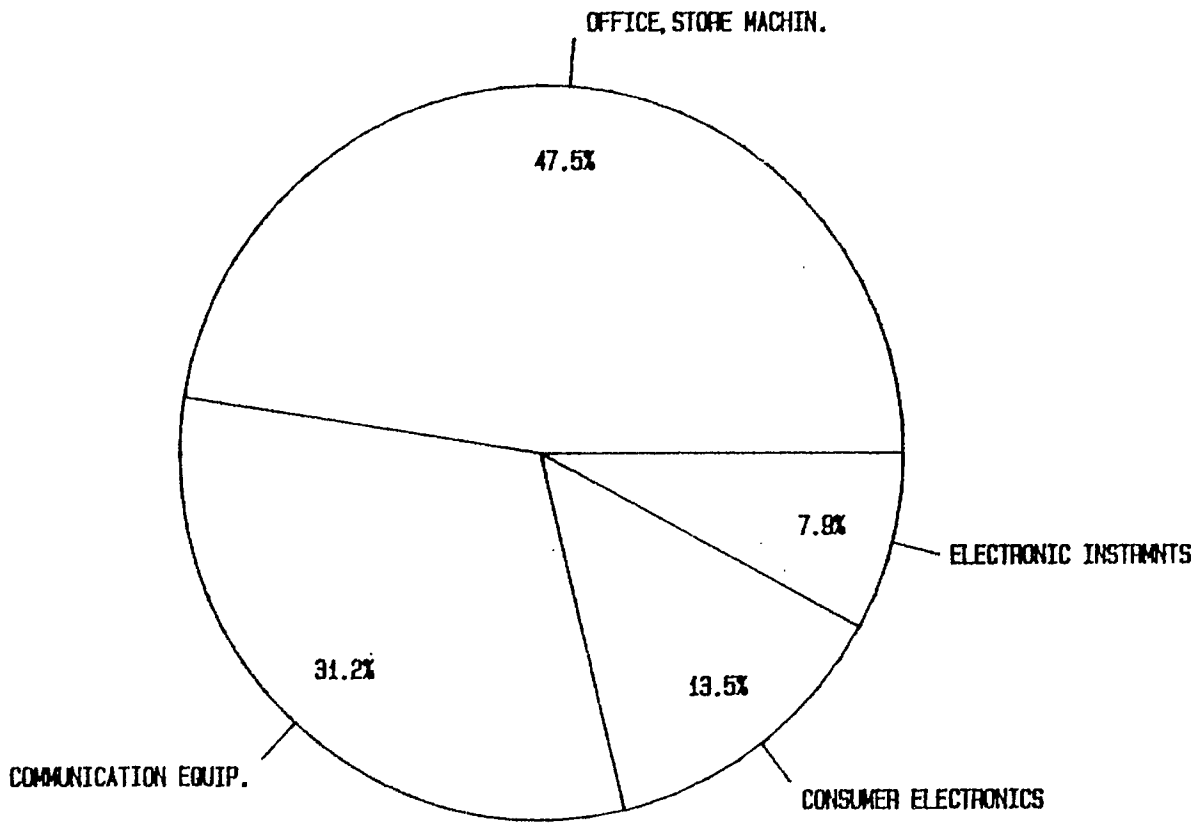
SHARE OF TOTAL ELECTRONICS SHIPMENTS

1984



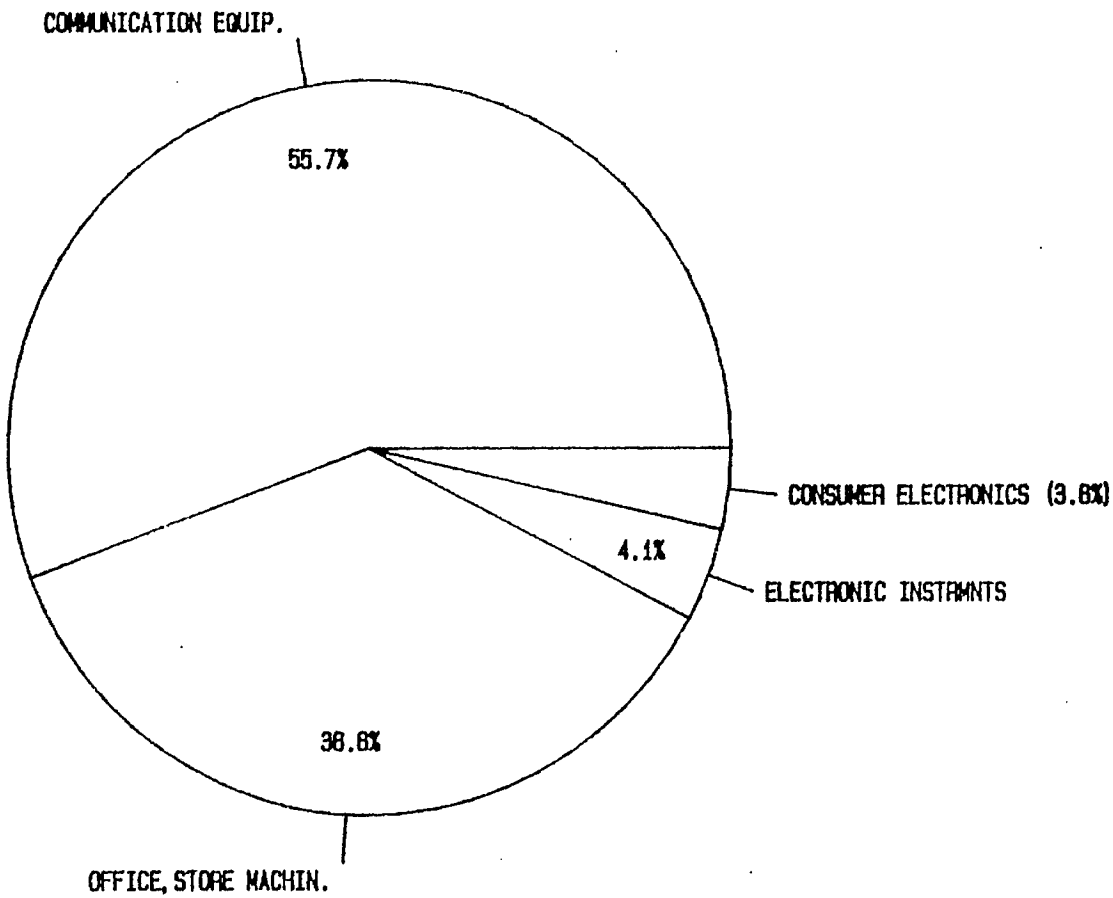
SHARE OF TOTAL ELECTRONICS IMPORTS

1984



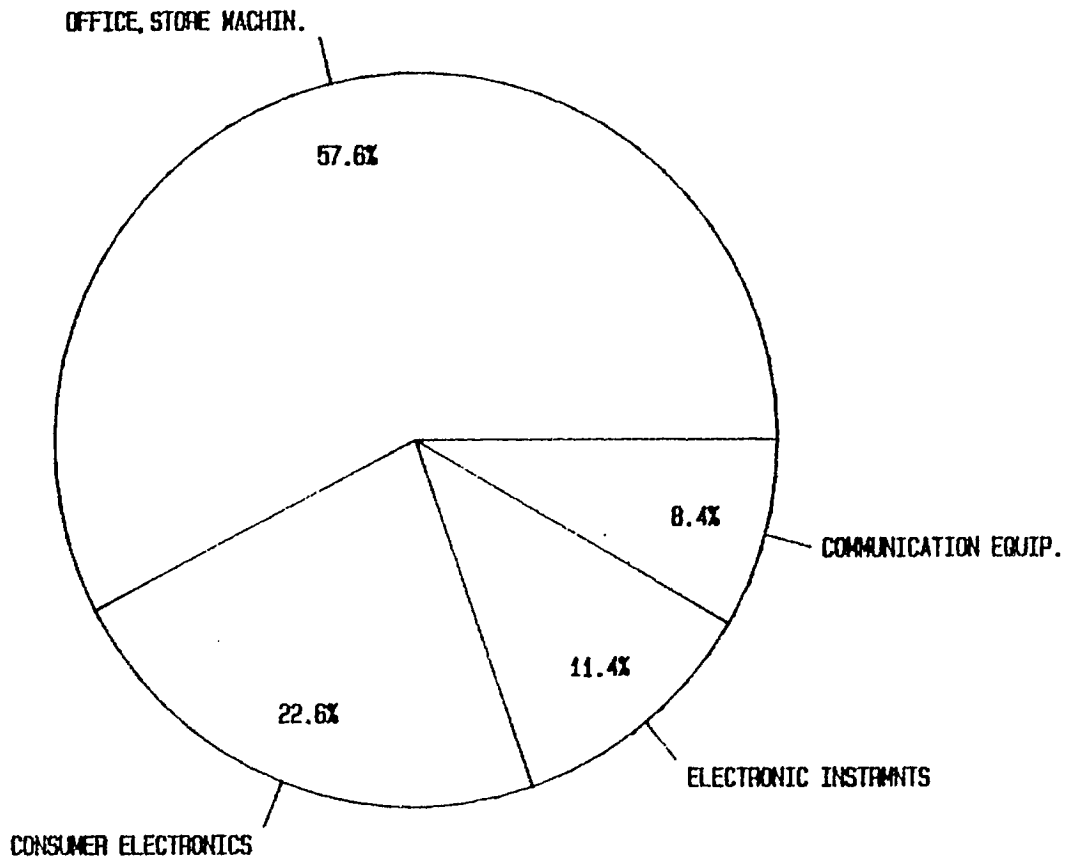
SHARE OF TOTAL ELECTRONICS EXPORTS

1984



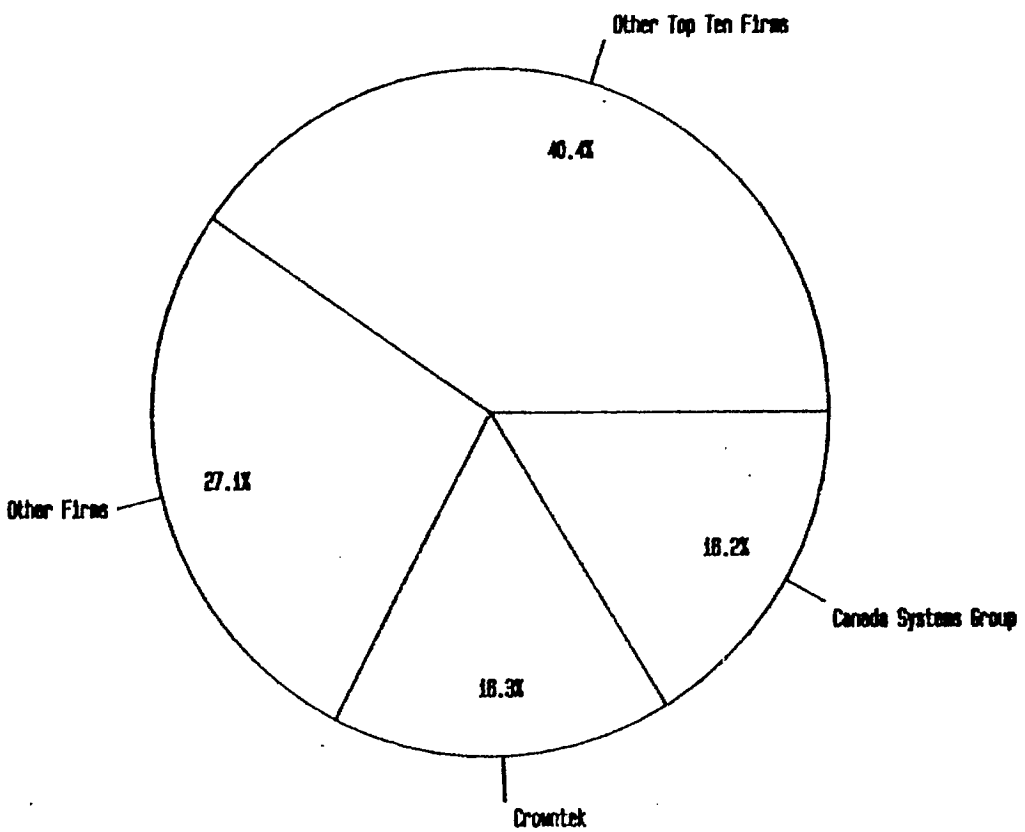
SHARE OF TOTAL ELECTRONICS TRADE DEFICIT

1984



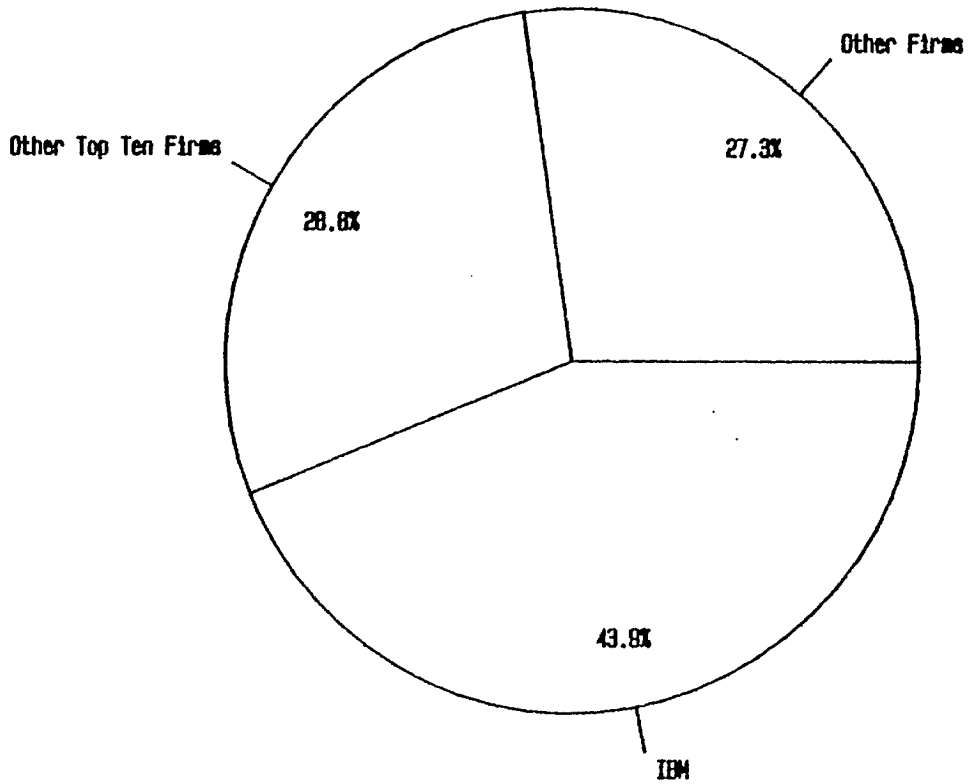
TOP SERVICE BUREAUX IN CANADA

Share of Total Industry Revenue, 1984



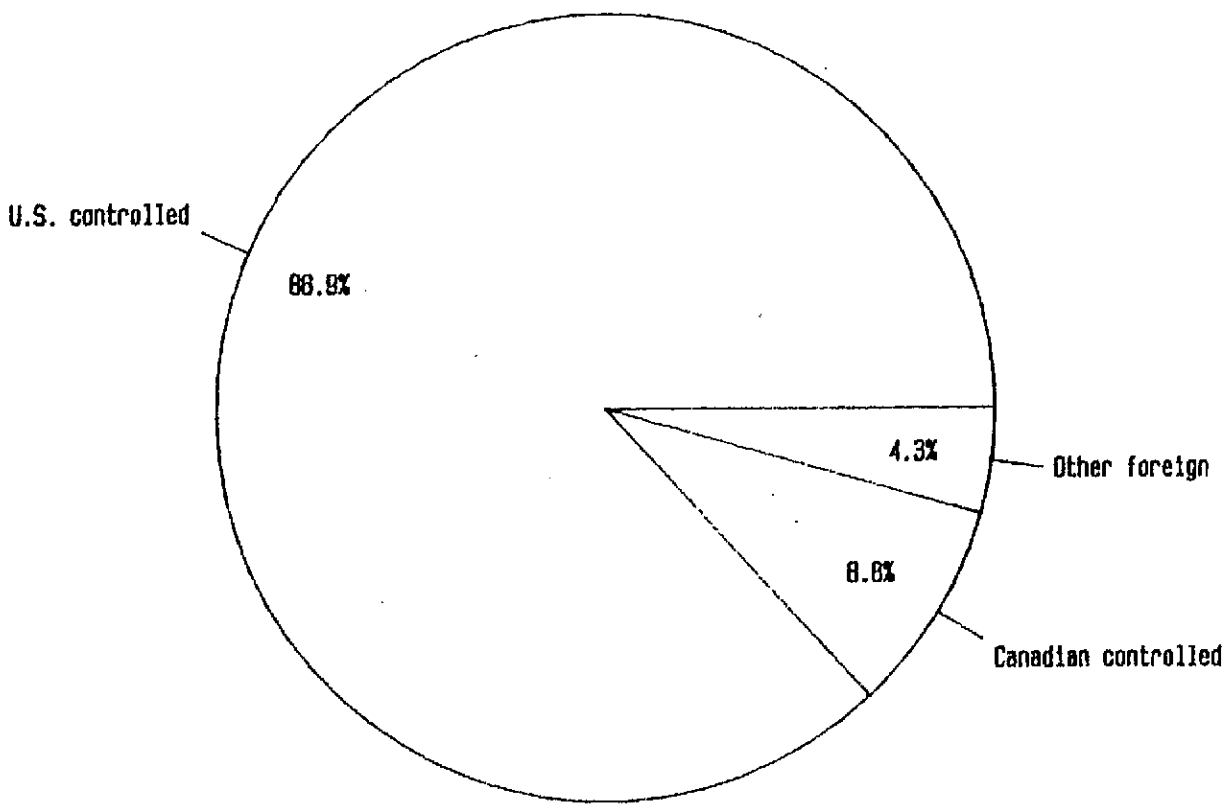
TOP EDP HARDWARE SUPPLIERS IN CANADA

Share of Total Industry Revenue, 1984



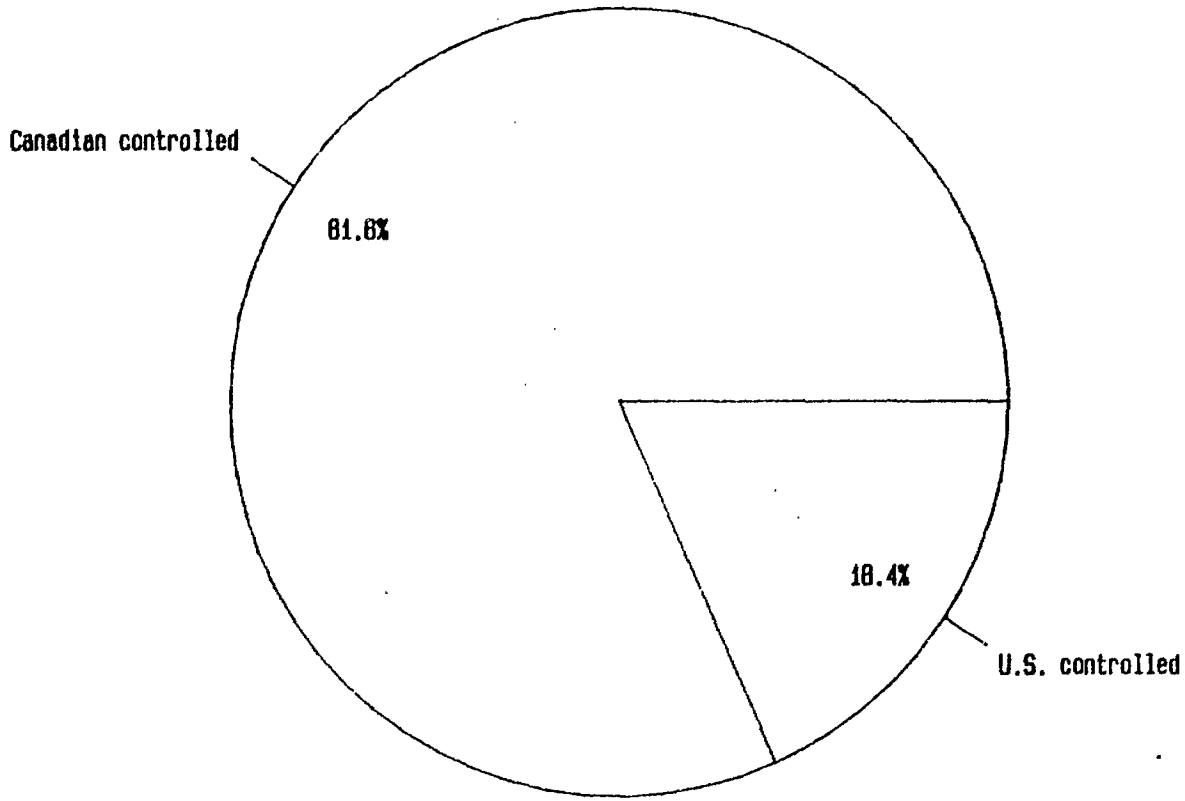
REVENUE OF TOP EDP HARDWARE FIRMS-CANADA

By Ownership of Firm, 1984



REVENUE OF TOP SERVICE BUREAUX IN CANADA

By Ownership of Firm, 1984



Impact of Communications Industries on the Canadian Economy: An Input-Output Analysis

by

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Presented at the 19th Atlantic International Economic Conference, Rome, March 9-16, 1985

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Chantal Leduc and Karen Stanford provided invaluable research assistance to the project.

Impact of Communications Industries on the Canadian Economy: An Input-Output Analysis

Summary

The present study is an attempt at analyzing the impact of communications industries on the Canadian economy. The study was carried out with the application of an open input-output model of the Canadian economy on the main components of communications industries: telecommunications, informatics, content/broadcasting, and content/non-broadcasting.

Based on 1971, 1975, and 1980 data, the study first established the significance of communications industries in Canada. It was estimated that these industries accounted for Cdn$ 17.5 billion in gross domestic product at market prices or 7.4% of the total value for all Canadian industries in 1980.

A simulation was subsequently carried out to assess the effects of an increase of Cdn$ 1 million in the final demand for the output of each of the four industries considered. It was found that the economic benefits of such an increase in expenditure on the informatics, content/broadcasting,and content/non-broadcasting industries would be much higher than those that would accrue from a similar expenditure on the telecommunications industry.

1.0 Background

The Canadian economy, like the economies of other industrialized countries, has steadily become more and more information-oriented. The permeation of information into the fabrics of an industrialized economy entails a whole host of issues such as: education, skill retraining, technological adaptation, and social and economic implications.

In the last several years a number of studies have been carried out to assess the increasingly significant role of information in the economy or the "informatization" of society. These studies usually covered the whole information sector such as those carried out by Porat (5) and Rubin and Taylor (8) on the U.S. information sector, by Karunaratne and Cameron on the Australian information economy (2), and by Jussawalla and Cheah on the Singaporean economy (1). In Canada, the Department of Communications has initiated several studies of the information sector in the last few years. This series of studies began with an analysis of the information sector conducted by Serafini and Andrieu (9) followed by an attempt to define the sector in a comprehensive way (6) and some work done on the components of the sector such as the informatics and telecommunications industries (3,4,7). The present study is yet another effort made by the Department to gain further insight into the pervasive impact, on the economy, of communications industries-the generators, carriers, and receivers of information.

2.0 Purpose

The purpose of this study is to quantify the impact of various components of the communications industries, namely telecommunications, informatics, content/broadcasting, and content/non-broadcasting, on the Canadian economy. The study focuses on the economic effects, in terms of gross domestic product and employment, of these components of the information sector on other industries.

3.0 Methodology

3.1 Definition of Communications Industries

For the purposes of the study, communications industries consist of the following main components:
-telecommunications: equipment and services;
-informatics: hardware, software, and services;
-content/broadcasting: radio and television;
-content/non-broadcasting: printing, publishing, and the performing arts.

In terms of the 1970 Standard Industrial Classification(SIC), the classification which is currently used in the input-output model applied in the study, the above components are in turn defined as containing the following three-digit industry groupings:

Telecommunications

-Telephone Systems (SIC 544);
-Telegraph and Cable Systems (SIC 545);
-Communications Equipment Manufacturers (SIC 335);

Informatics

-Office and Store Machinery Manufacturers (SIC 318);
-Computer Services (SIC 853)

Content/Broadcasting

-Radio and Television Broadcasting (SIC 543);
-Manufacturers of Household Radio and Television Receivers (SIC 334).

Content/Non-Broadcasting

-Commercial Printing (SIC 286);
-Publishing Only (SIC 288);
-Publishing and Printing (SIC 289);
-Motion Picture Theatres (SIC 841);
-Motion Picture Production and Distribution (SIC 842);
-Platemaking, Typesetting, and Trade Bindery Industry (SIC 287).

For a detailed explanation of the composition of the above industries see Appendix A.

A few comments on the composition of the communications industries under consideration are in order. The choice of the particular industry groupings was largely dictated by the availability of machine-readable data which are required by the input-output model. Thus, while the telecommunications and content/broadcasting groups account for most of the industries which can be reasonably assigned to them, the informatics and content/non-broadcasting groups either exclude some industries which should be taken into consideration or, at the other extreme, contain other "impure" elements. For example, in the informatics group, the Office and Store Machinery Manufacturers Industry (SIC 318) also consists of establishments engaged in the manufacturing of typewriters, cash registers, coin-operated vending machines, etc., besides electronic computers and components. Likewise, the content/non-broadcasting group excludes some industries which should, in principle, belong there: Book Stationary Stores (SIC 691) and Theatrical and Other Staged Entertainment Services (SIC 845). The presence of some inappropriate industries as well as the absence of some appropriate ones within the four industry groups under consideration do not affect the findings of the study since these industries are in general insignificant compared to the whole industry groups.

3.2 Application of the Input-Output Model

The input-ouput model used in the study is the open version of Statistics Canada's input-output model of the Canadian economy. Due to the limitations on the memory of the computer used by Statistics Canada the model can handle, at the most detailed level, 191 industry groupings (L level of aggregation), 136 categories of final demand, 595 commodities, and 7 primary inputs (wages and salaries, supplementary labour income, net income of unincorporated business, other operating surplus, commodity indirect taxes, other indirect taxes, and subsidies).

In its simplest form, the input-output model is a linear transformation of final demand categories into industry outputs. In other words, given a level of demand for the output of a particular industry, the model specifies, in monetary terms, the amounts of inputs, both primary and intermediate, required to satisfy this demand. For an elaborate explanation of the structure of Statistics Canada's model see Appendix B.

The input-output model not only gives historical figures on the value of inputs used in the production of each of 191 industries contained in its database, it can also be used to simulate the impact of, say, an increase in the final demand for ouptut of an industry on all other industries.

The current version of Statistics Canada's model is based on the 1970 Standard Industrial Classification for which there are detailed data running from 1961 to 1980. In view of the fact that the industries in the database of the model are at a much higher level of aggregation than those in the 1970 Standard Industrial Classification, it was necessary to define, in the best way possible, the four components of communications, i.e. telecommunications, informatics, content/broadcasting, and content/non-broadcasting, in terms of the model's L-aggregation, bearing in mind that some of the industries in the L-aggregation are not the most appropriate groupings for the purposes of this study. We thus defined the above industries in terms of the requirements of Statistics Canada's input-ouput model as follows:

Industry	1970 Standard Industrial Classification (SIC No.)	L-Aggregation
Telecommunications	544,545,335	106,159
Informatics	318,853	95,183
Content/Broadcasting	543,334	105,158
Content/Non-Broadcasting	286,288,289,841·287	73,74,174,175

The model was first run on 1980 data to determine the significance of communications industries in the production of outputs of other industries. It was then run on 1971, 1975, and 1980 data to assess the effects of an increase of Cdn$ 1,000,000 in final demand for output of each of the communications industries.

4.0 Findings

4.1 Economic Significance of Communications Industries

In order to determine the economic significance of communications industries, as we define them in the study, the input-output model was run on 1980 data. The results of this run are presented in Tables 1-6.

Table 1 shows the composition and value of the primary inputs of communications industries in 1980. From this table it can be seen that together these industries generated a gross domestic product at market prices of Cdn$ 17.6 billion or 7.4% of the total value of all Canadian industries in 1980 (Cdn$ 237.6 billion)

Tables 2-4 give the value of communications industries' products used as intermediate domestic, imported, and total intermediate inputs in the production of other industries. Table 5 gives the value of primary and intermediate inputs as well as outputs of all industries while Table 6 shows, in percentage terms, the contributions of communications industries to the production of other industries.

Table 6 reveals that the telecommunications and informatics industries were present in almost all other industries. While the role of the telecommunications industry was most predominant in the education and health services, wholesale trade, and other finance, insurance and real estate industries, informatics was found most predominant in the other services to business management, other finance, insurance, and real estate, and wholesale trade industries. The content/broadcasting and content/non-broadcasting industries were both very predominant in the travel, advertising and promoting industry.

TABLE 1
Communications Industries: Primary Inputs, 1980
(Current Cdn $, '000)

	Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
Government Goods and Services	5,431	1,725	10,427	13,871	31,454
Commodity Indirect Taxes	36,253	31,371	10,566	10,626	88,816
Subsidies	-13,651	-27,113	-526,744	-105,210	-672,718
Other Indirect Taxes	309,115	82,181	11,496	85,058	487,850
Wages and Salaries	3,014,223	2,886,503	758,257	2,566,654	9,225,637
Supplementary Labour Income	419,860	161,478	63,837	145,392	790,567
Net Income Unincorp. Business	1,192	206,318	384	168,546	376,440
Other Operating Surplus	3,504,837	1,754,699	408,382	1,608,066	7,275,984
Total	7,277,260	5,097,162	736,605	4,493,003	17,604,030

TABLE 2
Communications Industries as Intermediate Inputs to Other Industries:
Value of Domestic Inputs, 1980
(Current Cdn $, '000)

Using Industry	Providing Industry: Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
1. Agriculture	64,101	23,789	514	2,894	91,298
2. Forestry	6,760	31,889	676	120	39,445
3. Fishing, Hunting & Trapping	1,819	2,008	81	54	3,962
4. Metal Mines	11,132	63,737	342	382	75,593
5. Mineral Fuels	22,774	96,116	431	602	119,923
6. Non-Metal Mines and Quarries	4,337	20,848	77	1,023	26,285
7. Services Incidental to Mining	9,573	21,569	288	201	31,631
8. Food and Beverage Industries	77,383	111,954	751	93,139	283,227
9. Tobacco Products Industries	3,077	4,105	24	4,118	11,324
10. Rubber and Plastics Prods. Inds.	20,907	32,050	100	2,812	55,869
11. Leather Industries	4,571	6,008	96	1,041	11,716
12. Textile Industries	16,922	18,879	124	4,815	40,740
13. Knitting Mills	3,916	4,249	40	2,136	10,341
14. Clothing Industries	13,553	13,098	128	3,441	30,220
15. Wood Industries	24,654	40,234	289	1,077	66,254
16. Furniture and Fixture Industries	10,177	10,664	105	2,658	23,604
17. Paper and Allied Industries	38,378	84,705	297	16,541	139,921
18. Primary Metal Industries	44,371	55,556	637	2,053	102,617
19. Metal Fabricating Industries	69,868	65,431	1,139	6,737	143,175
20. Other Machinery Industries	43,915	56,606	1,220	1,130	102,871
21. Transportation Equip. Industries	113,615	244,785	22,358	1,638	382,396
22. Other Elec. Prods. Industries	58,669	32,108	1,965	4,101	96,843
23. Non-Metallic Mineral Prods. Inds.	19,145	25,962	184	2,001	47,292
24. Petroleum and Coals Prods. Inds.	20,432	41,571	151	475	62,629
25. Chemicals and Chemical Prods. Inds.	75,684	103,710	613	19,310	199,317

TABLE 2 (cont.)
Communications Industries as Intermediate Inputs to Other Industries:
Value of Domestic Inputs, 1980
(Current $,'000)

Using Industry	Providing Industry: Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
. Misc. Manufacturing Inds.	34,036	35,114	5,835	12,352	87,337
. Construction Inds.	194,236	424,129	8,023	6,709	633,097
. Transport and Storage	382,142	301,490	2,808	16,787	703,227
. Other Communication	4,356	10,120	7	10,120	24,603
. Elec. Power, Gas, Other Utilities	17,945	37,503	72	3,396	58,916
. Wholesale Trade	383,825	340,715	1,235	30,453	756,228
. Retail Trade	267,926	236,066	772	35,097	539,861
. Other Finance, Ins. and Real Estate	684,098	905,588	1,177	108,299	1,699,162
. Education and Health Services	174,694	87,581	330	10,036	272,641
. Other Services to Business Management	80,931	191,500	786	15,006	288,223
. Accommodation and Food Services	101,883	116,248	13,348	89,558	321,037
. Other Personal and Misc. Services	21,287	19,425	240	775	41,727
. Transportation Margins	0	0	0	74	74
. Operating, Office, Lab. and Food	68,798	137,189	6,147	1,416,314	1,628,448
. Travel and Advertising, Promotion	87,452	115,134	997,453	2,133,803	3,333,842
. Telecommunications	390,804	41,519	2,876	34,233	469,432
. Informatics	178,438	187,387	1,293	7,242	374,360
. Content/Broadcasting	125,713	100,159	60,578	219,300	505,750
. Content/Non-Broadcasting	71,706	114,353	5,832	646,398	838,289

TABLE 3
Communications Industries as Intermediate Inputs to Other Industries:
Value of Imported Inputs, 1980
(Current Cdn $, '000)

Using Industry	Providing Industry: Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
1. Agriculture	1,619	671	15	22	2,327
2. Forestry	212	1,806	50	5	2,073
3. Fishing, Hunting & Trapping	1,882	229	48	1	4,233
4. Metal Mines	405	7,180	22	19	11,859
5. Mineral Fuels	803	8,611	28	29	9,471
6. Non-Metal Mines and Quarries	142	1,834	5	75	2,056
7. Services Incidental to Mining	305	3,422	20	7	5,810
8. Food and Beverage Industries	1,913	10,646	32	7,826	20,417
9. Tobacco Products Industries	80	304	1	325	710
10. Rubber and Plastics Prods. Inds.	562	3,587	4	224	4,377
11. Leather Industries	128	407	6	85	626
12. Textile Industries	454	2,232	4	497	3,187
13. Knitting Mills	100	284	2	208	594
14. Clothing Industries	345	1,250	4	459	2,058
15. Wood Industries	645	2,454	13	51	3,163
16. Furniture and Fixture Industries	621	6,809	4	192	7,626
17. Paper and Allied Industries	983	5,392	11	1,382	7,768
18. Primary Metal Industries	1,745	3,891	19	52	5,707
19. Metal Fabricating Industries	6,844	7,161	718	566	15,289
20. Other Machinery Industries	2,094	8,446	1,094	112	11,746
21. Transportation Equip. Industries	51,520	57,616	69,911	74	179,121
22. Other Elec. Prods. Industries	41,565	5,080	2,276	315	49,236
23. Non-Metallic Mineral Prods. Inds.	965	1,796	22	127	2,910
24. Petroleum and Coals Prods. Inds.	530	3,744	9	19	4,302
25. Chemicals and Chemical Prods. Inds.	1,949	11,645	38	1,610	15,242

TABLE 3 (cont.)
Communications Industries as Intermediate Inputs to Other Industries
Value of Imported Inputs, 1980
(Current Cdn $, '000)

Using Industry	Providing Industry: Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
26. Misc. Manufacturing Inds.	28,247	9,276	7,455	2,549	46,527
27. Construction Inds.	39,962	41,372	4,233	230	85,797
28. Transport and Storage	13,239	25,055	206	1,227	39,727
29. Other Communication	113	1,956	0	368	2,437
30. Elec. Power, Gas, Other Utilities	467	1,553	4	298	2,322
31. Wholesale Trade	14,698	50,804	812	2,506	68,820
32. Retail Trade	6,827	20,750	32	2,464	30,073
33. Other Finance, Ins. and Real Estate	17,554	139,249	70	13,942	170,815
34. Education and Health Services	4,700	9,656	455	3,391	18,202
35. Other Services to Business Management	2,185	33,908	128	548	36,769
36. Accommodation and Food Services	2,597	19,543	257	629	23,026
37. Other Personal and Misc. Services	548	2,132	213	260	3,153
38. Transportation Margins					
39. Operating, Office, Lab and Food	186,937	78,351	5,671	242,667	513,626
40. Travel and Advertising, Promotion	11,851	21,429	18,959	44,363	96,602
41. Telecommunications	366,901	29,601	4,787	3,067	404,356
42. Informatics	50,194	356,958	1,018	654	408,824
43. Content/Broadcasting	149,175	24,185	16,319	718	190,397
44. Content/Non-Broadcasting	1,859	18,508	232	37,514	58,113

TABLE 4
Communications Industries as Intermediate Inputs to Other Industries:
Value of Domestic and Imported Inputs, 1980
(Current Cdn $,'000)

Using Industry	Providing Industry: Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
1. Agriculture	65,720	24,461	529	2,917	93,627
2. Forestry	6,972	33,695	726	125	41,518
3. Fishing, Hunting & Trapping	3,701	2,237	129	55	6,122
4. Metal Mines	11,537	70,917	364	401	83,219
5. Mineral Fuels	23,578	104,727	459	631	129,395
6. Non-Metal Mines and Quarries	4,479	22,682	81	1,098	28,340
7. Services Incidental to Mining	9,878	24,992	307	208	35,385
8. Food and Beverage Industries	79,357	122,599	784	100,966	303,706
9. Tobacco Products Industries	3,157	4,409	25	4,443	12,034
10. Rubber and Plastics Prods. Inds.	21,469	35,637	104	3,036	60,246
11. Leather Industries	4,699	6,415	102	1,126	12,342
12. Textile Industries	17,376	21,110	128	5,311	43,925
13. Knitting Mills	4,016	4,533	42	2,344	10,935
14. Clothing Industries	13,898	14,348	132	3,900	32,278
15. Wood Industries	25,298	42,688	302	1,128	69,416
16. Furniture and Fixture Industries	10,798	17,473	109	2,849	31,229
17. Paper and Allied Industries	39,361	90,098	309	17,923	147,691
18. Primary Metal Industries	46,116	59,448	657	2,105	108,326
19. Metal Fabricating Industries	76,713	72,591	1,857	7,303	158,464
20. Other Machinery Industries	46,009	65,052	2,314	1,242	114,617
21. Transportation Equip. Industries	165,135	302,401	92,269	1,711	561,516
22. Other Elec. Prods. Industries	100,234	37,189	4,241	4,416	146,080
23. Non-Metallic Mineral Prods. Inds.	20,111	27,758	206	2,127	50,202
24. Petroleum and Coals Prods. Inds.	20,961	45,316	160	495	66,932
25. Chemicals and Chemical Prods.Inds.	77,633	115,355	651	20,920	214,559

TABLE 4 (cont.)
Communications Industries as Intermediate Inputs to Other Industries:
Value of Domestic and Imported Inputs, 1980
(Current Cdn $,'000)

Using Industry	Providing Industry: Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
26. Misc. Manufacturing Inds.	62,283	44,390	13,290	14,901	134,864
27. Construction Inds.	234,198	465,501	12,257	6,939	718,895
28. Transport and Storage	395,381	326,545	3,014	18,014	742,954
29. Other Communication	4,468	12,076	7	10,487	27,038
30. Elec. Power, Gas, Other Untilities	18,411	39,055	76	3,693	61,235
31. Wholesale Trade	398,522	391,518	2,046	32,958	825,044
32. Retail Trade	274,752	256,815	804	37,561	569,932
33. Other Finance, Ins. and Real Estate	701,652	1,044,837	1,248	122,241	1,869,978
34. Education and Health Services	179,394	97,237	785	13,427	290,843
35. Other Services to Business Management	83,116	225,408	914	15,554	324,992
36. Accommodation and Food Services	104,480	135,790	13,605	90,187	344,062
37. Other Personal and Misc. Services	21,836	21,557	452	1,035	44,880
38. Transportation Margins	0	0	0	74	-
39. Operating, Office, Lab. and Food	255,735	215,540	11,818	1,658,982	2,142,075
40. Travel and Advertising, Promotion	99,303	136,563	1,016,412	2,178,166	3,430,444
41. Telecommunications	757,705	71,120	7,663	37,301	873,789
42. Informatics	228,633	544,345	2,311	7,896	783,185
43. Content/Broadcasting	274,888	124,344	76,897	220,018	696,147
44. Content/Non-Broadcasting	73,565	132,861	6,064	683,912	896,402

TABLE 5

Values of Inputs and Outputs: All Industries, 1980
(Current Cdn $,'000)

Industry	Primary Inputs	Intermediate Inputs	Output
1. Agriculture	8,987,013	7,475,117	16,462,130
2. Forestry	2,115,846	2,573,378	4,689,224
3. Fishing, Hunting & Trapping	594,542	248,860	843,402
4. Metal Mines	5,238,785	2,914,171	8,152,956
5. Mineral Fuels	10,243,344	7,833,189	18,076,533
6. Non-Metal Mines and Quarries	1,370,665	965,840	2,336,505
7. Services Incidental to Mining	1,835,789	1,352,656	3,188,445
8. Food and Beverage Industries	7,865,242	21,113,049	28,978,291
9. Tobacco Products Industries	428,909	781,246	1,210,155
10. Rubber and Plastics Prods. Inds.	1,717,402	2,491,402	4,208,804
11. Leather Industries	442,917	663,427	1,106,344
12. Textile Industries	1,730,021	2,724,706	4,454,727
13. Knitting Mills	360,541	588,592	949,133
14. Clothing Industries	1,647,595	2,240,613	3,888,208
15. Wood Industries	3,106,849	5,525,912	8,632,761
16. Furniture and Fixtures Inds.	1,027,275	1,317,405	2,344,680
17. Paper and Allied Inds.	6,020,406	8,742,414	14,762,820
18. Primary Metal Inds.	5,023,702	12,661,521	17,685,223
19. Metal Fabricating Inds.	4,671,942	7,340,479	12,012,421
20. Other Machinery Inds.	3,075,864	4,136,905	7,212,779
21. Transporation Equip. Inds.	4,973,961	14,900,000	19,873,961
22. Other Elec. Prods. Inds.	2,106,092	3,232,465	5,338,557
23. Non-Metallic Mineral Prods. Inds.	1,909,762	2,438,297	4,348,059
24. Petroleun and Coals Prods. Inds.	1,861,904	16,703,830	14,841,926
25. Chemicals & Chemical Prods. Inds.	3,765,316	7,980,686	11,746,002

TABLE 5 (cont.)

Value of Inputs and Outputs: All Industries, 1980
(Current Cdn $,'000)

Industry	Primary Inputs	Intermediate Inputs	Output
26. Misc. Manufacturing Inds.	1,436,381	2,537,504	3,973,885
27. Construction Inds.	22,336,145	27,240,319	49,576,464
28. Transport and Storage	13,835,436	11,021,490	24,856,926
29. Other Communication	1,020,782	380,194	1,400,976
30. Elec Power, Gas, Other Utilities	7,862,891	2,097,096	9,959,987
31. Wholesale Trade	13,814,671	6,027,802	19,842,473
32. Retail Trade	17,727,140	7,239,520	24,996,660
33. Other Finance, Ins. & Real Estate	28,074,112	11,071,822	39,145,934
34. Education and Health Services	5,256,107	1,501,017	6,757,124
35. Other Services to Business Management	5,168,946	1,670,842	6,839,788
36. Accommodation & Food Services	7,134,631	5,449,561	12,584,192
37. Other Personal & Misc. Services	2,560,005	1,107,694	3,667,699
38. Transporation Margins	-	9,862,390	9,862,390
39. Operating, Office, Lab. and Food	1,565,651	16,898,971	18,464,622
40. Travel & Advertising, Promotion	1,001,484	9,124,702	10,126,186
41. Telecommunications	7,277,260	2,040,300	9,317,560
42. Informatics	5,097,162	2,819,435	7,916,597
43. Content/Broadcasting	736,605	1,111,314	1,847,919
44. Centent/Non-Broadcasting	4,493,003	4,100,810	8,593,820

TABLE 6
Communications Industries as Intermediate Inputs:
Percentage of Contributions to the Total Value
of Output of Other Industries, 1980

Using Industry	Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
1. Agriculture	0.4	0.1	-	-	0.6
2. Forestry	0.1	0.7	-	-	0.9
3. Fishing, Hunting & Trapping	0.4	0.3	-	-	0.7
4. Metal Mines	0.1	0.9	-	-	1.0
5. Mineral Fuels	0.1	0.6	-	-	0.7
6. Non-Metal Mines and Quarries	0.2	1.0	-	-	1.2
7. Services Incidental to Mining	0.3	0.8	-	-	1.1
8. Food and Beverage Industries	0.3	0.4	-	0.3	1.0
9. Tobacco Products Industries	0.2	0.4	-	0.4	1.0
10. Rubber and Plastics Prods. Inds.	0.5	0.8	-	-	1.4
11. Leather Industries	0.4	0.6	-	0.1	1.1
12. Textile Industries	0.4	0.5	-	0.1	1.0
13. Knitting Mills	0.4	0.5	-	0.2	1.1
14. Clothing Industries	0.3	0.4	-	0.1	0.8
15. Wood Industries	0.3	0.5	-	-	0.8
16. Furniture and Fixture Industries	0.5	0.7	-	0.1	1.3
17. Paper and Allied Industries	0.3	0.6	-	0.1	1.0
18. Primary Metal Industries	0.3	0.3	-	-	0.6
19. Metal Fabricating Industries	0.6	0.6	-	-	1.3
20. Other Machinery Industries	0.6	0.9	-	-	1.6
21. Transportation Equip. Industries	0.8	1.5	0.5	-	2.8
22. Other Elec. Prods. Industries	1.9	0.7	-	-	2.7
23. Non-Metallic Mineral Prods. Inds.	0.5	0.6	-	-	1.1
24. Petroleum and Coals Prods. Inds.	0.1	0.3	-	-	0.4
25. Chemicals and Chemical Prods. Inds.	0.7	1.0	-	0.2	1.8

TABLE 6 (cont.)
Communications Industries as Intermediate Inputs:
Percentage of Contributions to the Total Value
of Output of Other Industries, 1980

Using Industry	Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting	Total
. Misc. Manufacturing Inds.	1.6	1.1	0.3	0.4	3.4
. Construction Inds.	0.5	0.9	-	-	1.4
. Transport and Storage	1.6	1.3	-	-	3.0
. Other Communication	0.3	0.9	-	0.7	1.9
. Elec. Power, Gas, Other Utilities	0.2	0.4	-	-	0.6
. Wholesale Trade	2.0	2.0	0	0.2	4.2
. Retail Trade	1.1	1.0	-	0.1	2.3
. Other Finance, Ins. and Real Estate	1.8	2.7	-	0.3	4.8
. Education and Health Services	2.7	1.4	-	0.2	4.3
. Other Services to Business Management	1.2	3.3	-	0.2	4.7
. Accommodation and Food Services	0.8	1.1	0.1	0.7	2.7
. Other Personal and Misc. Services	0.6	0.6	-	-	1.2
. Transportation Margins	-	-	-	-	-
. Operating, Office, Lab. and Food	1.4	1.2	-	9.0	11.6
. Travel and Advertising, Promotion	1.0	1.3	10.0	21.5	33.9
. Telecommunications	8.1	0.8	-	0.4	9.4
. Informatics	2.9	6.9	-	0.1	10.0
. Content/Broadcasting	14.9	6.7	4.2	11.9	37.7
. Content/Non-Broadcasting	0.9	1.5	-	8.0	10.4

4.2 Effects of an Increase in Final Demand

A simulation was carried out in order to assess the economic effects on other industries of an increase of Cdn$ 1,000,000 in the final demand for output of each communications industry. These effects were evaluated in terms of the gross domestic product and number of employment-years created after the first round of impact (direct effects) and ultimately (direct and indirect effects).

Table 7 shows the direct economic effects of an increase of Cdn$ 1,000,000 in the final demand for output of the telecommunications, informatics, content/broadcasting, and content/non-broadcasting industries in 1980. It can be seen from Table 7 that while the direct GDP effect was strongest in the case of telecommunications, the direct employment effect was strongest in the case of informatics. It can also be seen that while the telecommunications industry was strongest in terms of the income generating capability, the informatics industry was the most labour-intensive of all the four industries considered in the study.

Tables 8-11 depicts the combined direct and indirect effects of the increase in final demand for output of each communications industry on other industries. These effects are expressed in terms of the gross domestic product generated to other industries. It can be seen from Table 10 that the combined effect was strongest in the case of the content/broadcasting industry with a GDP of Cdn$ 1,046,171 generated and it was weakest in the case of the informatics industry with a GDP of Cdn$ 847,547 generated.

Table 12 summarizes the combined employment effects of an increase in final demand in 1971, 1975, and 1980. It shows that the employment generating capability of the informatics, content/broadcasting, and content/non-broadcasting industries far exceeded that of the telecommunications industry. This gap remained practically unchanged during the 1971-1980 period.

Tables 13-16 show the economic benefits of an increase in the final demand for communications goods and services in a more general way. Here two measures of expansionary effects are used: the GDP multiplier and the employment multiplier. These measures are defined respectively as the ratio of the direct and indirect over the direct GDP and employment-years generated by all industries following an increase in final demand for the output of one particular industry. These measures provide indications of the relative impact of one industry on other industries. Thus it can be seen from Tables 13-16 that both the GDP and employment multipliers of the content/broadcasting and content/non-broadcasting industries are considerably higher than those of the telcommunications and informatics industries.

TABLE 7
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Output of Selected Communications Industries, 1980:
Direct Effects
(Current Cdn $)

	Telecommunications	Informatics	Content/ Broadcasting	Content/ Non-Broadcasting
Commodity Indirect Taxes	3,891	3,963	5,718	1,236
Subsidies	-1,465	-3,425	-285,047	-12,243
Other Indirect Taxes	33,176	10,381	6,221	9,898
Wages and Salaries	323,499	364,614	410,330	298,662
Supplementary Labour Income	45,061	20,397	34,545	16,918
Net Income, Unincorporated Business	128	26,061	208	19,612
Other Operating Surplus	376,154	221,648	220,996	187,119
GDP at Factor Cost	744,842	632,721	666,079	522,311
Number of Employment-Years Created	16.2	25.5	18.5	21.5

TABLE 8

Impact of an Increase of Cdn $1,000,000 in Final Demand for Output of the Telecommunications Industry, 1980: Direct and Indirect Effects on Other Industries (Current Cdn $)

	Wages and Salaries and Supp. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
1. Agriculture	45	148	165	358
2. Forestry	332	13	94	440
3. Fishing, Hunting & Trapping	11	12	8	30
4. Metal Mines	548	1	1,211	1,760
5. Mineral Fuels	306	-2	2,381	2,685
6. Non-Metal Mines and Quarries	73	5	66	144
7. Services Incidental to Mining	82	0	57	138
8. Food and Beverage Industries	243	3	138	384
9. Tobacco Products Industries	1	0	1	2
10. Rubber and Plastics Prods. Inds.	645	4	269	918
11. Leather Industries	28	0	9	37
12. Textile Industries	185	1	65	251
13. Knitting Mills	5	0	2	7
14. Clothing Industries	42	0	12	54
15. Wood Industries	689	8	177	873
16. Furniture and Fixture Industries	136	6	29	171
17. Paper and Allied Industries	1,240	1	888	2,129
18. Primary Metal Industries	2,700	6	1,233	3,939
19. Metal Fabricating Industries	1,880	31	725	2,637
20. Other Machinery Industries	593	2	303	898
21. Transportation Equip. Industries	608	0	167	776
22. Other Elec. Prods. Industries	3,872	1	1,272	5,145
23. Non-Metallic Mineral Prods. Inds.	504	2	246	753
24. Petroleum and Coals Prods. Inds.	298	1	281	580
25. Chemicals and Chemical Prods. Inds.	1,072	0	978	2,050

TABLE 8 (cont.)
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Output of the Telecommunications Industry, 1980:
Direct and Indirect Effects on Other Industries
(Current Cnd $)

	Wages and Salaries and Supp. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
26. Misc. Manufacturing Inds.	374	7	95	476
27. Construction Inds.	7,502	659	1,191	9,352
28. Transport and Storage	3,517	215	1,371	5,103
29. Other Communication	4,399	24	-1,348	3,075
30. Elec. Power, Gas, Other Utilities	1,346	2	3,523	4,871
31. Wholesale Trade	6,196	354	2,204	8,754
32. Retail Trade	1,948	265	552	2,765
33. Other Finance, Ins. and Real Estate	6,621	71	6,467	13,159
34. Education and Health Services	4	8	1	13
35. Other Services to Business Management	1,518	497	293	2,308
36. Accommodation and Food Services	724	124	245	1,093
37. Other Personal and Misc. Services	203	82	42	327
38. Transportation Margins	0	0	0	0
39. Operating, Office, Lab. and Food	0	0	0	0
40. Travel and Advertising, Promotion	0	0	0	0
41. Telecommunications	385,231	137	389,917	775,086
42. Informatics	2,707	187	1,567	4,461
43. Content/Broadcasting	654	0	328	982
44. Content/Non-Broadcasting	3,856	55	1,587	5,498
Total	442,940	2,932	418,609	864,481

TABLE 9
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Output of the Informatics Industry, 1980:
Direct and Indirect Effects on Other Industries
(Current Cdn $)

	Wages and Salaries and Suppl. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
1. Agriculture	137	452	503	1,093
2. Forestry	458	18	130	606
3. Fishing, Hunting & Trapping	24	26	18	67
4. Metal Mines	179	0	362	541
5. Mineral Fuels	617	-4	5,073	5,686
6. Non-Metal Mines and Quarries	53	2	80	135
7. Services Incidental to Mining	149	1	103	252
8. Food and Beverage Industries	581	6	326	913
9. Tobacco Products Industries	1	0	1	2
10. Rubber and Plastics Prods. Inds.	1,092	5	366	1,463
11. Leather Industries	55	0	17	72
12. Textile Industries	289	3	114	406
13. Knitting Mills	11	0	3	14
14. Clothing Industries	114	1	32	147
15. Wood Industries	453	5	107	565
16. Furniture and Fixture Industries	34	1	8	43
17. Paper and Allied Industries	1,884	1	1,446	3,330
18. Primary Metal Industries	1,166	3	545	1,715
19. Metal Fabricating Industries	2,624	50	946	3,620
20. Other Machinery Industries	1,479	5	757	2,241
21. Transportation Equip. Industries	856	1	255	1,112
22. Other Elec. Prods. Industries	1,037	0	426	1,464
23. Non-Metallic Mineral Prods. Inds.	313	1	147	461
24. Petroleum and Coals Prods. Inds.	682	2	639	1,323
25. Chemicals and Chemical Prods. Inds.	1,213	1	1,064	2,278

TABLE 9 (cont.)
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Output of the Informatics Industry, 1980:
Direct and Indirect Effects on Other Industries
(Current Cdn $)

	Wages and Salaries and Suppl. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
26. Misc. Manufacturing Inds.	1,028	20	236	1,284
27. Construction Inds.	2,299	203	949	3,451
28. Transport and Storage	9,058	651	3,162	12,872
29. Other Communication	4,276	23	-1,310	2,990
30. Elec. Power, Gas, Other Utilities	1,626	2	4,269	5,897
31. Wholesale Trade	9,677	533	3,443	13,673
32. Retail Trade	8,985	1,223	2,544	12,751
33. Other Finance, Ins. and Real Estate	30,282	309	25,638	56,229
34. Education and Health Services	16	29	3	47
35. Other services to Business Management	8,580	2,974	1,602	13,156
36. Accommodation and Food Services	3,859	656	1,304	5,810
37. Other Personal and Misc. Services	1,115	490	217	1,822
38. Transportation Margins	0	0	0	0
39. Operating, Office, Lab. and Food	0	0	0	0
40. Travel and Advertising, Promotion	0	0	0	0
41. Telecommunications	10,651	3	12,009	22,662
42. Informatics	396,695	26,866	228,403	651,964
43. Content/Broadcasting	2,327	1	1,097	3,425
44. Content/Non-Broadcasting	6,921	118	2,925	9,965
Total	512,885	34,703	299,959	847,547

TABLE 10
Impact of an Increase of Cdn $1,000,000 in Final Demand for Output of the Content/Broadcasting Industry, 1980: Direct and Indirect Effects on Other Industries (Current Cdn $)

	Wages and Salaries and Suppl. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
1. Agriculture	190	626	697	1,514
2. Forestry	640	25	182	848
3. Fishing, Hunting & Trapping	36	39	27	102
4. Metal Mines	233	0	490	723
5. Mineral Fuels	604	-4	4,871	5,472
6. Non-Metal Mines and Quarries	80	5	93	178
7. Services Incidental to Mining	161	1	111	273
8. Food and Beverage Industries	928	10	498	1,437
9. Tobacco Products Industries	5	0	6	11
10. Rubber and Plastics Prods. Inds.	961	5	362	1,328
11. Leather Industries	51	0	15	67
12. Textile Industries	324	2	121	448
13. Knitting Mills	11	0	4	15
14. Clothing Industries	84	1	24	108
15. Wood Industries	948	10	230	1,188
16. Furniture and Fixture Industries	363	16	78	457
17. Paper and Allied Industries	2,319	1	1,726	4,046
18. Primary Metal Industries	1,345	4	628	1,977
19. Metal Fabricating Industries	2,212	32	861	3,106
20. Other Machinery Industries	970	4	497	1,471
21. Transportation Equip. Industries	1,041	1	327	1,369
22. Other Elec. Prods. Industries	2,007	1	713	2,722
23. Non-Metallic Mineral Prods. Inds.	513	2	247	762
24. Petroleum and Coals Prods. Inds.	630	2	591	1,223
25. Chemicals and Chemical Prods. Inds.	1,380	1	1,226	2,607

TABLE 10 (cont.)
Impact of an Increas of Cdn $1,000,000 in Final Demand
for Output of Content/Broadcasting Industry, 1980:
Direct and Indirect Effects on Other Industries
(Current Cdn $)

	Wages and Salaries and Supp. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
26. Misc. Manufacturing Inds.	2,041	40	416	2,497
27. Construction Inds.	6,686	588	1,535	8,809
28. Transport and Storage	11,068	724	3,698	15,490
29. Other Communication	2,697	15	-826	1,885
30. Elec. Power, Gas, Other Utilities	2,640	2	6,947	9,589
31. Wholesale Trade	10,193	583	3,626	14,401
32. Retail Trade	5,743	782	1,626	8,151
33. Other Finance, Ins. and Real Estate	26,435	265	22,168	48,868
34. Education and Health Services	13	24	2	40
35. Other Services to Business Management	14,662	5,028	2,755	22,445
36. Accommodation and Food Services	4,656	794	1,577	7,027
37. Other Personal and Misc. Services	2,549	1,149	487	4,185
38. Transportation Margins	0	0	0	0
39. Operating, Office, Lab. and Food	0	0	0	0
40. Travel and Advertising, Promotion	0	0	0	0
41. Telecommunications	29,157	12	28,212	57,381
42. Informatics	26,444	1,944	15,539	43,927
43. Content/Broadcasting	466,131	218	231,110	697,459
44. Content/Non-Broadcasting	37,424	3,643	29,501	70,568
Total	666,574	16,595	363,002	1,046,171

TABLE 11

Impact of an Increase of Cdn $1,000,000 in Final Demand for Output of the Content/Non-Broadcasting Industry, 1980: Direct and Indirect Effects on Other Industries (Current Cdn $)

	Wages and Salaries and Suppl. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
1. Agriculture	395	1,302	1,449	3,145
2. Forestry	7,260	288	2,062	9,611
3. Fishing, Hunting & Trapping	49	54	37	141
4. Metal Mines	219	0	463	683
5. Mineral Fuels	882	-6	7,104	7,980
6. Non-Metal Mines and Quarries	110	5	166	281
7. Services Incidental to Mining	186	1	129	315
8. Food and Beverage Industries	1,827	23	964	2,814
9. Tobacco Products Industries	2	0	2	4
10. Rubber and Plastics Prods. Inds.	1,251	7	494	1,753
11. Leather Industries	111	1	32	144
12. Textile Industries	611	3	221	836
13. Knitting Mills	18	0	6	24
14. Clothing Industries	101	1	29	131
15. Wood Industries	3,768	30	772	4,570
16. Furniture and Fixture Industries	93	4	21	118
17. Paper and Allied Industries	29,733	3	29,299	59,036
18. Primary Metal Industries	1,498	12	786	2,296
19. Metal Fabricating Industries	1,984	31	724	2,738
20. Other Machinery Industries	1,053	4	539	1,595
21. Transportation Equip. Industries	808	1	226	1,035
22. Other Elec. Prods. Industries	766	0	337	1,103
23. Non-Metallic Mineral Prods. Inds.	448	2	232	682
24. Petroleum and Coals Prods. Inds.	807	3	757	1,567
25. Chemicals and Chemical Prods. Inds.	4,231	2	4,107	8,340

TABLE 11 (cont.)
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Output of the Content/Non-Broadcasting Industry, 1980:
Direct and Indirect Effects on Other Industries
(Current Cdn $)

	Wages and Salaries and Supp. Labour Income	Net Income Unincorp. Bus.	Surplus	GDP at Factor Cost
26. Misc. Manufacturing Inds.	2,029	33	571	2,633
27. Construction Inds.	3,725	328	989	5,042
28. Transport and Storage	17,205	1,114	6,231	24,550
29. Other Communication	9,346	51	-2,863	6,533
30. Elec. Power, Gas, Other Utilities	3,913	5	10,235	14,153
31. Wholesale Trade	13,977	799	4,973	19,748
32. Retail Trade	12,214	1,662	3,458	17,334
33. Other Finance, Ins. and Real Estate	21,676	221	22,323	44,220
34. Education and Health Services	10	19	2	31
35. Other Services to Business Management	5,759	1,759	1,150	8,668
36. Accommodation and Food Services	4,520	771	1,531	6,822
37. Other Personal and Misc. Services	990	371	218	1,579
38. Transportation Margins	0	0	0	0
39. Operating, Office, Lab. and Food	0	0	0	0
40. Travel and Advertising, Promotion	0	0	0	0
41. Telecommunications	5,694	1	6,556	12,251
42. Informatics	8,693	639	5,108	14,441
43. Content/Broadcasting	3,642	2	1,708	5,352
44. Content/Non-Broadcasting	351,520	20,506	202,172	574,198
Total	523,125	30,052	315,322	868,499

TABLE 12
Impact of an Increase of Cdn $1,000,000 in Final Demand for Output of Communications Industries: Direct and Indirect Effects on Employment (No. of Employment-Years Created)

	Year		
	1971	1975	1980
Telecommunications	55.6	35.5	20.0
Informatics	76.4	54.7	33.2
Content/Broadcasting	77.0	53.9	33.4
Content/Non-Broadcasting	81.1	52.4	33.4

TABLE 13
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Output of the Telecommunications Industry:
GDP and Employment Multipliers

	1971	1975	1980
GDP Generated, Total	883,234	888,194	864,481
GDP Generated, Direct	744,056	746,113	744,842
GDP Multiplier	1.19	1.19	1.16
Employment Created, Total	55.6	35.5	20.0
Employment Created, Direct	43.8	28.1	16.2
Employment Multiplier	1.27	1.26	1.23

(1) Current Cdn $
(2) Employment - Years

TABLE 14
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Output of the Informatics Industry:
GDP and Employment Multipliers

	1971	1975	1980
GDP Generated, Total	831,863	853,227	847,547
GDP Generated, Direct	621,165	646,083	637,721
GDP Multiplier	1.34	1.32	1.33
Employment Generated, Total	76.4	54.7	33.2
Employment Generated, Direct	58.9	43.0	25.5
Employment Multiplier	1.30	1.27	1.30

(1) Current Cdn $
(2) Employment - Years

TABLE 15
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Ouput of the Content/Broadcasting Industry:
GDP and Employment Multipliers

	1971	1975	1980
GDP Generated, Total	1,013,876	1,136,748	1,046,171
GDP Generated, Direct	636,879	728,203	782,203
GDP Multiplier	1.59	1.45	1.57
Employment Generated, Total	77.0	53.9	33.4
Employment Generated, Direct	44.0	33.5	18.5
Employment Multiplier	1.73	1.61	1.80

(1) Current Cdn $
(2) Employment - Years

TABLE 16
Impact of an Increase of Cdn $1,000,000 in Final Demand
for Ouput of the Content/Non-Broadcasting Industry:
GDP and Employment Multipliers

	1971	1975	1980
GDP Generated, Total	859,129	855,428	868,499
GDP Generated, Direct	527,999	523,910	522,311
GDP Multiplier	1.62	1.63	1.66
Employment Generated, Total	81.1	52.4	33.4
Employment Generated, Direct	53.1	33.4	21.5
Employment Multiplier	1.53	1.57	1.55

(1) Current Cdn $
(2) Employment - Years

5.0 Conclusion

The present study is an attempt to assess the impact of communications industries on the Canadian economy. For the purposes of the study, these industries consist of the telecommunications, informatics, content/broadcasting, and content/non-broadcasting industries. The availability of data on the industries covered by the 1970 Standard Industrial Classification and the aggregation of industries in the input-output model of the Canadian economy imposed some limitations on the definition of communications industries used in the study. Thus, these industries either include some activities which are not quite "communications-related" or exclude other activities which are clearly appropriate to communications. This problem affects the definitions of the informatics and content/nonbroadcasting industries to a greater extent than it does the telecommunications and content/broadcasting industries. Since the excluded or redundant activities do not represent a significant part of the industries involved, the general findings of the study are largely unaffected.

It was found that while the telecommunications and informatics industries were present in almost all industries in Canada, the content/broadcasting and content/non-broadcasting industries played a significant role in only a limited number of industries, most notably the travel advertising and promotion industries.

A simulation of the effects of an increase in final demand for communications goods and services showed that the telecommunications industry created far less employment than did the informatics, content/broadcasting, and content/non-broadcasting industries. It also showed that the overall economic benefits of an increase in final demand, in relative terms, were much more pronounced in the cases of the content/broadcasting and content/non-broadcasting industries than those generated by the telecommunications and informatics industries.

With some refinements in the collection of industrial data and some modifications in the aggregation of industry groups used in the input-output model the type of analysis presented here provides a valuable tool for assessing the role played by communications industries in the economy and for evaluating the economic effects of various policies dealing with the information sector.

APPENDICES

APPENDIX A

Definition of Communications Industries

1. Telecommunications

1970 SIC No. and Description	L Sequential No. and Industry Group
544 Telephone Systems Establishments, whether owned by governments or not, primarily engaged in providing telephone service which sometimes includes the construction of telephone lines. These systems often include maintenance of equipment and lines and the operation of schools for training of operators.	159 Communications Industries, NES
545 Telegraph and Cable Systems Establishments primarily engaged in transmitting messages by telegraph, cable or wireless for a fee. This industry includes establishments primarily engaged in providing teletype service, wirephoto service, or a system of co-axial cables for closed circuit communication systems.	
335 Communications Equipment Manufacturers Establishments primarily engaged in manufacturing radio and television transmitters, radar equipment, closed circuit television apparatus, and the related parts and equipment. Included are establishments primarily engaged in manufacturing telephone and telegraph equipment and parts of electric and electronic signalling apparatus. This industry includes establishments primarily engaged in manufacturing electronic control panels and similar devices. Repair and overhaul of electronic equipment, except household equipment, is classified here.	106 Communications Equipment Mfgrs

2. Informatics

1970 SIC No. and Description	L Sequential No. and Industry Group
318 Office and Store Machinery Manufacturers Establishments primarily engaged in manufacturing office and store machinery such as typewriters, cash registers, coin-operated vending machines, mechanical computing machines, and scales and balances. Establishments primary engaged in manufacturing electronic computers, data processors and related control devices are included here.	95 Office & Store Machinery Mfgrs
853 Computer Services Establishments primarily engaged in providing computer facilities on a rental or time-sharing basis, and such ancillary activities as programming, planning and systems analysis, etc.	183 Misc. Services to Bus. & Pers. (1)

(1) In addition to SIC 853, this industry group also consists of the following elements:

SIC 851 Employment Agencies and Personnel Suppliers
855 Security and Investigation Services
867 Offices of Management and Business Consultants
869 Miscellaneous Services to Business Consultants
891 Labour Organization and Trade Association
895 Machinery and Equipment Rental
899 Miscellaneous Services, NES

3. Content/Broadcasting

1970 SIC. No. and Description	L Sequential No. and Industry Group
543 Radio and Television Broadcasting Establishments primarily engaged in radio and television broadcasting and in the operation of radio and television broadcasting studios for the purpose of broadcasting programs of entertainment, news, talks and the like. This industry includes broadcasting systems such as those operated by the Canadian Broadcasting Corporation and privately owned stations and networks providing a broadcasting service similar to that of the CBC. This industry also includes establishments primarily engaged in operating closed circuit radio or television systems providing a variety of programs such as those broadcast by the CBC, to particular subscribers. Establishments primarily engaged in broadcasting messages for a fee are included in Industry No. 545-Telegraph and Cable Systems. Establishments primarily engaged in operating closed circuit television or radio systems to provide a communication service are included in Industry No. 545-Telegraph and Cable Systems, whereas those providing such service to assist particular industrial processes are included in Industry No. 869-Miscellaneous Services to Business Management.	158 Radio & Tel. Broadcasting
334 Manufactuers of Household Radio and Television Receivers Establishments primarily engaged in manufacturing radio and television receiving sets. The industry also includes establishments primarily engaged in manufacturing record playing, tape playing and recording equipments and parts. Establishments primarily engaged in manufacturing records, tapes and other media for recording vocal or instrumental perforances are classified in Industry No. 399.	105 Radio & Television Receivers
Excluded:	
678 Radio, Television, and Electrical Appliance Repair Shops Establishments primarily engaged in the repair of radios, television sets, and similar equipment or in repairing household electrical appliances.	165 Retail Trade includes SIC Nos. (631-699)

4. Content/Non-Broadcasting 1970 SIC No. and Description	L Sequential No. and Industry Group
286 Commercial Printing Establishments primarily engaged in the production of commercial and/or job printing regardless of the printing method or process used (letter press, including flexographic, planographic or lithographic; intaglio or gravure; stencil printing or silk screen; etc.) The following list of printed products is intended to be representative but not complete: newpapers, periodicals, books, maps, and all other printing done on a job or contract basis for other individuals or firms; printed office stationery and forms, snap-out sets (carbonized sets or carbonless reproducing sets), continuous forms, calendars, greeting cards, post cards, playing cards, wrapping, tickets, envelopes, tags, seals, labels, stamps (postage, revenue, trading, etc.), engraved stationery, bank notes, stock and bond certificates, catalogues, printed advertising matter, etc. Establishments primarily engaged in publishing are included in Industry No. 288-Publishing Only if the publisher does not print his own publications, or in Industry No. 289-Publishing and Printing if the publisher prints his own publications. Establishments primarily engaged in providing blue prints and such copying services are included in Industry No. 869-Miscellaneous Services to Business Management.	73 Printing & Publishing
288 Publishing Only This industry includes establishments primarily engaged in publishing only and which do no printing. The term "publishing" as applied in this industry, includes publishing of books, newspapers, periodicals, almanacs, maps, guides and similar products.	

4. Content/Non-Broadcasting (cont.)

1970 SIC. No. and Description	L Sequential No. and Industry Group
289 Publishing and Printing Establishments primarily engaged in publishing and printing newpapers, periodicals, books, almanacs, maps, guides and the like. Establishments primarily engaged in printing newspapers, magazines, books, etc. for publishers are included in Industry No. 286-Commercial Printing. Establishments which publish only and do no printing are included in Industry No. 288-Publishing Only.	
841 Motion Picture Theatres Establishments primarily engaged in operating regular motion picture theatres and outdoor motion picture theatres. Also included are other motion picture exhibitors not elsewhere classified.	174 Motion Picture Theatres
842 Motion Picture Production and Distribution Establishments primarily engaged in the production and the distribution of motion pictures. Included are film exchanges, motion pictures, libraries and booking agencies as well as establishments engaged in processing and reproducing standard motion picture films.	
287 Platemaking, Typesetting, and Trade Bindery Industry Establishments (trade shops) primarily engaged in providing specialized services to the printing and publishing trades, advertising agencies or others: the making of image bearing photographic films, plates and printers dyes of all types; doing typesetting; making binders or covers, doing hand or machine bindery work and allied post-printing converting or finishing operations.	74 Engraving, Stereotyping Ind.

4. Content/Non-Broadcasting (cont.)

1970 SIC No. and Description	L Sequential No. and Industry Group
Excluded:	
691 Book and Stationery Stores Establishments primarily engaged in retail dealing in new or used books and stationery.	165 Retail Trade (includes SIC. No 631-699)
845 Theatrical and Other Staged Entertainment Services Establishments primarily engaged in the production and /or presentation of theatrical and other staged entertainment. Theatre companies, opera companies, road companies, orchestras, bands and pop groups as well as own account entertainers are included in this industry.	175 Other Recreational Services (includes the following: SIC 834 Bowling Alleys and Billard Parlours 844 Golf Clubs and Country Clubs 849 Miscellaneous Amusement and Recreation Services

APPENDIX B
The Input-Output Model

1. Accounting Framework

The Input-Ouput models of the Canadian economy, built and operated by Statistics Canada, are based on the Input-Output Tables which consist of the following principal accounts:(*)

-Commodity Accounts: detail the supply and demand of individual commodities;
-Industry Accounts: detail the commodity composition of the output of industries and the complete cost of production (including profit) of industries.

The elements of the Input-Output Tables are related together as shown in Chart 1.

2. Input-Output Model

There are two versions of input-output models: an "open" model and a "closed" model. In the open input-output model incomes generated in the process of production accruing to other sectors of the economy are not spent. In other words, all the components of the gross national expenditure constitute the exogeneous final demand. This version differs from the closed input-output model in which incomes generated in the process of production accruing to households are spent on goods and services, taxes or savings. In the "closed" model consumer expenditures are calculated and hence are not part of the exogeneous final demand.

The present study was based on the open input-output model.

Two fundamental assumptions are used in the formulation of the model:

i) Industries will preserve their observed share of the market for each domestically produced commodity, irrespective of the levels of commodity production. In mathematical terms:

$$g = Dg \quad (1)$$

where:

g (=) vector representing the values of industry outputs;
q (=) vector representing the values of domestically produced commodity outputs;
D (=) matrix of coefficients which are calculated by dividing each element in a column of the output martix V of Chart 1 by the corresponding total commodity output. D is called the Domestic Market Share Matrix

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(*) For a more complete treatment of this subject see (10)

CHART 1

The Accounting Framework of Canadian Input-Output Tables

	Commodities	Industries	Final demand categories									Total
			PE	FCF	VPCW	VPCA	GGCE	XE	XR	Less M	Less GR	
Commodities		U	F									q
Industries	V											g
Commodity indirect taxes Other indirect taxes Less subsidies Wages and salaries Supplmentary labour income Net income of Unincorporated business Other operating surplus		YI	YF									n
Total	$\hat{q}$	$\hat{g}$	$\hat{e}$									

Final Demand Categories

PE - Personal expenditure on goods and services
FCF - Fixed capital formation, business and government
VPCW - Value of physical change on inventories, withdrawals
VPCA - Value of physical change in inventories, additions
GGCE - Gross government current expenditure on goods and services
XD - Domestic exports of goods and services
XR - Re-exports of goods and services
M - Imports of goods and services
GR - Government revenue from sale of goods and services

Notation

V: is a matrix of the values of outputs
U: is a matrix of the values of intermediate inputs
F: is a matrix of the values of commodity inputs of final demand categories
YI: is a matrix of the values of primary inputs of industries
YF: is a matrix of the values of primary inputs of final demand categories
q: is a vector of the values of total commodity outputs
g: is a vector of the values of total industry outputs
e: is a vector of the values of total inputs (commodities plus primary) of final demand categories
n: is a vector of the values of total primary inputs (industries plus final demand categories)

Defintion of Matrices

V: is a matrix of the values of commodity outputs. In it, each row shows the distribution by commodity of the output of an industry; each column shows the distribution by industry of the output of a commodity. The data relate to domestic output only. The gross output of an industry is the aggregate value of goods and services produced and work done by the industry. It is equal to the value of industry's sales plus any increase (less any decrease) in the value of physical change in stocks of finished products and work in progess.

U: is a matrix of the values of intermediate commodity inputs. In it, each row shows the distribution by industry of the input of a commodity, each column shows the distribution by commodity of the input of an industry.

F: is a matrix of the values of commodity inputs of final demand categories; personal expenditure on consumer goods and services; fixed capital formation, business and government; value of physical change in inventories, withdrawals and additions; gross government current expenditure on goods and services; exports; imports; and government revenue from the sales of goods and services.

YI: is a matrix of the values of primary inputs of industries. Primary inputs are those inputs which are not current outputs of other industries. These are indirect taxes, subsidies, wages and salaries, supplementary labour income, net income of unincorporated business and other operating surplus. (In this report, the term "other operating surplus" and "surplus" have been used interchangeably.)

YF: is a matrix of the values of the primary inputs associated with final demand categories. These consist of indirect taxes, labour income, and depreciation which is part of the surplus. The labour income includes wages and salaries and supplementary labour income paid by the government and personal sectors. The estimate of surplus (depreciation) relates to the government sector and non-profit institutions in the personal sector.

ii) The values of the inputs of each industry are fixed proportions of the value of the total output of the industry and are thus independent of the composition of this output. In mathematical terms:

$$Ui = Bg \quad (2)$$

where:

U (=) the matrix of commodity inputs of Chart 1;
i (=) unit column vector equal in dimension to the number of industries;
B (=) matrix of coefficients which are obtained by dividing each element in a column of matrix U by the corresponding total industry output. B is called the Industry Technology Matrix.

It is further noted that the matrix product Ui is a vector containing the sum of the intermediate inputs of all industries by commodity.

The above assumptions, together with the accounting balance between total supply and total demand, yield the following expression which defines a linear tranformation of final demand categories into industry outputs;

$$g = (I-DB)^{-1} D(e^* + x_D + x_R - m - a - v) \quad (3)$$

where:

I (=) identity matrix with dimension equal to the number of commodities
m (=) vector of the values of imports;
a (=) vector of the values of government production
v (=) vector of the values of withdrawals from inventories (VPC)
x_D (=) vector of the values of domestic exports;
x_R (=) vector of the values of re-exports
e^*(=) vector of the values of the following final demand categories: Personal Expenditure on Goods and Services (PE); Fixed Capital Formation, Business and Government (FCF); Additions to Value of Physical Change in Inventories (VPCA); and Gross Government Expenditures on Goods and Services (GGCE)

The model embodied in (3) does not account for any leakages from the domestic industries. To the extent that imports, withdrawals from inventories and government production of goods and services share with domestic industries in the supply of commodities, the impact of an increase in the final demand on domestic industries will be reduced. In this case, the values of imports, government production, and withdrawals from inventories can be expressed as follows:

$$m = \hat{\mu}(Bg + e^* + x_R) \quad (4)$$

$$a = \hat{\alpha}(Bg + e^* + x_D) \quad (5)$$

$$v = \hat{\beta}(Bg + e^* + x_D) \quad (6)$$

Where $\hat{\mu}$, $\hat{\alpha}$, and $\hat{\beta}$ are respectively the diagonal matrices whose elements are calculated as the ratios of imports to $(Bg + e^* + x_R)$, government production to $(Bg + e^* + x_D)$ and withdrawals from inventories to $(Bg + e^* + x_D)$.

With m, a, and v replaced by (4), (5), and (6), equation (3) now gives the following open output determination model which makes allowance for leakages out of intermediate and final demand:

$$g = (I-D(I-\hat{\mu}-\hat{\alpha}-\hat{\beta})B)^{-1} D(I-\hat{\mu}-\hat{\alpha}-\hat{\beta})e^* + (I-\hat{\alpha}-\hat{\beta})x_D + (I-\hat{\mu})x_R \quad (7)$$

The results of the present study were computed on the basis of equation (7).

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COMMITTEE FOR SCIENTIFIC AND TECHNOLOGICAL POLICY

SCIENCE, TECHNOLOGY AND COMPETITIVENESS

Analytical Report of the Ad hoc Group

(Note by the Secretariat)

1. The attached document is the analytical report prepared by the Ad hoc Group of Government Experts on Science, Technology and Competitiveness.

2. The Group has chosen to prepare an analytical report, as distinct from a descriptive report which would assemble statistical data measuring differences in competitiveness between Member countries and ranking them. The Group has discussed statistical data prepared by the Science and Technology Indicators Unit. It has also noted a number of descriptive reports by the European Commission, several United States agencies and other Member governments as well as some international business fora. The Group has examined the analytical approaches on which these reports are based. It considers that, at this stage, it would best fulfill the task set to it by the CSTP by producing an analytical report rather than a further descriptive study.

3. The analytical report is submitted to the Committee for discussion and recommendation for derestriction under the responsibility of the Secretary General.

4. The Committee is also asked to recommend the derestriction under the Secretary General's responsibility of the papers prepared for the study by OECD consultants [see the list in annex 2].

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TABLE OF CONTENTS

Executive Summary

1. This report on technology and international competitiveness is set in the context of the far reaching and widespread changes in technology which have become an increasingly important component of the overall economic situation facing Member countries. Since the mid and late 70s the accelerated diffusion of data processing technology across industry and services, the advent of microprocessor technology and its rapid diffusion into manufacturing, widespread change in telecommunications technology, the continuous development of new materials as substitutes for many of the older products of the metal industries, the rise of biotechnology and other related developments, have in the space of about ten years, brought about deep changes in the industrial landscape of most Member countries.

2. Such changes are often viewed as though they represented simply the "growth" of some industries and the "decline" of others. The report argues that today such an approach is insufficient in that it fails to capture the way in which a wide set of structural relationships linking different industries one to another and affecting their international competitiveness, are being modified under the impact of current technical change.

3. The report addresses both the micro and the macro-economic dimensions of international competitiveness. It recognises the international competitiveness of national economies as being built on the competitiveness of the firms which operate within, and export from, its boundaries. Competitiveness is, to a large extent, an expression of the dynamism of domestic firms, their capacity to invest, to innovate both as a consequence of their own R&D and of successful appropriation of exogeneous technologies. The report, however, also identifies the competitiveness of national economies as being something more than a simple result of the collective or "average" competitiveness of its firms. There are many ways in which the features and performance of a domestic economy, viewed as an entity with characteristics of its own, will in turn affect the competitiveness of firms.

4. The report lays special stress on the structural factors, notably those moulded by technology, which affect the pattern of international specialisation and the competitiveness of countries. The reference to "structural factors" embraces a wide variety of economic and institutional phenomena which relate to the way economies hold together and work. In some cases such phenomena will relate the activity of firms in the form of "externalities" or on contrary "diseconomies"; in other cases they will emerge as factors which stimulate or on the contrary place a break on firms' progressiveness and competitiveness. The report retains the notion of "structural competitiveness" as a way of expressing the idea that while the competitiveness of firms will obviously reflect successful management practice by entrepreneurs or corporate executives, it will also stem from the strength and efficiency of a national economy's productive structure, its long term performance regarding the rate and structure of capital investment, its technical infrastructure and other factors determining the externalities on which firms can build.

5. The report also seeks to draw the attention of policy makers to the strong systemic features of major technologies and the current role of "core technologies" in driving technical change and modifying competitiveness. This

concept expresses the fact that at any given phase of economic development there may only be a few key technologies whose mastery is decisive for growth and competitiveness. These technologies emerge in given specific, easily identifiable sectors of industry and the research system, but they draw on a wide spectrum of scientific and technical knowledge and have far-reaching influences and impacts over a wide range of industries. The existence of core technologies implies that the competitiveness of many industrial sectors, of agriculture and mining and a large part of the service sector will depend on the extent to which inter-industrial and inter-sectoral transfers of technology occur, and on the way which technologies opportunities, created by R&D undertaken in specific parts of the economy, and lead to innovations and increased competitiveness by firms in other parts of the system. The recognition of core technologies gives the diffusion process great importance: it is the whole of the economy which must become aware of the nature and implications of the technical changes which are underway.

6. The structural dimensions of competitiveness identified in this report mean that there are no "quick fixes" available to policy makers. The data discussed suggests that the modification of technological-performance of an economy is a long-term endeavour which hinges less on the performance of any given single sets of firms or industries than on the capacity to improve the functioning of a wide spectrum of economic structures, and mechanisms and social processes.

7. The fact that the technological progressiveness of firms and their capacity to use technology in relation to international competitiveness, are dependent to a fairly large extent on the structural attributes of their economic environment, also has important implications for policy. Identifying the major points in firms' environments which impede or promote innovation should be a key step in formulating national technological policies. These nodal points can include the system of university/industry links, the functioning of labour markets, the responsiveness of capital markets to the opportunities of innovation, or regulatory policies affecting competition and market structure.

8. Formerly, many countries could go a long way by institutionalizing and funding sector-specific technology oriented R&D. Current core technologies being more generic in nature, require a general capacity of learning and applying a wide range of new techniques across industries. This implies a shift in focus in public funding from sector-specific technological capacity to general technological programs which aim at acquiring basic technical skills and exploiting technological opportunities across sectors.

9. Finally, in the face of technology-based or technology driven changes in the structure of world trade, one of the most crucial assets of countries for adjustment may lie in their scientific and technological infrastructure and in the level of education and scientific qualification of their people. The possession of this asset, which can only be built up through a long process of investment in "human capital" and in the appropriation of technological and scientific competence, may in the future represent an even more durable source of difference in comparative advantage between countries than it did in the past.

I. Introduction

1. Since the mid 1970s Member countries have been increasingly concerned about preserving or improving the international competitiveness of their economies. Obviously the concern existed previously, but from 1975 onwards, in the context of the weak and hesitant cyclical recovery which followed the economic downturn of 1973-74, the search for competitiveness began to loom larger among government objectives.

2. Subsequent events in the 70's -- the second "oil shock", persistent balance of trade and balance of payments problems for many Member countries, the slow but continuous rise of unemployment, the persistent weakness of investment in most countries, notably in manufacturing, and finally, from late 1981 onwards the new widespread recession in world production and trade -- imposed the search for improved international competitiveness as a major priority for most OECD governments.

3. Simultaneously with these developments Member countries began to experience the effects of profound technical change of a type involving strong impacts on the structure of industrial output and skills, and the pattern of international specialisation. Innovation, whether in the form of new products or improved production processes, has always represented a necessary ingredient of competitiveness and has been used as such by firms. In times of rapid and quite deep technical change, the emergence of new production processes and totally new products will modify, possibly in a quite radical manner, the foundations of the competitiveness. Finally there are also phases in economic history during which radical technical changes stems from fundamental modifications in the central or "core" technologies around which industrial economies are structured.

4. This last type of far reaching and widespread change in technology does not occur frequently. Over the last 150 years it may not have occured more than two or three times [Schumpeter, 1938; Freeman, 1981 and subsequent publications; Piatier, 1983]. It is, however, taking place today. Since the mid and late 70s the accelerated diffusion of data processing technology across the whole economy, the advent of microprocessor technology and its rapid diffusion into manufacturing, widespread change in telecommunications technology, the continuous development of new materials as substitutes for many of the older products of the metal industries, the rise of biotechnology and other developments, have in the space of about ten years, brought about deep changes in the industrial landscape of most Member countries.

5. Such changes are often viewed as though they represented simply the "growth" of some industries and the "decline" of others. In present circumstances such an approach is insufficient in that it fails to capture the way in which a wide set of structural relationships linking different industries one to another and affecting their international competitiveness, are being modified under the impact of current technical change. The very bases of industrial strength and competitiveness are changing -- rapidly -- and this is one of the dimension of the challenges and constraints facing Member countries.

6. Macro-economic theory only accords limited attention to technical change and generally views it as an incremental process posing only limited problems of adjustment. Attention should now be paid by economists and policy makers of the fact that profound technical change of the type underway today, generates a rather radical type of innovation-based competition which will "strike at the foundations of existing industries and of the firms engaged" [Schumpeter, 1947, p. 84].

7. The aim of this report is to make some progress towards a wider understanding of these issues and some of their implications for Member governements. It attempts to assemble and assess the available evidence concerning the role played by technology and innovation in international competitiveness and the mechanisms through which the relationships between technology, innovation and trading performance assert themselves in times of rapid and deep technological change.

II. The notion of international competitiveness

8. The difficulties surrounding the use of the term international competitiveness have been recognised by many studies and reports. An OTA report has observed that "One of the immediate problems in analysing international competitiveness is that no consensus exists on its definition. The term "competitiveness" is not used consistently in public discussions; in fact, contradictory meanings are sometimes implied within the same article or report". [US Office of Technology Assessment, 1981, p. 169]. This use of contradictory meanings in a same report is exemplified by the long and substantive study commissionned by the Joint Economic Committee of the U.S. Congress where some contributions, for instance, equate competitiveness and comparative advantage, while others distinguish the two phenomena. Some contributions consider competitiveness to be synonymous with productivity or with unit costs; while others again consider that such factors may help to explain competitiveness, but that only market shares can measure the phenomena correctly.

9. This report accepts the complexity of the term. It recognises the notion of competitiveness as possessing several important complementary dimensions which must all be addressed when considering the relations between competitiveness and technology. The report recognises in particular that competitiveness is used today with reference both to micro-economic and macro-economic phenomena.

Micro-economic competitiveness

10. The twofold reference to micro and to macro-economic phenomena is one of the principal factors accounting for the complexity surrounding the term. The micro-economic meaning is the original one. It refers to the capacity of firms to compete and so, on the basis of their success or "competitiveness" to gain market shares, increase their profits and grow. In the micro-economic meaning, competitiveness is recognised as involving, by necessity, the existence of an active economic agent -- namely the management of the firm -- making choices, defining strategies and seeking to control variables. This element is one which is not readily recognised and sometimes explicitely denied when one moves from the micro to the macro-economic level.

11. Managerial and industrial economics have a wide range of data (market shares, profits dividends investment), on the basis of which it can assess carefully and indeed claim to measure with precision the competitiveness of firms. There exists, furthermore, a wide agreement between business management economists concerning the meaning of these measures of micro-economic competitiveness.

12. The factors being behind micro economic competitiveness have long been one of the special concerns of corporate, industrial and managerial economics. They have recently been the object of a variety of surveys and industrial case studies, from which two important albeit somewhat general conclusions can be drawn.

13. These studies show first that in many industrial branches and sectors competitiveness cannot be reduced to a question centered on prices and the cost of inputs, notably labour inputs (e.g. wages and indirect labour costs). To quote one of the European Management Forum's recent annual surveys: "Competitiveness is not a unidimensional concept. In the market-place buyers will weigh a price advantage against poor quality or lack of after-sales service and so on. The notion that competitiveness might be reduced to considerations of costs and productivity is thus a dangerous one". [European Management Forum, 1980].

14. Second they point to a variety of factors contributing to explain the difference in productivity and/or product quality, very many of which are inextricably bound up with technology and innovation in one form or another. Factors leading to differences in the productivity of labour and capital (scale economies, process systems, size of inventories, management, labour relations, etc.) and differences in the quality and performance of products, are recognised by industrial and business management studies to play in many instances a decisive role in competitiveness.

Approaches to the competitivenes of national economies

15. The multi-dimensional character of competitiveness applies perhaps even more strongly when ones moves from the level of firms to that of countries. Here however the high degree of agreement within business management economics about competitiveness and the firm, yields the ground to a situation where on a number of important issues economists hold widely diverging positions. These issues include inter alia the appropriate measure of competitiveness in the case of countries, the factors accounting for competitiveness, the role of the external adjustment mechanisms, and the role of government as an active force in competitiveness.

16. Some authors still hold that "the analogy between the competitiveness of a firm in a domestic economy and the competitiveness of a country in the world economy, which is often the basis of popular theorizing, is tenuous indeed" [Riedel, in US Congress Joint Economic Committee, 1980, p. 230]. The term has however been adopted by every day language and permeated much public debate and government policy. It has also been the object of number of different analytical approaches by professional economists.

17. The oldest approach to the competitiveness of national economies is the one which views macro-economic competitiveness as being principally, if not exclusively, a question of prices, costs and exchange rates. This approach introduces a clear cut distinction between competitiveness, defined as a macro-economic problem associated with questions of price, costs and exchange rates, and shifts in comparative advantage, which result from "micro-economic development changes in the productive efficiency of specific industries relative to newly emerging and expanding, or contracting and dying, industries within the domestic economy, and where corrective policies are micro in the sense of fostering adjustment through inter-industry shifts in resources," [Bartel, in US Congress Joint Economic Committee, 1980, p. 104].

18. The price and cost approach to macro-economic competitiveness has been subjected to widespread criticism. Seemingly incongruous and totally "perverse" relations, have been repeatedly detected in empirical studies comparing the movement of cost and price indicators and the actual export performance of countries [Kaldor (1978), Lawrence in Joint Economic Committee, 1980]. The approach has lost ground in scientific fora, but still forms the basis of much government policy towards competitiveness at the expense of approaches based on a better understanding of issues related to technology, investment and structural change.

19. Some economists argue that, in principle, at the proper exchange rate every country should become competitive. In present circumstances this approach may not be particularly helpful. There is little agreement among experts regarding the extent to which variations in exchange rates can be held today to bear a relation to previous changes in competitiveness, and not be seen to have changed as a result of other different monetary or political phenomena. The argument also makes heavy calls on adjustment processes based essentially on changes in costs, employment and the level of real incomes. Once technology is considered as an important basis of comparative advantage and as a factor requiring, but also facilitating the adjustment of domestic productive structures, a rather more dynamic and forward looking review of the adjustment process can be taken.

20. A second well developed approach to competitiveness builds on the foundations of international trade theory. It relates measures competitiveness by the basis of world market shares and changes in market shares and competitiveness to comparative advantage as shaped by factor endowments. During the 1960s the latter were extended to include first skilled labour or "human capital" and latter technology and innovation as expressed by r&D expenditure. The extension followed recognition of the need to re-examine the traditional conclusions of trade theory which resulted from Leontief's demonstration that contrary to the expectation of factor endowment based theory based on labour and capital, U.S. exports of manufactures were clearly more labour intensive (and less capital intensive) than their imports. Such studies have generally taken the form of simple regressions which add independent variables associated with technology, skills and human capital to the previously dominant capital and labour variables, which had so obviously failed to explain adequately trade patterns in earlier empirical tests.

21. This report has developed a somewhat different methodological approach to the study of competitiveness and technology from that used by trade studies. This is why it wishes to stress at this point that within the framework and postulates of traditional international trade theory and analysis, this type of empirical verification has now shown, as fully as is required by the methods of empirical verification used in statistical tests, that innovative activity is indeed, alongside human capital (that is qualified labour) one of the most important factors shaping the "comparative advantage" of advanced industrial economies [for a review of the evidence, see inter alia Graham, 1979].

22. These findings concur with those resulting from industrial case study material which point to the considerable role played by non price factors in explaining trade performance in many industries. They have obvious policy implications. In the case of the United States, these have been spelt out in the following manner: "It is important for formulating policy to sort out the reasons underlying the loss of U.S. export competitiveness. The conventional focus on import demand and management of aggregate demand would lead to slower U.S. growth to dampen domestic inflation and to improve the current account. The (...) evidence suggests a better alternative approach: if differences in productivity growth are related to technology change, economies of scale, new products and new markets, the policy should address the supply side and bring more resources into investment, research and development and innovation, rather than slow down growth and/or impose wage and price controls." [Bartel, in US Congress Joint Economic Committee, 1980, p. 110]. While this report argues that these two approaches are probably complementary rather than alternative ones, the issue is real. It is not specific to the United States of course, but applies to practicaly all OECD economies.

III. Structural dimensions of the working and competitiveness of national economies

23. An examination of available indicators suggests that the best available (or least objectionable) measures of the competitiveness of national economies are those used by trade studies, e.g. shares in world exports, ratios of foreign penetration of home markets, along with their numerous variants and sub-variants all examined at the most disaggregated level available [see for instance Morgan Guaranty Trust, 1984]. Indicators of this type are best used in long time series which capture, at least partially, the dynamic features of competitiveness in relation to changes in parameters, whether technical or other. Changes in market shares may be as or more singificant than their actual level. The long term evolution of the current account or basic balance of countries represent another useful indicator [BMWI, 1984]. There is also increasing agreement that foreign direct investment should be considered as a measure of competitiveness. The adequacy and usefulness of market share and foreign trade balances as measures of competitiveness have of course recently been increasingly jeopardised by the instability of exchange rates and the role played by purely monetary or political factors in determining the movement of the later.

24. This report has adopted the following position. First it views the micro and the macro-economic dimensions of competitiveness as being complementary ; second it considers that the macro-economic dimensions must include factors relating to the manner in which economies are structured and participate in the international division of labour. In this respect the report argues that:

* the international competitivenes of a national economy is built on the competitiveness of the firms which operate within, and export from, its boundaries, and is, to a large extent, an expression of the will to compete and the dynamism of firms, their capacity to invest, to innovate both as a consequence of their own R&D and of successful appropriation of external technologies;

* but the competitiveness of a national economy is more than the simple outcome of the collective or "average" competitiveness of its firms; there are many ways in which the features and performance of a domestic economy viewed as an entity with characteristics of its own, will affect in turn the competitiveness of firms.

25. Some of these overall macro-economic features or factors, relate to the macro-economic policies adopted by governments; other "macro" dimensions concern the complex network of relationships which hold national economies together and contribute to determine the way they relate in turn to the world economy. This report does not suggest that demand management policies are not important for competitiveness, but simply that their capacity and effectiveness has often been exagerated at the expense of a proper analysis of the structural factors, notably those moulded by technology, which shape the pattern of specialisation by countries. Considerable delays have occured in developing an appropriate analytical understanding of this second set of phenomena.

26. The reference to "structural factors" is a complex one. It embraces a wide variety of economic and institutional phenomena which relate to the way economies hold together and work, and which represent for firms in some cases either "externalities" or on contrary "diseconomies", and other cases factors which stimulate or on the contrary act as a break on their progressiveness and competitiveness. The term "structural competitiveness" [Mistral, 1983] has been coined to express the idea that while the competitiveness of firms will obviously reflect successful management practice by entrepreneurs or corporate executives, it will also stem from the strength and efficiency of a national economy's productive structure, the long term trends in the rate and structure of capital investment in that economy, its technical infrastructure and other factors determining the externalities on which firms can lean. The strong systemic features of today's major key or "core" technologies which are discussed below in section IV.2 only serve to reinforce the need to approach a number of issues with the help of this notion of "structural competitiveness".

27. The field work carried out in the form of interviews with machine-tool firms also confirmed this. The fact that successful and unsuccessful strategies in the machine tool industry were found to follow some quite clear country-specific patterns posed an interesting challenge. It suggested the need to consider a wider set of factors, and to examine whether successful management philosophies and the adoption of appropriate, or on the contrary inappropriate strategies by management, might not be the reflexion and result of more basic phenomena related to the structure of national economies. In the case of machine tools differences between countries regarding the characteristics and size structure of buyers, the opportunities for and efficiency of organisation and para-market forms of relationships between firms, and financial factors influencing the time horizon adopted by management in their planning were identified as bearing on strategies for innovation and competitiveness and the performance of firms.

28. Fairly well researched aspects of economic structure which all have a bearing on the "structural competitiveness" of countries include the size of domestic markets; the structure of domestic production relationships between the different sectors and industries, which make up a given economy, as apprehended through input-output analysis [Leontief, 1951 and Carter, 1970] and the size distribution and market power of supplier firms. Other less well examined factors include the characteristics and size distribution of buyers and the efficiency of non-market relations between firms and production units (integration, quasi-integration and the numerous mode of organisation between firms which have developed alongside with and in complement to the market).

29. The institutional, social and political factors contributing to structural competitiveness are more numerous and complex still. In a contribution made by Germany in the initial phase of the work a wide range of social and economic factors were quoted as possible parameters of competitiveness. Examples given included no exaggerated conflict in the field of income distribution; price stability, flexibility and the readiness to adapt of all participants in the market, and a balanced economic structure based both on small, medium-sized and big companies. Likewise it was suggested that the scientific, technological and industrial parameters of competitiveness might include inter-alia the acceptance of new technologies, favourable scientific and technological infrastructure and realistic requirements pertaining to risk containment and environmental protection.

30. This report has been forced to narrow down somewhat the number of parameters encompassed, but it has nonetheless been led to recognise that structural and institutional phenomena of the type just enumerated often have a direct bearing on competitiveness and the relationship between technology and competitiveness. Identifiable linkages work both ways:

* structural phenomena pertaining both to basic economic structure, market structures and organisation, and also to the structural dimensions of the scientific and technological infrastructure and of government-industry relations, will influence the competitiveness of individual firms and represent one of the sets of factor which will shape their capacity to recognise and use technological opportunities in production and marketing;

* but, many, if not all, the main features of economic and market structure are themselves shaped by technical change and will be modified through the diffusion of new technologies, notably when these are radical generic or core technologies.

31. The following sections of this report explore the two-way relationships and linkages, and discuss, in paragraphs set at the end of each section, some identifiable implications for government policy. Overall policy implications are discussed in the last section.

IV. Towards an adequate understanding of technology and innovation in relation to trade, comparative advantage and competitiveness

32. Empirical testing carried out on the basis of international trade analysis had led to the recognition of the role of technical innovation in shaping the "comparative advantage" of industrialised economies. Such studies establish a relation, albeit of a rather general kind, between innovative activities and competitiveness.

33. This relation requires closer definition however if it is to form a basis for government action. General recommendations for the increase of R&D expenditure have for instance been made on the basis of trade studies. Such recommendations are probably neither useful nor sound analytically. They have the fault of all policy prescriptions which rely upon any one particular variable alone.

34. R&D expenditure has by necessity been used extensively as a proxy for innovative activities in the trade studies made upto now. Soete (1980) has also made tests using patent data. Pending the development of S&T output indicators capable of representing the numerous technology transfer processes which occur domestically and of course also between countries [Antonelli, 1982], R&D indicators remain the best available proxy for innovative activities in econometric trade studies.

35. An understanding, however, of the relations between technology and international competitiveness both in its micro-economic and macro-economic dimensions, requires a representation of innovative activity which covers more aspects than those presently encompassed by R&D statistics and an analytical approach more complex than that of simple regression analysis.

1. The cumulativeness and appropriability of technology

36. This report has been confronted, like many other studies, with the use of the word technology :

* in the proper sense of the term, technology is defined as "the stock of knowledge (technical or management) which permits the introduction of new products or process" [Mansfield, 1968]. "Techniqe differs from technology to the extent that the former is a method of production at a given moment which is defined by the equipment and the management method used, while the latter is the whole of the knowledge used in production";

* in common parlance technology is used almost synonimously for innovation or innovative activity.

It is in fact important to reserve as far as possible the use of the word technology to the first proper definition of the term and then to establish its meaning in relation to wider innovative activities.

37. Innovation encompasses a wide variety of phenomena ranging from basic research through production technology to design, and for many economists, also to marketing techniques. In different industries innovation will stems from very different sources and many occupy a place of greatly varying importance within the overall set of factors which command production and marketing and affect profitability and competitiveness. Innovation cannot be reduced to nor does it arise solely from R&D.

38. Whether it be at the R&D end of chain -- where the capacity to recognize the economic opportunities created by the progress basic scientific knowledge and master the job of "translating" such knowledge into new products and production processes is decisive -- or in industrial production -- where industrial and industrial "know-how" and long drawn out "learning by doing" processes are all important -- innovation is the outcome of complex and

lengthy processes of accumulation and appropriation of technology. These include the conditions for the sucessful assimilation and appropriation of exogeneous knowledge by firms. In the case of scientific knowledge, successful appropriation generally requires prior participation in the production of knowledge in the same or in closely related areas. In the case of industrial technology, appropriation by firms requires likewise an accumulation of industrial know-how for which there is generally no short cut.

39. The "appropriation" of technology refers to two distinct but complementary phenomena:

i) the degree and manner in which, technology developed in government or university research laboratories or in industry in general, and possessing an "exogeneous" character as far as individual firms are concerned may be "appropriated" -- e.g. acquired and assimilated -- by other industries and companies via different channels of diffusion (acquisitions of patents and licences, imitation, mobility of skilled personnel, purchases of intermediate goods or equipment); and

ii) the degree and manner in which technology, once it has been generated internally through intra-mural R&D, or acquired from outside and adapted for the purpose of a specific production, may be kept "appropriated" by firms, whether by the patent system, by normal trade secrets relating to industrial know-how or by qualitative leads in the learning curves associated with the mastery of new technologies.

40. It is on account of this process of appropriation that economists range technology and industrial know-how among the firm's "intangible" [Caves, 1982] or "firm specific" assets [Dunning, 1981]. These are assets which form the basis of a firm's competitiveness and which it will generally only release under special conditions.

41. Industry specific differences in the precise phenomena encompassed by the innovative process, the sources from and manner in which firms acquire and/or develop their technology and in the degree to an manner in which firms can make this technology a "firm-specific asset", imply that the relationship between technology, innovation and competitiveness will also tend to be quite strongly industry-specific.

42. Some fairly wide patterns of relationship may exist nonetheless. A taxonomy developed by Pavitt [1983] from an approach initially suggested by Nelson can perhaps provide a basis for further analysis. Chart 1 shows the way in which a number of variables, notably:

* the sources from and ways in which an industry obtains its technology;

* the main users or customers of the industry's products and their specific sensitivity and requirements for innovation; and

CHART 1. SOURCES AND PATTERNS OF INDUSTRIAL INNOVATION

Categories of firms		Representative sectors and industries	Sources of technology	Type of users	Sensitivity of users	Means of appropriation of technology
Supply dominated final demand orientated firms		- Agriculture - Housing - Private services - Unconcentrated traditional manufacturers of consumer goods	Government R&D + extension services Suppliers of equipment and inputs Big buyers in downstream, processing	Private or institutional consumers Concentrated firms in wholesale and retail trade	Price sensitive + product differentiation	Non technical (e.g) trade marks, Marketing, Advertising, Aesthetic design
Production intensive	Scale Intensive	- Bulk materials (Steel, glass) - Assembly (consumer durables + auto)	- Production engineering - Suppliers - Intra-mural R&D	Industrial firms downstream and private consumers	Price sensitive + product differentiation (for final consumers suppliers)	Process secrecy + Know-how, Technical lags, Patents, Dynamic learning economies
	Specialised Suppliers	- Machinery - Instruments	- Design + Development - Users	Industrial firms	Performance Sensitive	Industrial and Design know-how Knowledge of users, Patents
Science-based	Directed essentially towards industrial users or final consumers	Chemicals Pharmaceuticals	Intra-mural R&D, Gov. and university R&D, nationaly or internationaly, Production engineering	Industrial firms, private and institutional consumers	Performance and price sensivite	- R&D, and know-how - Patents - Process secrecy + know-how - Dynamic learning economies
	Based on or strongly marked by public procurement	Aircraft, aerospace, heavy electrical, telecommunications, semiconductors, computers		Industrial firms, Government agencies in defense, basic services & space	Highly performance sensitive (sometimes to the exclusion of price	Access to an spin-off from gov. procurement

Source: Adapted and developed from Pavitt, 1983.

* the means by which firms in the industry may appropriate and protect technological knowledge with a view to competition;

may, in conbination, contribute to shape the relationship between technology, innovation and the competitiveness of firms according to patterns which are wider than those of a single industry, yet narrower than those of the very wide categories of manufacturing or services. These patterns will derive their internal consistency from the interactions occuring between the particular features of basic innovative activity and the diffusion of technology, and the industry-specific characteristics of markets and industrial organisation.

2. The dynamic nature and systemic features of major technologies and the concept of generic or core technologies

43. All sectors of the economy and all industries make continuous calls on technology and innovation. Yet as the statistics show [OECD, 1984], industrial R&D is extremely highly concentrated and takes place essentially within five or six industrial sectors. In instances where the policy issues to be addressed concern the relation between technology, innovation and competitiveness accross the whole of manufacturing and not simply in the high technology sectors, this becomes a question which requires particularly careful consideration.

44. The wide differences which are observed in R&D intensities between industries cannot be interpreted as only meaning that some industries make few calls on technology and others heavy ones. While there are cases where the distinction is of course a very real one (the opposition for instance between leather products and semiconductors) the competitiveness of modern economics depends to a high degree on the wide spectrum of industries which are somewhere in-between these two extremes. In this perspective, differences in R&D intensities are best interpreted as signifying, first that in some industries technology is more immediately geared to R&D than it is in others, and second that such industries may also represent the "technology base" on which other industrial sectors rely and from which inter-sectoral transfers of technology must take place to other parts of manufacturing, agriculture and services [de Bresson and Townsend, 1978; Scherer, 1982].

45. The identification of numerous inter-industry flows of technology raises a number of important questions: do these flows correspond to any distinguishable pattern, do they amount to the existence of technology "systems", are they the expression of some kind of hierarchy between technologies and so between industrial sectors?

46. Historical evidence exists regarding the systemic features of major technologies. Historians of technology have been quicker and more readily disposed to analyse these than have economists, (a major exception being Schumpeter of course). Data is at hand showing that in each successive phase in the historical evolution of the capitalist economy, a limited number of specific, easily identifiable technologies, located in specific parts of manufacturing, have exerciced an influence well beyond the industries where they were based. They have had across-industry, inter-sectorial impacts and influences, of a technological but also of an economic nature, in a way which

suggests the existence of technological trajectories (1) [Rosenberg, 1976; Nelson and Winter, 1977; Scherer, 1982], and of something akin to technological systems [Gille, 1978; Sahal, 1981].

47. The way the industrial system may be structured to an important extent around a few core technologies and the "technological system" which stemms from the relationship between them can be grasped with the help of a graphic illustration based on the system formed by the industrial countries' first key technologies, in the middle 19th century, as shown in Chart 2. If a similar chart should be plotted once the changes underway today have worked out their full effects, semi-conductors and computers will probably occupy the place occupied by steam engines.

48. Over the last few years further concepts have been developed with the object of approaching the same basic reality. This is the case, in particular, for the concepts of "generic" or "core" technology which seeks to express the fact that at any given phase of economic development there may only be a few key technologies with pervasive effects on the economy, whose mastery is decisive for growth, competitiveness and strategic independance. These technologies may emerge in given specific, easily identifiable sectors of industry and the research system, but at the same time:

i) they draw on a wide spectrum of scientific and technical knowledge;

ii) they must be serviced by a strong science and technology base and a large R&D effort, often far removed from the final point of industrial application, and

iii) they will have far-reaching influences and impacts over a wide range of industries, services and other activities and will give rise to a widespread and long drawn out process of inter-industry transfer of technology.

49. According to the U.S. National Academy of Engineering who coined the term "core" technology in a recent report, today's list of advanced technologies with core technology features "includes microelectronics, computers, new materials, robotics, telecommunications, aerospace, and biotechnology. The list of technologies deemed "advanced" changes over time. A new list may supersede this one in a decade or two" [National Research Council, 1983].

50. In recent Japanese studies widespread recognition is likewise made of the systemic character of today's new technologies. Imai [1984] considers that in "high technology" it is necessary to use the twofold criteria of technology with a "high intensity of research and development", as well as that of

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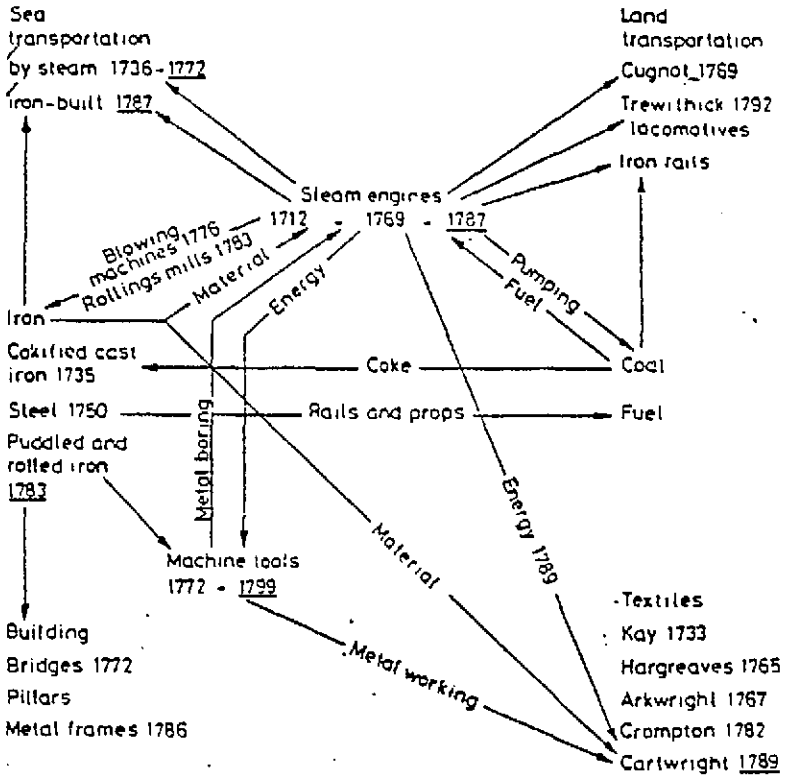
(1) The notion of trajectory has two complementary meanings in relation to technology. It refers to a) the directions along which scientific and technological progress moves in the solution of a set of technological and economic problems ; and b) the directions which technology takes as it diffuses across industry through inter-sectorial transfers of technology.

Chart 2

Simplified Diagram of the Technological System of the First Half of the 19th Century[a]



[a] The dates correspond to the first recorded innovation, the generalized diffusion comes later.

Source: Gille [1978, Figure 4].

"having the characteristics of a system". By this is meant that "individual technological elements are utilized in the economy combined into a system, and that each technological element is evaluated according to the function it fulfills within the entire system (...). The focus is on the combination of technologies and not on each separate technology. The reason for adding this second criterion to the definition of high technology is that, although highly intensive research and development is evident in isolated individual technologies (...), the reason high technology is made an issue in connection to industrial policy or is regarded as a new economic infrastructure is probably strongly attributable to its systemic characteristic."

51. Periods marked by the substitution of one technological system by another involves what may be refered to as changes in "technological paradigms" defined as "models" or "patterns" for the solution of given technological problems, based on given principles derived from natural sciences and on given material technologies [Dosi, 1981 and 1982]. The emergence of new paradigms can contribute to explain the respective roles of continuity and discontinuity in technical change. "Incremental" innovations can probably be reinterpreted in terms of "normal" technical progress within existing paradigms, in opposition to "radical" innovations which are often associated with new emerging technological paradigms.

52. The concepts are all still quite new ones and their precise economic significance has not yet been laborated. They are too recent to have yet been subjected to close scrutiny, discussion, study or testing. In particular, the impact of changes in the industrial location of key technologies on international trade specialisations and competitiveness has not yet been the object of systematic inquiry. The hypothesis which this report begins to examine and which will be discussed in subsequent sections of this report, is that changes in the nature of and location within industry of "core technologies" are probably associated with extensive economic and industrial changes of a structural type, both at the domestic and at the international level, many of which will bear directly on the competitiveness of firms and of economies.

3. Some conclusions with implications for policy

53. A number of policy implications stemming from the approach to the understanding of technology discussed in this section may already be drawn at this point.

i) The first point is that since innovation cannot be reduced to R&D, and encompasses in reality a wide variety of phenomena ranging from basic research through production technology down to product design, general simple minded recommendations to governments to increase R&D expenditure will not represent an adequate solution for strengthening the relation between technology and innovation and international competitiveness.

ii) The next point is that while some general patterns common to several industries or sectors may exist, as illustrated in chart 1, the fact that technology and innovation are to a high degree "industry-specific", may develop in different institutional structures and follow different trajectories, have discrete features and be appropriable by firms in particular ways, suggests that the relationship between technology, innovation

and competitiveness will to large extent also be "industry-specific". This implies that policy measures and instruments of a general kind need to be supplemented by industry specific measures if they are to assist in enhancing competitiveness. Work by the CSTP's Group on Innovation Measures and the Economic Climate point in the same direction.

iii) The existence of "core technologies" and the recognition that technologies often possess systemic features may also have some important policy implications for governments which require a more detailed discussion.

54. Core technologies obviously call first of all for policies aimed at strengthening the capacity of firms in an economy to grasp the nature of the opportunities and constraints created by the new technologies and the nature of the trajectories they are likely to follow.

55. This understanding is not limited to the high technology industries within which core technologies emerge. The existence of core technologies implies that the competitiveness of many industrial sectors, or agriculture and mining and of a large part of the service sector -- and hence of domestic economies as a whole -- will depend on the extent to which inter-industrial and inter-sectoral transfers of technology occur, and on the way which technologies opportunities, created by R&D undertaken in given parts of the economy, are successfully transformed into innovations and lead to increased competitiveness, through processes of technological transfer and appropriation by firms in other parts of the system. The recognition of core technologies gives the diffusion process great importance: it is the whole economy which must become aware of the nature and implications of the technical changes which are underway.

56. The policies which are required are something more than simply policies aimed at accelerating the diffusion of the new technologies throughout manufacturing and services. They may imply the development of a capacity at national level, for recognising a technology's potentialities, analysing its international development and forecasting the trajectories it may conceivably follow and the impacts which it is likely to have, thus helping firms and institutions to seize opportunities or make necessary adjustments in time. Some Member countries have established agencies or services charged with these responsibilities.

57. In the case of large OECD countries possessing well developed scientific and technical infrastructures, large financial resources and large domestic markets, the recognition of the existence of generic or core technologies has recently led to large investments in R&D by firms and governments, aimed not merely at understanding and applying, but also at achieving an indigenous capacity to develop the new technologies, in some cases quite broadly and in others in a more limited manner.

58. This policy has been justified in some instances on military strategic considerations or on overall long term economic development reasons. The U.S. National Academy report quoted previously has however also suggested reasons directly related to international competitiveness, which could advocate policies aimed at strengthening the capacity to develop and produce such technologies. The report argues that "Were the United States to lose its capacity to innovate core technologies, it might still benefit from foreign innovations, just as other countries have benefited from advanced technologies

originating in the United States. It is the innovating country, however, that has the best access to new technologies and, thus, the best opportunities to use them. The rapidity of change in many important technological fields requires knowledge of technological innovation in progress and immediate access to new technologies. Without that knowledge and access, a country's capacity to plan for new products would lag those of the innovating country" [p. 26].

59. The decision to embark or not to embark on R&D programmes and projects aimed at developing an indigenous capacity for producing some, or many of constituent elements of today's core technologies is one which each country will take on the basis of an assessment of its specific, economic and social needs and objectives and its previously accumulated scientific and technical assets. The discussion of the small country issue has shown however that some "small" Member countries are aware of the magnitude of the costs involved and are conscious that their firms may not possess the requisites for launching into the production of the new technologies, whether in the form of finance, domestic markets or accumulated scientific and technological expertise.

60. The report to the CSTP on the "small country" issue [STP(83)5] also suggested that "the issues raised by and the opportunities opened up for countries by the new technologies may not concern only the small countries, but also many bigger ones which may be faced with problems of choice and strategy, similar in nature if not in intensity. In many ways, countries which are small in size or in economic resources represent a privileged observation ground. Their size and resources act as a magnifying glass with regard to many of the issues discussed above; and in instances where large countries may still be in a position to postpone their choices and decisions, these are forced upon small countries." [SPT(83)5, paragraph 61].

61. The challenge and constraints of the new technologies for competitiveness and the conditions required for successful entry will receive further clarification from some of the analysis contained in following sections.

V. Technical change and shifts in comparative advantage and international trade specialisation

62. The understanding of technology and innovative which has just been set out must now be related to the comparative advantage of countries, that is to the way countries enter into the world economy and participate in the international division of labour. For a very long time the insertion of countries within the world economy has been explained principally on the basis of their "factor endowment" in natural resources, cheap labour or abundant capital (1).

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(1) The reference to comparative advantage, which postulates in the strict acceptance of the concept that a country which possesses an absolute cost advantage in two industries should relinquish to the country with whom it trades production in the industry for which it is relatively less well positioned, may also have contributed to obscure many real issues and introduce a quasi "theological" bias into many discussions.

63. This oversimplied approach has been associated furthermore with a set of extremely irrealistic assumptions, which some authors may often progressively "loosen", in the course of the analysis, but which tend nonetheless to influence strongly their methodology and findings [for a critique see for instance Michalet, 1978 and Kaldor, 1980]. These assumptions are notably those of perfect competition as representing the most representative form of market structure within domestic economies and internationally; homogeneous production functions and similar techniques between countries; the non-mobility of factors of production across national frontiers; the absence of government action notably in areas affecting trade directly or indirectly.

64. The factor endowment approach has sought to encompass technology and innovation, but it has not really headed the parting advice of one of its major exponents [H.G. Johnson, 1975] that innovative capacity must be viewed as a basic "source of difference in comparative advantage, and technological change as a chronic disturber of existing patterns of comparative advantage". The factor endowment approach has reduced innovation to an extremely static "factor" with which some countries, notably the U.S., have been better "endowed" upto now than others. "Neo factor" endowment trade analysis will claim to have succeded in assimilating technology and innovation, but it has only done so by giving it the same analytical treatment as that given to other factors, i.e. relative factor price analysis of the basis of "endowments" by countries. Many of the most original features of technology are mutilated by such an approach, which has also little to propose at the level of government policy excepting further and possibly increased expenditure on R&D, in order to maintain the "endowment" and offset relative decreases in "comparative advantage" vis-à-vis other countries.

65. The unconventional features and effects of innovation and technical both with respect to the traditionally held foundations of comparative advantage and the positions of countries in world trade, may be related to the important characteristics of technology discussed above.

1. The appropriability and cumulativeness of technology as a foundation for fairly stable trade advantages

66. The discussion developed above showed innovative capacity to be the outcome of lengthy and costly processes of investment in R&D, scientific discovery, and of learning, imitation, and improvement processes in technology. The extensive literature on the conditions for success and the reasons for many failures in the transfer of technology to developing countries contains a wide range of evidence which fully confirms this point. The issue should not however be limited to developing countries.

67. To the extent that technology is "knowledge about specific applications", which builds on the results of basic and applied science, but also on a cumulative process of "learning by doing", technical progress will, much of the time and in many instances, take the form of incremental improvements. As a result there may be phases of development (as in the 60s) in which this purely incremental aspect of innovation may appear to be the most striking one. Absolute advantage technological-gap trade may appear dominant to the point of seeming to override the other more specifically "chronic disturber" effects of technical change.

68. The phenomena discussed under the heading of "appropriability" will also account for the irreversible non-random and cumulative character of technology, and hence for the relative stability of patterns in the distribution of innovative capacity between firms and countries. Historical studies and industrial case material show that the directions of technical change are often strongly influenced by the state-of-the-art of the technologies already in use. Along with evolutionary growth models [Nelson and Winters, 1982] such studies show likewise that the probability for firms and countries of making technical advances, is also, among other things, generally a function of the technological levels already achieved by them.

69. In the area of industrial structures and organisation these phenomena all point to the existence of barriers to entry and the relative stability of these once they have been established. In the field of international trade and in relation to macro-economic competitiveness, they point to the existence of an international trading system where, at any given point in time or phase of development, some (possible large) part of trade will be based on absolute advantage rather than comparative advantage and lead to fairly durable asymmetries in the structure of trade and the pattern of goods exchanged between trading partners.

70. Some aspects of these asymetries were discussed in OECD in the late 60s during the discussions on "gaps in technology". The basic reality behind the existence of gaps was also subjected, at about the same time to some initial conceptualisation [Posner, 1961], Hirsch [1965] and Vernon [1966].

71. Industrial case studies carried out at the time in a number of industries [synthetic materials (Hufbauer, 1965), plastics (Freeman, 1963), electronic capital goods (Hirsch, 1965) and chemical process plant (Freeman, 1965), established the existence of imitation lags, dynamic economies of scale, process innovation, and a range of scientific and techical activities in a range of industries, which indicated that the temporary monopoly position of firms [Schumpeter, 1938] and so the technology gap trade which such monopoly leads to might be more permanent than initially hypothesised. Imitation lags could be prolonged if R&D threshold costs were high, and the competitive efforts of would-be imitators repeatedly frustrated if the initial innovators were able to maintain a flow of process innovations related to scale economies and new generations of products. Such processes have more recently been shown to be extremely important in the semiconductor industry [Golding (1979), Sciberras (1977) and Dosi (1981)]. This empirical evidence pointed invariably to the conclusion that temporary monopoly positions and technology gaps can be sustained over long periods and give rise to patterns of international trade marked by one way relations and persistent cost advantages inconsistent with "factor endowment" explanations.

72. Limited initial empirical testing recently carried out by Soete and Dosi [1983] with the aim of defining the respective role in trade of technology gap advantages and cost based comparative advantages, suggests that trade based on relative specialisation by countries resulting from differences in the level of wages and other costs, can generally occurs only within the limits of temporary "absolute" advantages, defined as qualitative differences in productivity levels between countries, based on sustained technical advance.

2. Technology and the extension of intra-industry trade

73. A notable development in the structure of international trade over the last thirty years has been the growth and extension of so-called "intra-industry trade", i.e. trade between countries which possess broadly the same "factor endowments" and yet trade heavily between each other, exchanging in very many instances goods belonging to the same CITC categories and product groups. This type of trade is particularly intense within OECD : it accounts for a significant part of trade between the United States and Europe, a part of Japan's foreign trade, and a very large fraction of European trade notably within Europe.

74. Intra-industry trade reflects the emergence of an ever more complex and intricate international division of labour. It is an expression of a new type of interdependency, one of the main driving forces of which is technology. Technology's role in this respect is multifold. It calls for inputs to production which a single economy can rarely produce, and requires markets which are increasingly often international markets.

75. Technology lies behind the ever increasing sophistication of industrial and consumer products and of the production processes required for their manufacture, and so in the complexity and cost of the scientific, technical and industrial resources and skills involved in their development. Similarly technology is continually accentuating the opportunities and constraints of economies of scale, standardisation, long production runs and so the requirements for larger markets than those provided for by domestic economies.

76. Such developments create in themselves strong pressures for industrial adjustment, which the "chronic disturber" effects of technical change can accentuate even further in given circumstances.

3. Technology as a "chronic disturber" of comparative advantage

77. In many respects the dimensions of technology discussed above point in the direction of rather stable trade patterns, of asymmetries in trade flows which one established are not quickly nor easily reversible, as the experience of developing countries, has amply demonstrated. But in given circumstances, technology can be at the origin of deep changes in patterns of international specialisation.

78. These "chronic disturber" effects stricto sensu can take place in two main ways. Technical change may completely alter previous trade patterns by:

i) creating new differences or gaps between countries or suddenly widening gaps which were previously being reduced by convergence proceses due to the international transfer of technology in the level of productivity of labour, capital and materials and energy inputs to production; and

ii) modifying trade flows as a result of the marketing of either of totally new products or of new, better and differently sourced substitutes, whether they be material inputs to other industries or products for final consumption. This can lead in some cases to the appearance of new industries, and in others to wide spread substitution effects involving the disappearance of entire product groups and possibly large segments of entire industrial branches.

79. These two impacts summarily defined will in actual reality often overlap and not readily lend themselves to identification easily. There may however be instances where the impact of technical change on international patterns of specialisation and trade through one or another of these channels may be fairly easy to identify. To take a few examples:

i) Contemporary automation processes built on micro-processor technology are demonstrating their capacity to modify previous patterns of industrial specialisation developed in the 1960s on the basis of abundant sources of cheap unqualified labour. This is demonstrated by the reduction of offshore sourcing of electronic components in cheap labour economies and current developments in textiles and clothing.

ii) Classical examples of the trade displacing effects of technology on the nature and the sourcing of materials -- and so on previously "stable" trade specialisations by raw-material-producing developing countries -- have been provided in the past by the chemical industry's capacity to produce through science and technology, substitutes for these countries exports (notably synthetic rubber and man-made fibers).

iii) Substitution effects of this type have also been at work over the last ten years in advanced industrial economies where micro-electronic components and processes, for instance, have begun to displace on a large scale previous industrial control and precision techniques and equipment both in capital goods industries (machine tools and many other kinds of specialised capital goods), in scientific instruments and in the watchmaking and weighing equipment industries.

iv) Video equipment provides a current example of the effects on specialisation and trade of the advance gained by a single main supplier country in the creation of a totally new product group or sub-branch of an industry.

80. Radical developments in science and technology have still hardly been studied from the standpoint of their trade effects. Historical evidence of changes in patterns of international specialisation and ranking by major countries within the hierarchical structure of the world economy following changes in "technological paradigms" exists for the 19th century and the early 20th century. The possible impacts of contemporary changes in core-technologies on international trade specialisations have not been yet subjected to systematic inquiry. No easy classification is at hand. A few tentative distinctions can be suggested.

81. Important changes in the pattern of trade may take place in cases where after a previous scientific and technical breakthrough, some basic scientific and technological principles after being applied first in one industry or sub-industry, in relation to a given set of problems, are understood on this basis to have much wider and general applications. The chemical industries have repeatedly been the source, and the industries immediatly related to these [food processing, textiles and footwear, rubber etc.] often the theatre of this type of development, notably with respect to all the "man made" substitutes of natural productions.

82. Over the last ten years micro-electronic components and equipment (micro-processors) have begun to have similar widespread trade displacing effects, the extent of which is only slowly being recognised. These trade substituting or displacing effects resulting from the spread of micro-electronics are still part of an on-going process which would require study. Current developments in biotechnology and the latest generation of new materials (such as contemporary ceramics and the new industrial materials being produced from speciality plastics and nylons as a substitute for ferrous and non-ferrous metals [see Arrous and Zuscovitch in FAST, 1982]) may also be preparing further changes of this kind. In this regard the CSTP study on the economic and trade impacts of biotechnology is a timely one. A similar study on new materials may also be required.

83. Predictably the extent and nature of the impacts resulting from changes in technological paradigms on international trade patterns and country specialisations will depend, first on the level of development, size, wide or narrow trade specialisation and industrial sophistication of national economies, and second on the economic context in which substitutions occur. Countries, industries and firms with strong scientific and technological capacities may be predicted to be on the initiating end of such processes or at least to have a reasonable hope of adjusting to them successfully, notably through changes in industrial specialisation. Countries with weak scientific and technological capacities will often be on the receiving end of such processes and may consequently be forced to bear the full brunt of adjustment through painfull changes in exchange rates, employment and real incomes.

84. As exemplified historically by the case of rubber and fibres, when monoproducer raw material exporting countries with little or no scientific and technological capacity and next to no diversified industrial capacity, are hit by technology-based trade sustituting processess, the industrial and employment impacts on the economy may be considerable and the capacity to adjust "positively" in the short to medium run almost nil.

85. In the case of industrialised countries the foreign trade impacts of major changes in technology are generally much less pronounced and the capacity to adjust through changes in industrial specialisation also infinitely greater. The trade substituting effects of technological change and concomittent shocks can be absorbed by more easily the indigeneous industrial structure; this process will take the form of shifts in inter-industry relations, and of bankrupties and unemployment in declining industries which the growth of other branches can normally compensate. However, if important technology driven trade substituting processes coincide with deep cyclical downturns, or with structural crises such as the one experienced currently by the world economy, the trade specialisation pattern modification effects will be amplified and adjustment longer and harder to achieve.

4. Some conclusions with implications for policy

86. Taken in conjunction, section IV which attempted to lay out an adequate representation of technology based on the most recent research, and section V which has sought to discuss certain broad relations between this representation of technology and the position of countries in the pattern world trade, lead to a dynamic interpretation of "comparative advantage" in the broad sense of the term.

87. In this approach comparative advantage is no longer viewed as the ex-post result of an almost unchangeable set of countries' factor endowments, but as something open to change -- more slowly in some situations and more rapidly in others -- and which countries can build, to some degree and within given constraints, on the basis of conscious action on the part of firms and countries, but also that they can loose, at least partly, in times of radical technical change.

88. The analysis demonstrates that the scope for competitiveness centered principally on wage differentials will often be bounded by the limits set by significant, possibly qualitative, differences in productivity arising from technological leads and advantages and the on concomittent capacity of firms to wage successful competition based on given firm specific qualities of products. The analysis also shows that the elements of temporary monopoly, which are built into technological leads on account of technology's appropriability and cumulativeness may represent one of the strongest and most lasting foundations of competitiveness.

89. This foundation possesses a dynamic, reproductible and cumulative character, on the condition that firms and countries pay constant attention to the need to inact forward looking, future-orientated and future-preparing strategies, which include basic investment and investments aimed at developing and modernising the technology base as technologies change.

90. The analysis suggests that this approach is the only effective way of adjusting to the trade displacing effects which technology possesses in times of changes in core technologies, as illustrated today in the area for instance of industrial control and precision techniques and equipment, or in that of the latest generation of new materials substituting ferrous and non-ferrous metals. This confirms, of course, the conclusions drawn above in paragraphs 54 and 55 regarding the usefulness of policies aimed at helping firms to identify the opportunities challenges and constraints created by changes in core technologies.

91. Finally the analysis shows that in the face of technology-based or technology driven changes in the pattern of world trade flows, one of the best assets of countries for adjustment lies in their scientific and technological infrastructure and in the level of education and scientific qualification of their population. The possession of this asset, which can only be built up through a long process of investment in "human capital" and in the appropriation of technological and scientific competence, may represent one of the most durable sources of difference in comparative advantage between developed and developing countries.

VI. Technology, economic structure and industrial organisation

92. The issue which must now be addressed is whether any generalisations can be made regarding some overall factors which may affect the capacity of firms to meet the opportunities and constraints of technical change, notably in period of shifts in core technologies and "paradigm change".

93. This issue is raised by industrial case studies, which often show as in the instance of machine tools that successful and unsuccessful business strategies follow country-specific patterns. This suggests that while the international competitiveness of a national economy will build on the dynamism of firms, their will to compete and their capacity to invest and innovate, either through own R&D or by the successful appropriation of external technologies, there may still be many ways in which the structural characteristics of a domestic economy, which are by definition beyond the control of any single firm may affect these factors and so influence competitiveness of firms.

94. In many ways, this approach should be an obvious one. Anglo-saxon industrial economics has shown, for a long time now, that the conduct and performance of firms will almost invariably be shaped by the form and intensity of the competition to which they are subjected in different domestic supply structures [imperfect competition, oligopoly and monopoly]. This approach has been broaden by US and Japanese researchers to include other "non-market" forms of industrial coordination and organisation. Contemporary French approaches to "structural competitiveness" suggest that others factors yet such as the size of domestic markets, the degree of sophistication of industrial structures, the rate of investment and so the demand for capital goods and the degree of supremacy of domestic firms in their home markets notably for capital goods may represent important factors contributing to the competitiveness of firms.

95. The document on the small country [SPT(83)5] related the capacity of firms to meet the opportunities and constraints of technology in competition to three factors:

- the closeness of the links between the universities and industry, on which the commercial exploitation of the results of research depends;

- the closeness of the links between firms located on national territory, as customers and/or suppliers (the importance of the domestic market, and the ability to spread innovations throughout the economic structure);

- the economic strength, size and dynamic quality of the domestic firms exploiting the results of R&D investments in world markets [paragraph 11].

96. A subsequent paper by Ergas (1984) has suggested in a quite similar manner that technology related competitive performance will probably result from the interaction of three elements: 1) demand, which provides the incentive to innovate; 2) technical opportunity, which refers to the linkages between firms and the science system and 3) the industrial structure which links "demand push" to "technology push".

97. The analysis made in previous sections suggests that the relationship of these three elements with technology and innovation is a two way one. These elements, both individually and in their interdependency, affect the technical progressiveness and so the competitiveness of firms, but they are in their turn shaped by technology. Specific technologies will generally require specific market conditions, pose specific requirements with regard to linkages between the science system and industry linkages, and call for specific responses and solutions at the level of industrial organisation.

98. These, of course, are again obvious statements, or one that become obvious as soon as they are illustrated. To take an extreme example, the requirements for competitiveness and the nature of industrial barriers to entry in space products are clearly shaped by the specific features of space technology, the level of investment and the diversified technological and industrial expertise required in production. Consequently, they call for specific solutions at the level of the funding of R&D, the development of markets and the combination of appropriate industrial capacities. The obvious nature of the statement does not imply, however, that its implications are ones with which governments can necessarily come to grips easily in the area of industrial and commercial policy.

99. In times of paradigm change, furthermore, the conditions and responses which may have been highly successful in previous phases of technological development, may no longer be adapted for successful mastery of the new core technologies.

1. Structural features of demand and the size of domestic markets

100. Given its base in pure science, modern technology has the capacity both to create totally new markets and to revigorate demand for previous goods by supplying products at lower prices, of better quality and with new features. The fact that technology possesses such feature and constitutes, for certain categories of products at least, a major factor giving firms some degree of initiative (sometimes an important one) vis-à-vis demand, does not mean, however, that markets are a negligeable or subordinate part of the issues discussed in this report. On the contrary, structural features of markets may have a significant effect on the competitiveness of firms.

101. Although generalisation is made difficut by the strong sector-specific character of many markets, the firm's decisions concerning the exploitation of technological opportunity will generally be affected by a number of features of "demand", including the size of the market for a product ; the rate of growth of this market ; the sophistication of the market, in terms of the capacity of buyers to adapt to more technically complex products ; the flexibility of buying behaviour, defined as the willingness of buyers to change suppliers so as to acquire an improved product ; and the permeability of the market, in terms of the ease with which buyers obtain information about new products and producers.

102. Considerable attention has been paid by managers and economists to the size and rate of growth characteristics of markets and their influence on learning curves and the moment at which economies of scale can be achieved in the manufacture of new products. A very large economic, technical and managerial literature now exists demonstrating the strategic importance for firms of large and rapidly growing domestic markets, notably in the early stage of manufacture of new technologies and the phases where the rapid lowering of learning curves may be decisive in creating lead times over competitors.

103. Firms in economically larger economies (in terms of each of the components of demand outlined earlier) can be presumed to derive some advantage from the greater scale of their domestic market. In the initial stages of an innovation, the relevant market is generally highly specialised and hence often "local". As exemplified by Route 122 or Silicon Valley, the proximity between users and suppliers plays an important role in the design and "de-bugging" of new high technology products. Once the product design stabilises another factor acquires considerable importance. A large, homogenous domestic market will allow producers to develop more rapidly the process technologies needed to reap economies of large scale production, and to further expand their market through price reductions. Large scale government procurement may in some cases play the same role.

104. The Ergas paper also argues that in addition to their incentive effect demand conditions may also influence innovation through a "portfolio" effect. Innovation is an inherently risky process in that resources must be spent (for instance, for research and development) which may not (and frequently do not) yield a return; and particularly in the early days of a technology, a number of alternative ways are open for designing and engineering new products and processes but it is impossible a priori to know which of these "design approaches" will succeed. The larger the potential market is:

- the stronger will be the incentive to commit resources to innovation, since the potential returns are, in absolute terms, bigger;

- the greater the number of design approaches which can be explored concurrently, increasing the probability that the "optimal" approach will be exploited by a given date.

105. Firms in smaller economies may be at a disadvantage on both scores. In the face of insufficially sized domestic markets they will be forced to incur special risks and costs in their search for market expansion. Exports and foreign direct investment always imply additional risks for firms and may sometimes be beyond their resources. Other costs which small countries and small firms encurr more heavily than larger ones, occur in the form of fluctuations in exchange rates and hence in price competitiveness, overt and covert trade barriers, and differences between countries in technical standards, product regulations and patterns of demand. These issues have been recognised during the Group's discussion on "small countries" as well as in subsequent discussions in the CSTP and the Industry Committee in relation to trade in high technology products.

106. The high technology products sector studies confirm that the disadvantages of small size are real, both for countries and for firms, and that under the impact of current technical change they are tending to grow, even in industries such as pharmaceuticals or machine tools where small innovative firms have upto now represented a significant feature of the industry. Problems are most acute in the case of small countries in which the prevailing industrial pattern is one of small and medium enterprises. This is the case for example in pharmaceuticals where the small country problem is to a large extent that of the small innovative firm, which is being forced out of the industry by rising R&D investment thresholds, coupled with difficult in obtaining licenses from large companies. Small countries where long established multinational enterprises have developed an access to world markets through foreign investment are in a considerably better position.

107. Current developments in key technologies have sharpened requirements for competitiveness in relation to the size and the fragmented character of markets, notably in Europe. In the case of space products and to a lesser extent aircrafts, international technological and industrial cooperation notably that led by ESRA has been achieved successfully in response to the challenge. In the telecommunications equipment industry, rapid technological change and rapidly rising R&D and investment costs have already confronted small European countries which previously possessed telecommunication equipment industries with sharp problems and difficult choices. These will necessarily also be experienced sooner or later by larger countries with the concomittent need for laying the basis for a European industry stricto sensu.

108. In other industries part of the answer for small firms and countries "niche" market strategies, which have shown their effectiveness in a number of countries in industrial robots and some areas of microelectronics. On this point again a distinction must however be made between the opportunities open to small firms already operating within large domestic economies, who can readily have access to demand and also to a large set of available externalities, and small firms in small economies who do not enjoy similar advantages.

2. Industry supply structures and technical progressiveness

109. Work by industrial economists on the relations between the size and the market power of firms and their propensity to innovate has an obvious bearing on the issues examined by this report.

Size, market power and innovation

110. Industrial analysis has notably been centered on the so-called "Schumpeterian hypothesis" (which in fact belongs to Galbraith (1956) rather than Schumpeter) which argues that large firms possessing a significant amount of market power represent the industrial structure most conducive to innovation and technological progressiveness. This argument has been subjected to quite extensive empirical investigation [see inter alia Scherer, Mansfield, Soete, Turner and Williamson] which has generally taken the form of regression analysis between size or concentration ratios, representing proxies for market structure, and different technological input and output indicators: R&D expenditure, patents, lists of successful innovations, etc. Complete agreement over the results of these studies is far from existing. A number of pointers, however, are found in the literature.

111. In many industries, high levels of concentration are not conducive to innovation. Taking large firms rather than market power per se, one finds that R&D intensity increases absolutely as the size of firm increases, but as a proportion of sales the largest firms spend no more or possibly even less than medium sized firms. Econometric studies do not establish clearly whether the largest firms are obtaining scale economies in their R&D inputs. The concept of a minimum threshold level of firm size for effective R&D expenditures seems important. While the actual level of the threshold varies from industry to industry, there is no evidence that it is as high as the R&D expenditure of the largest firms in the industries concerned. Large firms tend not to be proportionately more important producers of major inventions. While they are more important as innovators they do not in all cases account for a larger share of innovations in relation to inputs and may still be slow to take up developments that are offered to them by smaller firms. If the level of R&D expenditure is held constant it seems that medium sized firms are often more productive than large firms. Small firms remain important sources of inventions though not of innovations.

112. Industrial case studies also often include an examination of industrial performance with respect to technological progressiveness and the way the latter may be related to the size and market power of firms and the effectiveness of barriers to entry. Over the past ten years or so, U.S. studies investigating the hypotheses favorable to size and market structure have progressively given the way to studies showing, as in the 30s and early 40s, a much greater degree of preoccupation with the way and seemingly "invulnerable" high entry barriers and high market power may be conducive to conservative approaches to technology and the other steps required to preserve the long run competitiveness of firms. The sudden irruption of highly dynamic Japanese firms breaking down what seemed to be high entry barriers and almost invulnerable oligopolies has of course been a factor leading to this more critical approach to size and market power.

113. Recent documented examples of conservative strategies and behaviour by U.S. oligopolies include steel, automobiles and consumer electronics (notably TV). In the two latter industries conservative strategies appear to have extended to and been reinforced by foreign direct investment and the reaping of rents acquired through the capacity to exploit certain advantages through multinationality.

114. The summing up given by Scherer (1970) of the findings resulting from both types of studies appears to retain all its validity: "Some degree of monopoly power, in the form of structural concentration, may be conductive to invention and innovation(...); but very high concentration has a favorable effect only in rare cases, and more often it is apt to retard progress by restricting the number of independent sources of initiative and by dampening firms' incentive to gain market position through accelerated research and development". In all events "it is vital that barriers to new entry be kept as modest levels, and that established industry members be exposed continually to the threat of entry by technically audacious newcomers (...)".

Small firms, progressiveness and competitiveness

115. The role of small firms in helping to preserve technical progressiveness and a sufficient degree of competition in the often predominantly concentrated market structures, which prevail in a many industries today has been widely discussed. Small firms are recognised to have in this, as in other respects, an extremely important role to play. A layer of smaller firms, exploring all the potentialities of technologies notably in the area of product innovation, may condition the behaviour of large firms and temper their tendency towards conservatism. In industries where the process of concentration has not moved to far and where scale factors in manufacturing and marketing have not completely eliminated small firms, the presence of these may strongly influence progressiveness and competitiveness.

116. As work on small and medium enterprises has demonstrated (see in particular OECD, 1982) the conditions however under which the existence of small innovative firms may be ensured are not necessarily easy to meet. In industries or segments of industries where the pace of innovation create the necessary breathing space for small firms to emerge, five main factors appear to be crucial:

- the supply of entrepreneurial skills, both technical and managerial,
- the supply of risk or venture capital [see for instance ICCP, 1984] -- that is, of investors primarily seeking capital gains as against a steady income, and, in the later stages of a new firm's development, the ease with which it can access growth funding from organised financial markets;
- the supply of a mobile pool of highly skilled labour, which minimises the extent to which a new firm must invest in developing its own labour supply;
- the availability of the required specialised equipment and intermediate inputs, which reduce the investment the new firm needs to make in vertically integrated production facilities;
- the transparency and simplicity of distribution channels, which limit the investmet required in marketing and makes it easier for new firms to access large scale demand.

117. The importance of the last factor is often overlooked. As exemplified by pharmaceuticals, it is the one where the large established firms in an industry will often have a decisive advantage over new small innovative firms. This is one of the factor explaining why the technological performance of small firms differs according to whether one consider inventions or innovations, and also why large less progressive firms are often in a position to absorb at a given moment the smaller innovative firms around them along with their innovations, know-how and scientific and technical potential. This last point has been the object of concern and public debate in Member countries and is discussed in several of the high technology products industry case studies.

118. A further factor which plays a role in encouraging the creation of new firms is the ease of exit, that is, the ease with which firms can be liquidated and the remaining value of their assets salvaged. If entrepreneurs must enter into long term commitments difficult to revise so as to secure access to labour and other inputs, the high costs associated with exit will deter entry. Equally, if brankruptcy proceedings are long and complex, and impose a heavy economic and social cost on those who seek bankruptcy protection, the high risk of failure will inhibit entrepreneurship. Countries, such as Italy and the U.S., where the number of small firms has increased over the last years, will be found to have easier exist conditions, on one score or another, than other countries.

119. Technical progressiveness and competitiveness appears to call for industrial structures achieving de facto division of labour between firms of difference size [Ergas, 1984]. These would comprise an inner core of large firms capable of risky, high cost, long term, "system oriented" R&D; these firms would adopt new design approaches as they gain acceptance, and use a strong process engineering capability to industrialise their large scale production, reducing prices and stimulating diffusion. Around this inner core would float a nebula of smaller firms, exploring technical alternatives at the product end, and conditioning the behaviour of large firms. Such a division of labour will also call for relations of cooperation between firms, which in practice co-exist with the more frequently studied relations of competition.

3. Cooperation between firms and organisation as factors in competitiveness

120. "Organisation" or "hierarchies" [Williamson, 1973], e.g. non-market, para-market or semi-market forms of cooperation between firms have, over the past few years, been receiving progressively greater analytical attention and are now identified as playing a role in competitiveness. This is the case notably of Japanese industrial and corporate manajgement studies which argue that a correct analytical approach to the understanding of many contemporary industrial phenomena must henceforth be sought through the recognition of the "mutual infiltration between the market mode and organisational principles" [Imai (1984), Imai and Itami (1984)].

121. The best known and most researched forms of non-market or para-market cooperation between firms are vertical and horizontal integration and group structures. Modern industrial groups (which are also generally multinational enterprises) are now recognised to represent both a specific entity, e.g. an enterprise which is considerably more than a mere addition of its constituent elements, and also an extremely convenient form of achieving non-market coordination and cooperation between a number of different firms viewed as partly independent management decision centers. For these firms, group

structures will represent a decisive way of achieving externalities and a non-market way of developing a highly productive division of labour (1).

122. Other numerous forms of coordination and cooperation have emerged along side formal vertical and horizontal integration and may account for the overall competitiveness of interelated industrial branches in certain countries. In some instances they may stemm from the strategies of larger firms, vis-à-vis smaller ones, as in the case of the contractual agreements established by large firms with a network of subcontractors and lead to contractual agreements amounting to what analysts now name "quasi-integration". In other instance cooperation and coordination may take place between large firms, as the case of consortia set up in relation to specific large industrial projects. In other cases coordination may address problems of importance to all firms in a branch and stemm from initiatives taken by medium and small firms: associative industrial research laboratories, industry fixed technical standards, common marketing services.

123. Imai (1984) argues that the particularly strong systemic characteristics of several of today's key technologies, such as data-processing, telecommunications and "télématique", space technology and space activities, represent objective constraints which are continually strengthening the need and widening the scope for the "organisation mode", along with numerous forms of infiltration between this mode and the market.

124. A key factor in the specific learning processes associated with technologies possessing systemic features may lie in the size and quality of the "system" created by coordination and by mutual infiltration between organisation and market within which the new technologies may be deployed, experimented and developed: "Since J. Schumpeter, the scale of enterprises has been a point of dispute in discussions concerning the efficiency of technological innovation. It is more pertinent to consider the size of the system within which the learning process for the development of technological innovation takes place as representing the real factor influencing the results of innovation. (...) Account must be also taken of the efficiency of the diffusion and transfer of knowledge and information within this sytem. If Japanese companies are to produce relatively favorable results in new aspects of innovation centering on high technology, they must rely on widespread and speedy transfer of knowledge and information and on the efficiency of the learning system." [Imai, 1984, p. 33].

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(1) American economists have coined the term "market failure" to cover the ever increasing number of instances where firms establish non-market or para-market forms of coordination, notably through integration, in preference to "arm's length" forms of relationships established through markets. The term is a curious one and obviously reflects uneasiness about the way firms are deliberately choosing the virtues of the "visible hand" (Chandler, 1975) as opposed to these of the "invisible" one. Recognition by Japanese business economists of the existence of two "modes": the "market mode" and the "orgnisation mode" and their ever deeper mutual infiltration, appears to reflect greater readiness to encompass the new developments. This may not be foreign to the finding made by Sciberras (1984) in his examination of firms strategies in the machine-tool concerning the very different degree of success of vertically integrated firms in the U.S. and Japan is maximising the benefits of internalised "external economies" and achieving effective coordination.

125. Findings from the machine-tool study confirm the part played by organisation, whether by integration or by quasi-integration achieved through subcontracting, or by coordination and externalities achieved by professional associations. The findings also point to the importance of supplier-user relations as a major modality of organisation in capital good industries. Similar evidence has been assembled by Watanabe (1983) showing that the success of Japanese firms in using computer controlled, numerical control technology may be related to the original features of the Japanese economic structure, notably the large domestic market created by the extensive sub-contracting relations which exist between the large metal working firms and engineering firms (including automobile firms) and a very large number of small engineering firms which have been required to equip themselves with NC machines. Watanabe suggests that the very high diffusion rates within Japanese industry, which have provided Japanese firms with all the advantages which invariably stemm from large markets and helped them prepare their drive towards foreign markets, may reflect structural phenomena of this type quite as much as any intrinsic quality of Japanese management.

126. In contrast to Japan, one of the features of the United States machine tool scene is the extremely weak diffusion of NC machine tools within US manufacturing, in particular in small and medium enterprises in the metal-working industry. Paradoxically, the economy which first developed NC appears also to be one of the ones where the internal diffusion of this technology has been slowest. The US machine tool builders have had the largest potential home market for NC, but left much of this market untaped until foreign competition has shown its potentialities. Here again dominant patterns of supplier-user relations shaping the environment of management decisions appear to offer a fruitful avenue of investigation. In the United States numerical control developed from 1950 onwards principally on the basis of government procurement R&D contracts and in connexion with the needs of ever more highly specialised procurement requirement in aviation and later in space. The particular pattern of excellence of the US machine-tool industry, and by contrast its weaknesses notably vis-à-vis Japanese firms appear to stemm from this relation linking machine tool and control equipment manufacturers to firms which have been primarily "performance sensitive" rather than "price sensitive" users [see above chart 1, columns 4 and 5] looking for highly sophisticated equipment rather than the type of machine useable by small firms.

4. National scientific and technical infrastructures and their interface with firms

127. Section IV and the conclusion to section V already contain a number of observations and findings regarding this third dimension of structure and organisation. Similarly a number of the CSTP's past and current projects, studies and reports contain valuable material and recommendations concerning the interface between firms and national scientific and technical infrastructures. The ongoing CSTP activity on University-Industry Relations is a clear example.

128. This report, consequently, does not enter into this area. It is sufficient to stress that the effective use of technology in competitiveness requires that the scientific and technical research system should be suppported appropriately notably in the area of fundamental research, but also that conditions applying to many sectors than R&D stricto sensu fulfilled. In

fact, it is impossible to separate measures concerning scientific and technical infrastructure from those which encourage the transfer of knowledge and its application in the economy and more widely in society. Measures which affect scientific and technical training and information in general play a role no less important than those relating to research structures proper, in that they determine a society's understanding of technology and its ability to produce and assimilate new technologies.

5. Some conclusions with implications for policy

129. This section has reviewed some of the major parameters which shape the economic and institutional environment of firms and affect their competitive conduct, their capacity to make the best use of technology in competitiveness and the rapidity with which they adjust to overall changes, opportunities and constraints.

130. The finding that the techical competence of firms and industries and their competitiveness are not merely an issue of management but are also dependent, to some possibly large extent, on the structural attributes of firms' environments has numerous implications for policy.

131. It means that policy aimed at improving the relation between technology and competitiveness has to go in hand with industrial policy. Measures aimed at promoting innovation, are unlikely to have a significant lasting effect in isolation. Identifying the major points in firms' environment which impede or promote their capacity and readiness to innovate should be a key step in formulating national technology policy. These points can include the system of university/industry links, functioning of labour markets, the responsiveness of capital markets to innovation opportunities, or regulatory policies affecting industrial structure.

132. In times of rapid and profound technological change, all these parameters will themselves be subjected to deeps and rapid modifications. As a result many, if not all, the industrial policies of a number of Member countries may require carefull reexamination, in the light of the characteristics and requirements of today's key technologies, notably their systemic features.

133. In some instances the exiguousness of domestic markets and domestic technological resources, and the impossibility of achieving scale economies on account of parcellisation created by national frontiers, may suggest policy solutions calling for an activated implementation of economic, industrial and technological integration policies, often prepared, as in the EEC and the Nordic countries, by R&D cooperation policies.

134. Competitiveness in world markets for certain categories of technologies and products may increasingly require domestic or international industrial joint ventures and consortia. This is the case for space products where they are the rule and for aircraft and advanced electronic systems where their number is steadily increasing.

135. For such core technologies, the technology base (which includes basic research), on which the innovation process builds is both a vital ingredient of success and one which almost invariably makes a call on larger resources than any single country can mobilize. The international acquisition of basic scientific, but also of more specialized and possibly propriatory technological knowledge, and hence the establishment not only of

international, inter-governmental, but also of intense scientific and technological cooperation between firms accross national boundaries, are an almost compulsory requisite for success. Advanced technology is an area where cooperation and competition almost invariably go hand in hand, and where competition may indeed be partially constrained by the requirements of cooperation. This trend towards novel combinations of competition and cooperation between major firms is amply documented by the high technology sector studies.

136. Government policies aimed at facilitating the emergence of small and medium innovation firms appear to be fully in accordance with many of the opportunities and constraints associated with the new technologies. While niche strategies always offer opportunities to SMEs the survival of many firms may nonetheless depend on sub-contracting and quasi-integration relationships with larger firms.

137. Recognition of organisation and coordination as a quasi-obligatory and normal mode of enterprise activity alongside and in combination with the market mode has become a requisite for competitiveness. Government assistance in the strengthening of forms of coordination and cooperation previously identified by firms, notably small and medium enterprises, may lead to a development of the externalities on which competitiveness can build and an expansion of the total "system" within which industrial and technological learning processes take place.

VII. Foreign direct investment, the diffusion and transfer of technology and competitiveness

138. The last area covered by this report concerns foreign direct investment. The rapid growth over the last twenty-five years of foreign direct investment and of multinational entreprises locating production activities outside their home countries, has demonstrated that firms reaching a given threshold in size and assets have the possibility of choosing the way to exploit their competitive advantages. They can decide between exports and production from plant abroad. In 1960 international production by the US-based multinationals, i.e. the production by branches and subsidiaries abroad, was roughly estimated to be three times the value of US exports. By 1971 this ratio had increased to four. For both Germany and Japan the same ratio rose from a small fraction in 1960 to about 2.5 by 1971 (OECD, 1981).

139. Country differences in the extent of foreign direct investment are partly a result of past historical development. Nonetheless international investment positions are generally also recognised to lie at the point of intersection between the firm specific ownership advantages of firms and the location advantages of countries [Dunning, 1981] and to reflect to some degree the competitiveness of national economies. Foreign investment positions are an indicator of international competitiveness much in the same way as market shaes in world exports. When a country engages in foreign direct investment (FDI) as well as trade in goods, the distinction between gross domestic (GDP) and gross national product (GNP) becomes important. GNP is output produced by the residents of a country both inside and outside its national boundaries. It is equal to GDP plus income earned overseas by its own residents less income accuring to foreign residents earned within its domestic territory [Dunning, 1984].

140. For home economies beneficial balance of payment effects of foreign investment will depend to some degree on the extent to which profits, interest and dividends are effectively repatriated. This may in some circumstances depend on financial and monetary factors which have little relation with industrial competitiveness (whether a country has a developed financial market, and has or not a currency used for transactions and reserves on the world market, relative interest rates at home and abroad etc.).

141. In host economies foreign direct investment has the capacity to promote wide spread beneficial effects from a number of standpoints: employment, export earnings, industrial development and the diffusion of new technologies. The exact extent and character of these effects is known however to vary considerably according to the level of income and the structural features of industry and technology in host countries. Foreign direct investment and the international transfer of technology, including that by MNEs, are in general a factor of international convergence in incomes and industrial structures. Nonetheless quite different patterns, opportunities and problems are observed according to whether FDI occurs between countries of approximately the same levels of income and productivity, possessing strong similarities in industrial structure, or is taking place from countries with a given levels of income and productivity, and given industrial patterns, to countries with quite different characteristics.

142. The need in this report to discuss briefly the ways in which the existence and activities of MNEs may affect the relationship between technology and competitiveness both in host and in home countries arises from the fact that a large part of the surge in international investment which occured from the late 1950s onwards has concerned industries marked by high levels of R&D intensity and a significant capacity to innovate. This chapter can only establish a few pointers directed related to some of the findings and issues identified in earlier sections. It will attempt to do so in the context of today, which differs to some extent from that of the 60s and early 70s during which many of the studies available on the strategy and effects of multinational enterprises were carried out.

143. Since the 1960s the internationalisation of OECD economies has developed continually. MNEs are now a permanent and familiar phenomena of the working of national economies and the everyday life of Member countries' citizens. This is due notably to science and technology which have represented a major (and even possily the major) driving force towards internationalisation. Science based MNEs are among those which have created for themselves the widest international recognition, audience and market.

1. Foreign investment and the international diffusion of technology

144. Both the extent of internationalisation within OECD and the nature of today's key technologies, call for much greater precision in the use of the terms diffusion and transfer of technology. This is an issue where considerable analytical confusion has often reigned.

145. Today within OECD the diffusion of new technologies embodied in products is extremely rapid and is achieved both through exports and through FDI and MNEs. To the extent that radical technological change is presently occuring at the very heart of the modern industrial system, these products

represent in extremely numerous cases inputs to further production. They take the form of capital goods -- or goods which like computers have all the characteristics of such goods -- or else of intermediate products which in the case of semi-conductors, micro-processors and new chemical-based materials have the effect of seriously modifying and sometimes revolutionising downstream production.

146. OECD countries have in general no problem of access to these products. Except in the case of classified "dual use" high technology products they do not have to inquire whether the capital goods and intermediates products incorporating the most advanced technology will be available to them. The problems they face are in general quite the reverse. They stem on the contrary from the extent to which the international availability of these products is forcing the pace of structural adaptation domestically and possibly preempting the possibility for domestic firms to achieve proficiency in their development and manufacture. The problems experienced by countries are those of monotoring the changes required for accomodating the new products and production processes, and possibly of giving their domestic firms a breathing space to face the pace of adjustment and competition.

147. The rapid diffusion of new technologies and industrial and managerial techniques involves an education process and the need to reeducate different professional groups, managers, engineers, skilled workers (both manual and clerical) in the use of the new capital goods and office equipment. MNEs supplying such high technology products are fully aware of this problem. They often offer courses of their own and are always willing to cooperate with national or local education authorities is setting up and manning courses aimed at improving diffusion processes.

2. Foreign investment and the international transfer of technology

148. The diffusion of new technology, in particular when it takes place in the capital goods sector, may be reviewed as already representing a process of technology transfer, notably when the agents in the process are multinational enterprises. Nonetheless, the transfer of technology stricto sensu refers to a different set of phenomena. While are links between these and the question of diffusion, they are nonetheless distinct. The transfer of technology is the transfer to the recipient firm or organisation of the capacity to produce the products embodying the new technology, which inevitably means according the recipient firm some degree of access to the technology itself. In its fullest meaning transfer of technology implies in fact the transfer to the recipient not only of the technical knowledge he needs to produce the products, but also of the capacity to master, develop and later produce autonomously, the technology lying behind these products.

149. It is sufficient to enunciate this definition to understand why firms will fix limits on their transfer of technology, develop complex policies regarding this transfer and examine closely the conditions within which it takes place. Technology has been shown above to have strong industry specific and often even firm specific dimensions, and to represent the outcome of costly and complex assimilation processes. Technology has also been shown to be an important, sometimes a decisive asset in competition. It represents one of the firm's specific ownership advantages or assets [Dunning, 1978, Caves 1982] which the firm seeks to appropriate, e.g. keep for itself the time it can.

150. This appropriation is bounded by the capacity of other firms to understand, on the basis of their own investments in science and technology, the foundations on which a competitors' new technology rests and to find their own route to the same or a closely similar technology and products. During the time it lasts, a lead in technology is the basis for a temporary monopoly advantage which a firms must exploit in the best way it can.

151. Foreign direct investment and the establishment of production affiliates represent a convenient and widespread way for firms of reaping the benefits of appropriated technology, is a manner which contributes at the same time, in a limited manner, to the transfer of technology to other countries, and also of course contributes to the other, sometimes more prominent, objectives governments may have in the area of employment, industrial development and exports. The solution given is one where the firms to which access to technology is accorded are affiliates, subject to the parent company's overall industrial, commercial and technological policies. International transfer of technology takes place, but within group structure and in a way which seek to avoid future competitors or aiding rival firms.

152. Parallel to this internal flow of technology within group structures [Michalet, 1977], an external circulation and release of proprietary technology and know-how by firms also takes place through licencing and other forms of effective external transfer. The magnitude of this external circulation is commanded by 1) factors related to the technologies involved, 2) the quality of the recipients and the terms on which contracts are established and 3) overall economic and political considerations, both general and country specific.

153. The first set of factors just listed mean that in high technology industries very short life cycles, dynamic learning curves and rapid mastery of products with new life cycles, may lead some firms to accept quite easily to licence out earlier, but still modern, vintages of technologies to firms that are not their immediate rivals and are not expected to become so within a forseable period.

154. The complexity of advanced technologies and the wide range of techniques and know-how which enter into many contemporary products and systems mean that firms are obliged in a number of instance to acquire and exchange technology with actual or potential competitors. The dense network of international industrial technology agreements and joint technology development ventures reported in the recent OECD work on trade in high technology products illustrate this phenomenum. Such agreements, however, will obviously only take place between firms of similar technological sophistication, possibly as part of loosely knit, international oligopolies, notably in high technology industries.

155. There may finally be situations where on account of adverse overall demand conditions and important market opportunities, possibly accompanied by political leverage, firms may accept to make their technology available externally in conditions which they would not generally consider normal.

156. Considerable time and energy has been devoted to explaining to developing countries why technology, contrary to some erroneous neo-classical representations, is not a "free good" and will only be transfered by firms under conditions which make this transfer, for one reason or another, a sound business proposition. This also applies within the OECD area and means that when countries decide that they should establish an indigenous capacity to develop and produce at least some constituent elements of a core technology, they should not look to foreign direct investment and MNEs as the main instrument for achieving this objective. MNEs can and will contribute, but only within the context of overall domestic policies which must start by relying on available indigenous scientific, technological and industrial capacities and skills.

3. Foreign investment and national capacities for R&D

157. In science based-industries and for advanced technologies, the technology base, on which the innovation process builds invariably calls on larger resources than any single company can mobilize. Valuable, or possibly indispensable scientific and technological assets may be accumulated in the scientific and technological capacity of other countries than a given MNE's home country. Investing in foreign countries and setting up research facilities there represent one way of getting access to the world's scientific and technical capacity.

158. Previous OECD work on MNEs and national scientific and technological capacities found considerable evidence on this point in computers and data-processing [Michalet and Delapierre, 1977] and in pharmaceuticals [Burstall, Dunning and Lake, 1981] where a number of firms had established world based R&D activities with laboratories in several Member countries. These had been chosen on account of their large and sophisticated market, but also their large and well trained scientific and technical manpower and their developed university research. This was a strong motive for direct investment and the setting up of research facilities by European firms in the US in the late 60's and early 70's. U.S. firms had often set up world based R&D capacities in such industries at a still earlier date, generally choosing a small number of European countries to locate their facilities.

159. In such instances MNEs will obviously contribute to the strengthening of domestic R&D capacities. In other circumstances evidence shows that R&D investments take the form of quite subordinate testing and trouble shooting facilities or at best minor projects. These may have beneficial spin-off effects for the host country scientific community, and can also stimulate host country firms and governments to develop their own R&D capacities in given areas, but they will not really contribute to their development.

4. Foreign investment and industrial structures

160. Finally FDI and the growth of MNEs may affect competitiveness both in host and in home countries is through its effects on industrial structures, the size of firms and their market power. This is an extremely wide and complex area of which a number of aspects are in fact currently being explored by the work of the Committee for International Investment and Multinational Enterprises on Multinational Enterprises and the structural adjustment process.

161. FDI represents a way of entry into a domestic industry, which may also represent a way of lowering entry barriers and will at all events modify size and concentration patterns, market structure and forms of competition or rivalry between firms. The effect on the host economy will depend to a very large extent on previously existing patterns of market structure and competition and the nature of host firms and governments reaction to entry. A wide range of situations may exist:

* there may be cases where market structure in host countries are marked by the existence of numerous firms not attaining threshold levels for R&D, investment and competition on world markets: foreign entry may have the effect of creating a constraint for concentration, with beneficial effects on competitiveness at least in the initial phases: much U.S. investment into Europe in the late 50's and early 60's probably had this effect;

* in other situations however, entry by foreign investment into a concentrated and oligopolistic industry will only contribute to reinforce these features: foreign affiliates will adapt their prices, competitive strategies etc. to local oligopoly conditions.

162. The effets of FDI on competitiveness through its impacts on industrial structure, investment and the structural dimensions of competitiveness which were discussed in earlier sections of this report, must also be considered from the perspective of home countries. While foreign investment positions and earnings undoubtedly represent an indicator of a country's competitiveness, it can to a greater extent than market shares be an expression of <u>past</u> competitiveness and mask current trends.

163. Like any other firm an MNE can only maintain its long term competitiveness if it "invests in the future" (Cox, 1980), through investment in equipment and in R&D. In some instances FDI may have a negative influence on this future-orientated investment. A number of U.S. authors have suggested that there may have been a relation between the progressive loss of competitiveness of several important US industries in the 60's and 70's and the feed back effects of easy (rent type) profits of investments in low productivity oligopolistic economies abroad. Of course, when firms attack highly progressive foreign industries on their home markets and are subject to retaliatory investment on their own domestic markets, the feed back effects will then be quite different, involve considerable increases in competition and lead to a shake up in market structures.

5. <u>Some conclusions with implications for policy</u>

164. Multinational enterprises have become a permanent and familiar feature of OECD economies, whose contribution is no longer in dispute in any Member country.

165. By definition multinational enterprises tend to react to economic signals and overall strategic considerations which are much wider than those of host countries, but are also often wider than those of the home economy. This is true notably of European based MNEs [Michalet, 1981 and 1984].

166. Policies for technology and competitiveness whether in home or in host countries must consider the contribution which MNEs may make, in a way which recognises as fully as possible their originality, the specificity of their mode of operation and the world wide character of strategic horizon. MNEs can be relied on to ensure the most rapid forms of technology diffusion, both internationally and domesticaly. They will also make a contribution to the development of indigenous scientific and technical capacities in host countries, but will generally only do so, of course, within the limits of sound business practice and in the context of clearly defined domestic policies. It would be a mistake however to expect MNEs to assume responsibility for ensuring the technology based competitiveness of domestic economies and monotoring the overall structural effects of technological change discussed earlier. MNEs can cooperate to this effect, but only once long term structural strategies and policies have been defined by countries.

VIII. Some overall policy conclusions

The central theme of this report

167. The analysis made in this report has argued that the relation between technology and international competitiveness must be approached through an understanding of technology's capacity to modify the comparative advantage of national economies and the way in which they achieve their insertion within the world economy.

168. In very many instances technical change accrues to firms and countries essentillay as an exogeneous and often also an external constraint, which requires them to adjust rapidly, by adapting their production processes and products to the technological standards and levels of productivity set by leader firms and countries. Even in the case of leaders, technical opportunities have a strong exogeneous dimension and stem to a large degree from the vast stock of scientific and technological knowledge, which is being continuously and rapidly generated as a result of the high level of R&D expenditures including those made for non economic government objectives.

169. In times of far reaching shifts in the basic technologies around which the manufacturing and service sectors of economies are organised, the requirement to adjust may however involve quite basic changes in the very foundations of national economies and the structural relations on which their cohesion is built. These changes represent an important dimension of the relationship between technology and competitiveness. They mean that firms and governments must tackle the issues posed by technology and competitiveness in a context where technological change is itself modifying many parameters in this relationship.

170. In market economies the responsibility and capacity for identifying the opportunities and for the requirements for rapid adaptation created by technical change and for incorporating into the firm's strategy and activity exogenous knowledge and constraints, lies principally with the management of enterprises. But, as several sections of the report have argued, the response of firms will be affected and shaped by a number of factors pertaining inter alia to the basic industrial structure, the competitive or uncompetitive nature of domestic market structures, the nature of labour markets and the development of the nation's scientific and technical infrastructure, education system and research capacity.

171. Historical and cultural factors will determine the extent to which countries consider that these may represent areas of government responsibility or not and the extent to which governments should assist in monitoring structural change. In all cases however awareness of these structural dimensions of international competitiveness in the face of far reaching technical change, should become an input to government approaches and policy decisions for technology, competitiveness and societal change.

A reconsideration of policies

172. Government policy making in the area of technology and competitiveness has built on the empirical findings of econometric trade studies which show a positive relation between proxies for innovative activity and trade performance, and of industrial and corporate economics case studies which demonstrate that in many sectors micro-economic competitiveness depends essentially on factors such as scale economies, manufacturing process technologies and differences in the quality and performance of products.

173. The issues however are not ones that can be reduced to a question of R&D expenditure by firms and governments. Innovation cannot be reduced to nor does it solely arise from R&D. It is the outcome of complex and lengthy processes in the accumulation and appropriation of technology. The way firms will actually use innovation in competitiveness is likewise related to complex conditions of demand and supply. As a consequence, it is probably quite as erroneous and misleading for appropriate and adequate policy making for technology and competitiveness to equate R&D with innovative capacity, as it is to equate the competitiveness of most industries in advanced industrial economies with wage costs.

174. More generally, the structural dimensions of competitiveness identified in this report means that there are no "quick fixes" available to policy makers. The data discussed suggests that the modification of technological performance of an economy is a long-term endeavour which hinges less on the performance of any given single sets of firms or industries than on the capacity to improve the functioning of a wide spectrum of economic structures, and mechanisms and social processes.

175. The finding that the technological competitiveness of firms and industries and their capacity to use technology in relation to competitiveness, are dependent to a fairly large extent on the structural attributes of their economic environment has important implications for policy. Identifying the major points in firms' environments which impede or promote innovation should be a key step in formulating national technological policies. These nodal points can include the system of university/industry links, the functioning of labour markets, the responsiveness of capital markets to the opportunities of innovation, or regulatory policies affecting competition and market structure.

176. Structural features of demand which affect the capacity of firms to use technology in competitiveness concern the size, rate of growth and sophistication of the domestic markets on which products are launched before been subsequently offered on world markets. Key features of industrial structure include a correct balance between the size of firms, their market power and the effectiveness of competition in supply, as well as the existence of appropriate non-market or para-market cooperation and coordination mechanisms which facilitate the flow of information between firms and provide

firms with access to key externalities. Both aspects of industrial structure point to the importance of innovative export-oriented small and medium enterprises and of policies aiding such firms to overcome barriers to entry.

Some implications of the new approach

177. Formerly, many countries could go a long way by institutionalizing and funding sector-specific technology oriented R&D. Consequently, the structure of research specialization in many Member countries reflects the industrial structure to a large extent. Current core technologies being more generic in nature, require a general capacity of learning and applying a wide range of new techniques across industries. This implies a shift in focus from sector-specific technological capacity to general technological programs which aim at acquiring basic technical skills and exploiting technological opportunities across sectors.

178. More generally technological policy should now be aimed at increasing the strength and resilience of nodes in a country's scientific and industrial networks. These nodes - which include the system of education and training, capital markets, and the system for industrial standardisation - diffuse throughout industry the technological strengths of individual firms. They also facilitate the adjustment of national industrial structures to changes in technological paradigms.

179. Emphasis on the environment for innovation as a whole necessarily modifies project evaluation procedures in the technology field. In particular greater weight needs to be given in project evaluation to the systemic effects of a particular project decision. Traditionally, technological policy has emphasized the externalities which may arise from innovation. The approach adopted in this report suggests that the interdependences between major R&D and industrial projects may deserve increased attention.

180. The fact that policies for technology and competitiveness obliged to encompass numerous varied and complex parameters if they are to be successful, is truer still in a time of deep technological change, of the kind which affects the nature and precise industrial location of the basic technologies around which industrial economies are structured. In many cases the new technologies call for new dimensions of market, a shift in the industrial base and a new mix of scientific, technological resources and managerial and professional skills.

181. This challenge can be taken up more easily by recognising the systemic features both of today's major technologies and of the type of change their modification brings with it. The report has repeatedly turned to this dimension of the problem. The approach is a new one. The fact that the systemic aspects of major technologies are now attracting analytical attention in countries with somewhat different intellectual traditions suggest that this is an important area of investigation which will require considerable study in OECD in coming years.

182. Finally the analysis made in this report has pointed repeatedly to the importance of "human capital" and the need for a permanent effort aimed at upgrading and developing education at all levels. In circumstances such as those of today, the economic health and future development of Member countries

depend to a very considerable extent on the capacity of their education system, notably their university education and research system to train and prepare the young generations. This task must be considered in a long-term perspective. Focusing education and scientific research on short-term economic needs and immediate benefits at a time when all the parameters of economic activity are changing, could jeopardise the achievement of the longer term requirements. It is these however that will be really decisive in determining that the challenges raised by the changes underway be met successfully.

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ANNEX 1

The CSTP remit and the method of work followed by the Ad hoc Group

1. The activity initiated by the CSTP on the relations between science, technology and international competitiveness was undertaken in response to the concern about competitiveness, at a moment when consciousness regarding the peculiar features of contemporary technical change was still in an early stage. The objectives of the activity were defined as aiming towards a better understanding of international competitiveness and its relations to technology notably:

i) by assessing the role played by science and technology in determining the international competitiveness of Member countries, both with regard to the exports of high technology products and to the upgrading of the competitiveness of industries generally considered as non-technology intensive;

ii) by analysing the various approaches chosen by Member countries in devising policies and in establishing instruments aimed at gearing science and technology to the objective of increasing international competitiveness.

2. During the Committee's initial discussions the issues were recognised:

* to be very complex issues in as much as both competitiveness and technology are affected by numerous, often unquantifiable variables;

* to represent an area of policy making of economic analysis where a number of conceptual approaches already existed and a number of empirical studies had already been carried out, and finally

* to be also an area where science and technology policy considerations cross economic policy considerations and are also often of a highly sensitive political nature, involving issues related to international trade and the international implications of domestic policies.

3. In view of this the Group established by the CSTP in November 1980 was asked to adopt a step by step approach. It was requested not to repeat the type of studies which had been done previously nor to duplicate work done elsewhere, and to postpone all consideration of government policies to the final phase of the work.

4. During the first phase of its mandate, the Group devoted considerable attention to the stock-taking and analysis of reports and studies which had previously been carried out in areas bearing generally on the relationship between technology and competitiveness. This work was based to a notable extent on contributions prepared in 1981 by Member countries. In these papers [see DSTI/SPR/81.20/01 and following numbers] Delegates set out their perception of the problem and acceptable parameters for the study, and gave a brief description and generally an assessment of the work done previously in the area in their country.

5. Later discussions by the Group were similarly based on contributions prepared by Delegates. One issue that was notably approached in this manner was the "small country" question, i.e. the degree to which technological parameters should be seen as affecting the competitiveness of small countries in a specific manner. The discussion was reported earlier in a separate document presented to the CSTP [SPT(83)5] which led to a first discussion by the Committee of an issue examined again in relation to trade in high technology products.

6. The Group was also fortunate in the high quality of the work commissioned by the Secretariat to outside consultants. This work has included a number of analytical discussion papers and a sector specific inquiry, based on field work, on the relationship between technology and competitiveness in the machine tool industry. The list of the reports considered by the Group is given below. The Group wishes to recommand to the CSTP the derestriction and circulation of these reports which all have a considerable methodological interest.

7. The Group observed a growing coincidence between its own concerns, interests and approach, and those of a number of research groups and individual researchers in Member countries. The Group was able to achieve a significant degree of synergy between their efforts and its own. One representative moment in this process was the organisation at Kiel in 1981 of the Institute of World Economy's annual economic symposium on "Emerging Technologies: Consequences For Economic Growth, Structural Change and Employment" in cooperation between the Kiel Institute and the OECD. A number of people closely associated with the Group's activity attended or presented papers at the symposium. These papers proved to be vital inputs to the group's thinking and the list is also given below.

ANNEX 2

Papers prepared by consultants for the study

"Technology, Industrial Structures and International Economic Performance" by G. Dosi - DSTI/SPR/81.43

"Competitiveness and Internationalisation" by C.A. Michalet - DSTI/SPR/81.63

"Technological Innovation, International Trade and Direct Foreign Investment: Old and New Problems for Economic Theory and Empirical Research" by F. Momigliano - DSTI/SPR/81.59

"Technology and International Competitiveness : the German Evidence and Some Overall Comment" by E.J. Horn - DSTI/SPR/81.60

"Technology Payments and the Economic Performance of Italian Manufacturing Industry - An Empirical Analysis" by C. Antonelli - DSTI/SPR/82.61

"Competitiveness of the Productive System and International Specialisation" by J. Mistral - DSTI/SPR/83.31

"Technology and International Competitiveness: An Interpretation of the Relationship in the Machine-Tool Industry" by E. Sciberras and B. Payne - DSTI/SPR/84.2

"Domestic and National Competitiveness, International Technology Transfer, and Multinational Enterprises" by J.H. Dunning - DSTI/SPR/84.19

ANNEX 3

Papers presented at the 1981 Kiel Symposium on Emerging Technologies: Consequences for Economic Growth, Structural Change and Employment (1)

I. Innovation and the Process of Economic Growth

C. Freeman, "Innovation as an Engine of Economic Growth: Retrospect and Prospects"
Comment: H.T. Söderström

F. Chesnais "Schumpeterian Recovery and the Schumpeterian Perspective - Some Unsettled Issues and Alternative Interpretations"
Comment: R. Nelson

G. Eliasson "Electronics, Economic Growth and Employment - Revolution or Evolution?"
Comments: H. Markmann and R. Noll

II. International Dynamics of Innovation

K. Pavitt and L.G. Soete International Differences in Economic Growth and the International Location of Innovation"
Comments: E.J. Horn and J.P. Martin

R. Vernon "Technology's Effects on International Trade: A Look Ahead"
Comment: A. Michalet

G. Lorenz "The Diffusion of Emerging Technologies Among Industrial Countries"
Comment: K. Pavitt and L.G. Soete

M.J. Peck and W. Wilson "Innovation, Imitation and Comparative Advantage: The Performance of Japanese Color Television Set Producers in the U.S. Market"
Comment: H. Ergas

III. Exploring the Economic Impact of Emerging Technologies

J.M. Chevalier "New Energy Technologies: Their Impact on Energy Prices"
Comments : L. Hoffmann and H.K. Schneider

H.J. Rehm "The Economic Potential of Biotechnology"
Comment: W. Prewo

W.K. Scheuten "The Impact of New Electronics"

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(1) These papers were edited by H. Giersch and published by the Kiel Institute [Tübingen, Mohr 1982].

S. Nishiyama "The Impact of New Electronic Technologies: Direction, Channels, Speed"
Comment: F.D. Weiss

IV. Government Policy

H. Brooks "Towards an Efficient Public Technology Policy: Criteria and Evidence"
Comments: J. Rembser, G.M. White

R. Gilpin "Trade, Investment and Technology Policy"
Comment: E.M. Graham

B.G. Katz and A. Phillips "Government, Technological Opportunities and the Emergence of the Computer Industry"
Comment: H.J. Warnecke

V. Summing up

W.H. Branson "Innovation, Economic Growth and Employment - Summary and Appraisal"