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UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER
REVIEW OF EXISTING PROGRAMS

BACKGROUND PAPER FOR
IRIC PROGRAM

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UNIVERSITY-INDUSTRY TECHNOLOGY TRANSFER REVIEW OF EXISTING PROGRAMS

BACKGROUND PAPER FOR
IRIC PROGRAM

MOSST,
Forecasting Division,
June, 1978.

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I INTRODUCTION

This document is presented in connection with the recently-announced IRIC program, and provides background information on a number of programs and mechanisms which stimulate the transfer of technology between universities and industry. A broad range of approaches are reviewed for Canada as well as other countries.

Particular emphasis is focussed on the Canadian experience, including a discussion of Federal programs and mechanisms, provincial research institutes, university based research institutes and technological and scientific societies. The review of the United States experience is mainly concentrated on recent National Science Foundation Experiments. The last section of this report contains a brief description of various approaches to technology transfer in other selected countries.

II. CANADA

i) Federal Programs and Mechanisms

The Department of Industry, Trade and Commerce (IT&C) is the principle federal department responsible for the support of science and technology in industry. Of the numerous IT&C industrial support programs, three are designed, in part, to stimulate industrial research through university-based mechanisms. The National Research Council (NRC) is the major federal agency responsible for the funding support of university research. Analysis of the various NRC programs has revealed that three major activities are designed to stimulate technology transfer from the university to industry. More details on each of these IT&C and NRC programs are provided below.

Other federal programs which may indirectly stimulate the transfer of research from the university sector into industry through such indirect mechanisms as consulting or contract work are provided in Appendix I.

The Department of Industry, Trade and Commerce (IT&C)

Industrial Research Institute Program

Since 1967, IT&C has sponsored ten university-based Industrial Research Institutes with the following program objectives[1]:

- to encourage universities to provide scientific services and to conduct research and development projects for industrial firms unable to maintain adequate facilities and personnel of their own;
- to encourage universities to provide specialist services to larger companies wishing to enter new fields or to undertake special research projects which do not justify the acquisition of permanent staff;
- to help alleviate the shortage of scientific and technical resources existing in some areas of Canadian industry;
- to provide universities, through closer association with industry, the opportunity to coordinate more closely their educational and training programs with the current requirements of industry; and

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[1]More detail on each of these Institutes is shown in Appendix II.

- to foster greater interaction between industry and universities, and thus assist universities to gain a better appreciation of industrial problems and enable industry to become aware of pertinent scientific and technical work being undertaken in universities.

Federal assistance takes the form of grants to underwrite the administrative cost of operating an institute during its formative years when income from contracts is insufficient to meet start-up expenditures. Each institute is expected to become self-supporting within five to seven years.

By December of 1977, nine industrial institutes were operating; seven of which were self-supporting. The remaining two institutes, one located at the Université du Québec à Montréal and the other at the University of Manitoba are still receiving financial support as shown in table 1. This program will end when funding of these two institutes terminates in 1978.

The Waterloo Research Institute, the first institute to become self-supporting, has been a major success story and deserves special attention. From 1967 to 1973 this institute received a total grant of $244,557. As of 1975, it had completed its second year of self-supporting operation. For the year 1975, contracts exceeding one million dollars were obtained and the institute has now reported even greater success in obtaining higher dollar value contracts. This success is mainly attributed to increased client confidence. A greater amount of time and effort is now being devoted to the practical exploitation in industry of ideas and developments from within the university and it is hoped that successful completion will give rise to income from royalties.

The establishment of the Waterloo Industrial Research Institute has been instrumental in creating a stimulative industrial environment for fostering innovation and technology transfer. The university has developed an aggressive program to generate external funding through contract research where direct technology transfer from the university to the marketplace is actively encouraged. As well, Waterloo now administers a successful Inventors Assistance Program, the first of its kind in Canada.

The extent to which these institutes have met IT&Cs program objectives has yet to be determined. However, the fact that a majority of research institutes are operating on a self-supporting basis is one indication that they have been providing satisfactory R&D services to their industrial clients. As well, there are encouraging signs that their activities have been partially successful in bridging the gaps between industry and universities. For example, in 1974, seventy-seven faculty members and seventy-five students were involved in contract activity at McGill, while at Windsor, thirty-nine faculty members and thirty-seven students participated in the work of the institute.

Centres of Advanced Technology Program

This program was introduced in 1970. It was principally designed to encourage universities and others with research capabilities to establish centres of expertise in specific technologies.

The major objectives of this program are:

- to provide industrial assistance in basic and applied research;
- to provide industrial technical development assistance;
- to provide graduate and undergraduate training relevant to industrial needs; and
- to promote industrially relevant research by graduate students and universities.

These centres are expected to become self-supporting within a seven year period, at which time they are intended to continue to provide industry with the same services.

Ten Centres of Advanced Technology have been established by IT&C (five at the universities) and five with provincial research councils). These centres, established with grants of up to $175,000 per annum for three to seven year periods, are based on an existing technical capability of the patent organization which is thus upgraded and expanded to the point of being able to offer advanced advice and assistance to Canadian industry. Currently, IT&C is funding two centres, one at the University of Western Ontario and one at the University of Toronto. Funding for this program is expected to terminate in 1981. Restrictions on program funding have prohibited the establishment of any new centres although discussions concerning establishment of further centres have taken place.

Total grants authorized to March 31, 1977 amounted to $6,380,000. Appendix III and table 1 provide supplementary details on this program.

Management Advancement Program

The Management Advancement Program of IT&C has resulted in the establishment of two management advisory institutes. One institute is located at the University of Alberta, the other at Laval University. Each institute will receive a total grant of $50,000 per year (starting in 1978-79) for a three year period with the possibility of a further extension of up to two years, subject to evaluation (see table 1). It is anticipated by IT&C that these institutes will provide a good base for improving the weak university small business interface which presently exists.

National Research Council

Project Research Applicable in Industry (PRAI) Grants

In 1970 NRC developed Project Research Applicable in Industry (PRAI) Grants to university staff aimed at overcoming some university/industry difficulties in communication. This program provides short-term complementary support for those whose university research has already led to the identification of a specific and novel technique, process or product promising to be of commercial value to Canadian industry. Total NRC expenditures on this program amounted to $254,000 in 1977-78. Thirty-one grants were made in 1973 and numbers have steadily decreased until in 1977-78 there were only five grants. From preliminary discussions with NRC, it appears that lack of interest and participation by the universities rather than available money were the main causes for the steady decline in the number of grants awarded.

Industrial Post-Doctoral Fellowships (IPDFs)

The Industrial Post-Doctoral Fellowships (IPDF) Program of NRC was designed to encourage highly qualified students who have recently received, or who are about to receive their doctoral degrees, to seek careers with industrial organizations in Canada. Applications are accepted only when submitted by a company on behalf of a candidate. The number of IPDFs in 1977-78 was relatively small, totalling 133 awards. Expenditures amounted to about $1.2 million in that same year. NRC has stated willingness and capability to provide more awards, however, the number of participants is limited by the small number of proposals received from interested companies.

It should be noted that, for a limited period of time, University Post-Doctoral Fellows may also be eligible for Industrial Post-Doctoral Fellowship Grants to facilitate a transfer of researchers from the universities into industry in a situation where the job market for new academic positions is poor.

Senior Industrial Fellowships Program

The Senior Industrial Fellowships Program of the National Research Council is designed to encourage stimulating and productive interchange between the university and industry. The program is directed at staff members of Canadian universities who have little or no industrial experience and it is primarily aimed at those who have been on staff for ten years or less. Fellows may spend a minimum period of one year with industrial organizations in Canada or with certain quasi-industrial federal cooperatives and provincial utilities such as Hydro Quebec. The National Research Council provides a component of their salary as a supplement to the university's contribution to ensure that the Fellow receives a total amount equal to his normal salary. Payment of the NRC portion is made to the university. In 1977-78, six Senior Industrial Fellowships were awarded at a total cost to NRC of approximately $84,000 as shown in table 2.

TABLE 1

ESTIMATE OF 1978-79 GRANTS BY IT&C TO UNIVERSITIES FOR INDUSTRIAL RESEARCH

	Termination Date	Estimated Grants 1978-79
Industrial Research Institute		
Université du Québec à Montréal	1978	$ 60,000
University of Manitoba	1978	51,000
Sub-Total		111,000
Centres of Advanced Technology		
Systems Analysis, Control and Design Activity (Western University)	1978	175,000
Biomedical Instrumentation Development Unit (University of Toronto)	1981	175,000
Sub-Total		350,000
Management Advancement Program		
University of Alberta	1981	50,000
University of Laval	1981	50,000
Sub-Total		100,000
TOTAL		561,000

TABLE 2

ESTIMATE OF 1977-78 SUPPORT BY NRC TO UNIVERSITY-RELATED INDUSTRIAL RESEARCH

	SUPPORT (77-78)
Project Research Applicable in Industry Grants	254,000
Industrial Post-Doctoral Fellowships	1,200,000
Senior Industrial Fellowships	84,000
TOTAL	1,538,000

ii) Provincial Research Institutes

The provincial governments in eight of the provinces have established research institutes to provide technical support to provincial industries and to assist in the exploitation of provincial natural resources. The main activities of these institutes is research and development. Although these institutes accounted for only one percent of the estimated R&D in 1975, they play an important role in the transfer of technology from laboratories to production units and act as an interface between the scientific and business community.

Although none of these provincial research institutes are located at Canadian universities most are situated near the university campuses. As such, they have the potential to stimulate the transfer of research results from the universities to industry through mechanisms such as the joint use of university laboratory facilities, consulting and contracting.

NOVA SCOTIA RESEARCH FOUNDATION

The objective of this institute "is to assist in the economic development of Nova Scotia by promoting, stimulating and encouraging the effective utilization of science and technology by industry and government and for this purpose to undertake, either singly or in conjunction with others, such research, development, surveys, investigations and operations which in the opinion of the Board be deemed appropriate".

The institute is funded by a grant from the provincial government, contracts and invested income. The contracts are from both governments and industry. The government contracts are from the provincial government, federal government and foreign governments. The industrial contracts are from Nova Scotia, other Canadian industries and foreign industries. Total revenue for the institute showed an increase of 7.6 percent in 1976-77 over the previous year. Table 1 attached shows a detailed account of revenue.

In the year 1976-77 there was a total staff of 94 at the institute made up of a president, vice-president, 2 scientific consultants, 5 managers, 32 professionals, 37 technicians and 16 support staff.

The Corporation is divided into six divisions which include Geophysics, Engineering Physics, Centre for Ocean Technology, Chemistry, Industrial and Information Services, and Operations Research and Marketing.

Fields of research at the institution consisted of industrial research corrosion, pollution control, coal, heavy water processing, chemistry, analytical services, surveys, etc. Major facilities at the institute include an analytical laboratory, pilot plant and glass blowing facilities. The institute's main concern is R&D 50 percent, followed by service and consultation 30 percent, quality control and testing 15 percent and evaluations and surveying 5 percent.

NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL

The Council carries out research, problem-solving and consulting on a cost-recovery basis for clients both in Canada and abroad.

Funding of the institute is by government grants, contracts, etc. Total revenue for the Council showed a 14 percent increase over the previous year. Table 2 attached shows more detail on revenue for the years 1975-76 and 1976-77.

Fields of application at the institution were natural resources, primary industries, manufacturing industries, service industries, developing countries and the environment.

CENTRE DE RECHERCHE INDUSTRIELLE DU QUEBEC (CRIQ)

The main purpose of the Centre is to contribute to the economic development of Quebec by encouraging innovation in manufacturing enterprises and in particular to the small and medium-sized industries which are in need of research.

In the 1969 Charter, amended in 1970, the National Assembly made a five year subsidy of $20 million to CRIQ on a progressive scale ending in 1974-75. For the year 1975-76, the Centre had to use its own resources. The government approved a new five year subsidy of $30 million for the years 1976-77 to 1980-81. This further financial support will allow the Centre to carry out its basic task of encouraging Quebec's modernization of industry through the development of technological innovation in its enterprises. The Centre provided five types of projects in the electronics, mechanical and material research sectors, These projects were classified as exploratory work, internal projects, technical information, external drafts and external projects.

As of March 31, 1976, the Centre was staffed by 53 engineers and scientists, 16 specialists, 65 technicians and 51 others, a total of 185 employees.

THE ONTARIO RESEARCH FOUNDATION

Over the past ten years the Ontario Research Foundation has geared its services more closely to the needs of small industry whose problems are generally of short-term duration. Income from industrial sources increased by approximately 4.7 times over this same period. The institute has continued its trend of increasing industrial work in spite of a decline in industrial R&D in Canada.

In 1976 the Ontario Research Foundation examined many aspects of the energy question and to this end formed an interdisciplinary Energy Group. Concerning the environment, the institute involved itself in projects for the government, industry and consultants. Also, the institute served several companies in material technology. Every segment of the institute is engaged in technology transfer in transforming resources, materials and ideas into goods and services.

Funding of the institute is made up of government grants and contracts as well as income from industry and other miscellaneous sources (see Table 3).

SHERIDAN PARK

Another effort for industry/university interface is "Sheridan Park". This park located near Toronto was created and financed with the help of the Ontario Government and has succeeded in attracting numerous R&D laboratories. The purpose of this enterprise, although not fully achieved, is to reduce the overhead costs at R&D centres and to promote scientific exchange.

THE MANITOBA RESEARCH COUNCIL

The purpose of this Council is to stimulate and facilitate the effective application of technology in Manitoba and to advise the Minister of Industry, Trade and Commerce on matters relating to science and technology.

The Council is assisted by four technical committees which identify research projects, advise on applications for research projects, and monitor and evaluate research projects. The Council, apart from a small food processing laboratory, does not operate research laboratories. Research projects are carried out in cooperation with universities or manufacturers in the province.

During 1976 programs and projects of the Manitoba Research Council achieved results that should have a favourable economic impact on the province.

In 1976 the Council had a staff of 10 with expertise in different fields and with varying responsibilities.

THE SASKATCHEWAN RESEARCH COUNCIL

The research activities of this Council for the year 1976 were tailored to meet the following goals:

- to undertake studies on how to best utilize Saskatchewan's resources, with emphasis on agriculture and agricultural processing;
- to promote the industrialization of Saskatchewan, with emphasis on in-Province upgrading of the primary resources; and
- to undertake environmental studies that contribute to the above and also help preserve or improve Saskatchewan's environment.

Funding of the Council is by provincial grants, other grants, contracts and fees from industry. There was an increase of approximately 16 percent in total revenue over the previous year.

The institute is divided into several divisions namely: administration, chemistry, engineering, industrial services, physics and a management services division. Each division provides some service to be used by all divisions. These services include general shops, precision instrument lab, electronics lab, chemical and radiochemical analytical labs, tritium and carbon dating facility, cartographic and drafting units, photographic lab, library and information retrieval services. These facilities enable the multi-disciplinary scientific staff to undertake a wide range of both field and laboratory projects.

The main activities at the institute in 1976 were in the categories of agriculture and agricultural processing, resource and development, industrialization, environmental studies (particularly relating to Saskatchewan's energy resources) and services.

THE ALBERTA RESEARCH COUNCIL

The primary goal of the Council is to encourage the economic and social development of Alberta by research in needed areas and the provision of technical services and information to both industry and government.

Funding of the Council is largely by the Alberta Government but is also obtained from research contracts with Alberta industry and Federal Government grants and contracts. Unavailable, at this time, is the total revenue of the Council and the percentage of funds contributed by each of the above sectors.

The main activities of the Council are in the fields of engineering, physical sciences and earth sciences. Some work is also conducted in microbiology, economics and information sciences. Although not directly engaged in social science research, social goals form part of the planning process. The activities of the Council can be divided into five main areas, namely: industrial development, resource evaluation, primary industry, transportation and environmental studies. The Council makes every effort to balance short and long-term projects its view being that problems which arise are equally as important as those already in existence.

The Council had a total staff of 346 in 1976 made up of 152 professionals, 120 technical, 59 clerical and 15 temporary and part-time employees. This represents an increase in staff of 10 percent over the previous year.

THE BRITISH COLUMBIA RESEARCH COUNCIL

B.C. Research is the technical operation of a non-profit independent society, the British Columbia Research Council. The institute provides R&D services to industry, business, and various government departments.

The institute is funded by a B.C. government grant, industrial contracts, other government contracts, royalties and other miscellaneous funds (see Table 5 for further details). The annual grant by the B.C. government allows for high-risk technological research. The high failure rate of this type of research is too risky for private funds. The grant also allows the institute to provide a free technical information service.

Activities at the institute consist of research, development and other technical work under contract and offers services in the fields of applied biology and chemistry, engineering physics, economics, market research, operations research, industrial engineering, management training, technical information and ocean engineering. The contracting system of the institute allows small companies use, on an interim basis, of technical expertise for new or improved technology and enables larger companies to supplement their own research and technological facilities.

As of 1974 the B.C. Research Institute had a permanent staff of over 150 persons.

TABLE 1

SOURCE OF REVENUE NOVA SCOTIA RESEARCH FOUNDATION

	1976-77 $	1976-77 %	1975-76 $	1975-76 %
Grant - Province of N.S.	750,000	33	770,000	35
Contracts	1,423,737	63	1,322,565	61
Investment Income	91,618	4	91,629	4
Total Revenue	2,265,355	100	2,184,194	100
Industrial Contracts	925,429	65	740,636	56
Government Contracts	498,308	35	581,929	44
Total Revenue	1,423,737	100	1,322,565	100
Industrial Contracts				
Nova Scotia	185,085	20	171,933	23
Other Canadian	640,682	69	502,575	68
Foreign	99,662	11	66,128	9
Total Industrial Contracts	925,429	100	740,636	100
Government Contracts				
Provincial	128,136	26	211,620	36
Federal	370,172	74	357,093	62
Foreign	---	---	13,226	2
Total Government Operations	498,308	100	581,939	100

SOURCE: Nova Scotia Research Foundation, Annual Report, 1976-77

TABLE 2

NEW BRUNSWICK RESEARCH AND PRODUCTIVITY COUNCIL

REVENUE		1976		1977
Province of New Brunswick Grant	$	600,000	$	600,000
Contract and Income		1,026,610		1,395,622
Total Revenue		1,626,610		1,995,622
% Increase over Previous Year		14.0		13.6
SOURCE OF FUNDS				
Canadian Industry	%	32	%	23
Canadian Government		36		37
Canadian Provincial Government		32		40
Total		100		100

SOURCE: New Brunswick Research and Productivity Council, Fifteenth Annual Report, 1976-77

TABLE 3

THE ONTARIO RESEARCH FOUNDATION

SOURCE OF REVENUE	1976 $	%
Ontario Government Grant	2,854,000	31
Ontario and Federal Government Contracts	1,331,000	15
Canadina Industry	4,758,000	52
Other Income	229,000	2
Total Revenue	9,172,000	100

SOURCE: Ontario Research Foundation, 1976 Annual Report

TABLE 4

SASKATCHEWAN RESEARCH COUNCIL

(for the years ending March 31, 1976 and 1977)

SOURCE OF REVENUE	31/3/76		31/3/77	
Province of Saskatchewan	$	%	$	%
- grants	2,100,000	56.9	2,281,400	53.5
- other grants, contracts fees from industry	1,475,550	40.0	1,889,430	44.3
- other income	25,996	0.7	33,413	0.8
- research grants	88,275	2.4	58,304	1.4
TOTAL	3,689,821	100.0	4,262,547	100.0

SOURCE: Saskatchewan Research Council, 31st Annual Report, 1977

TABLE 5

THE B.C. RESEARCH INSTITUTE

SOURCE OF REVENUE	December 31, 1976 $	%
Contract Research	3,241,738	86.3
B.C. Government Research Grant	320,000	8.5
Other Income	195,945	5.2
Total Revenue	3,757,683	100.0

SOURCE: The B.C. Research Institute, Annual Report, 1976

iii) University-Based Research Institutes

As of 1976, there were an estimated 234 university-based research institutes (including the university-based centres supported by IT&C). Quebec had the highest percentage (44 percent), followed by Ontario (26 percent), the West (19 percent) and the Atlantic Region (11 percent).

These centres carry out a large variety of activities, including functions such as research on economic development, language and communication, oceanographic and marine studies, and Canadian ethnic and regional studies. The majority of research institutes concern themselves with medical research (15 percent), foreign studies (6 percent), education (5 percent), and northern development (4 percent).

Most Research Centres in the Western Provinces are concerned with northern development, followed by agriculture, water, natural resources, medicine and space. In Ontario the highest concentration of the centres is in health fields, followed by industry, computing and other service fields. Quebec Institutes have their highest concentration in health fields, followed by education and foreign studies. The Atlantic Region, with the smallest number of institutes, has a concentration in community services followed by health and foreign studies (see table 1).

Although these numerous university-based research institutes have the potential to transfer technology from the university to industry, the extent to which this process occurs cannot be assessed. A limited amount of information exists concerning factors such as the number of research personnel, the size of the budget and program objectives. For example, MOSST was able to obtain only 29 annual reports from the 234 institutes and many of these reports did not cover the same period of time. However, it is not unreasonable to assume that a large number of institutes are rather small, with very limited resources. Centres such as the Institute for Materials Research (with a staff of 41 professionals, 1977), and the Pulp and Paper Research Institute of Canada, are the exception rather than the norm.

TABLE 1

RESEARCH CENTRES ASSOCIATED WITH CANADIAN UNIVERSITIES

PURPOSE	ACTIVITY	WESTERN	ONTARIO	QUEBEC	ATLANTIC	TOTAL
Economic Development	Economic	-	2	2	-	4
Urban Development	Urban	-	2	2	1	5
Northern Development	Northern	5	-	4	-	9
Developing Countries	Developing	-	-	1	-	1
Foreign Studies	Foreign	1	4	6	3	14
International Relations	International	1	2	-	-	3
Public Admin.	Public	-	2	1	1	4
Industrial Relations & Mgt.	Management	1	2	2	-	5
Language & Communication	Language	-	2	3	1	6
Education	Education	1	3	7	1	12
Behaviour & Mental Retardation	Behaviour	2	1	2	-	5
Community Service	Community	2	-	1	5	8
Cdn. Ethnic & Regional Studies	Regional	1	1	1	2	5
Culture, Sport & Recreation	Culture	-	1	5	-	6
Law	Law	2	1	5	-	8
Historical Studies	History	1	3	2	-	6
Administrative or Organizational Service	Organization	-	3	-	2	5
Agriculture	Agriculture	4	-	2	-	6
Forestry	Forestry	1	-	3	1	5
Oceanographic and Marine Fisheries	Ocean	1	-	4	2	7
Water Resources and Inland Fisheries	Water	3	-	4	-	7
Energy	Energy	1	-	1	-	2
Mineral Location and Extraction	Mineral	1	2	2	-	5
Other unspecified Natural Resources	Natural	3	1	-	-	4
Mfg. and Other Industry	Industry	1	7	2	1	11
Transportation and Telecommumications	Transtel	2	6	3	-	11
Environmental Studies and Pollution	Environment	2	3	5	1	11
Medicine, Hygiene & Nutrition	Medicine	3	7	24	4	38
Computing and Other Services	Computing	-	3	2	-	5
Space	Space	3	4	-	-	7
Other	Other	6	7	14	3	30
TOTAL		48	69	110	28	255

NOTE: There are about 255 centres, some centres may be counted more than once, due to the multiplicity of functions performed.

SOURCE: Statistics Canada, Univeristies and Colleges of Canada, Cat. No. 81-230, Annual, 1976 and Department of Industry, Trade and Commerce, Office of Science and Technology Annual Reports

iv) National Engineering and Scientific Societies

Another mechanism which aids in the transfer of technology between universities and industry is Canada's many scientific and technical societies.

At the national level there are approximately 125 societies while at the provincial, regional, and local levels there are well over 250. Membership in these organizations is wide ranging. For example, the Canadian Thoracic Society has a membership of only 54 while the Canadian Nurses Association membership numbers over 87,000.

The aims and objectives of these associations include:

- exchanging knowledge;
- providing advice on pertinent legislative matters;
- promoting a knowledge of the profession to the public;
- cooperating with other societies in matters of mutual interest;
- promoting science in the interest of society
- publishing journals;
- providing information to the public
- acting as a national voice.

This list is not exhaustive but indicates the potential of scientific and technological societies to contribute to technology transfer.

Members are employed in all sectors of the economy and the numerous meeting-point mechanisms such as national and regional conferences, and symposiums serve to stimulate the transfer of research results between these sectors. In addition, many societies have a large component of industrial members who contribute to technology transfer from the university through student awards, scholarships and bursaries. For example, the Canadian Institute of Mining and Metallurgy (CIMM), whose membership is chiefly from industry, awards prizes, trophies, and plaques to over fifty students each year.

III. UNITED STATES

In the United States, the links between universities and industry appear to have weakened in the two decades following World War II, approaching their nadir in the early seventies. The reasons for this are complex, but three principal factors have been isolated. First, the rapid growth of federal funds for academic research gave universities less incentive to maintain or increase their ties with industrial firms. Second, during the post-war growth phase of the university sector, new PhD's chose academia over industry. As well, professors tended to train their best students for careers in academic research. Third, industry reduced its role in basic research in favour of applied research, making working relationships with universities more difficult[1].

Since the early seventies, efforts have been made to improve university/industry relationships through a number of experimental programs. These included

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[1] For a more detailed discussion see: Bruce L.R. Smith and Joseph J. Kennedy, The State of Academic Science, the Universities in the Nations Research Effort, (New York: Change Magazine Press, 1977), pp. 51 - 78.

direct corporate funding of university research projects; cooperative research program; university/ industry research consortia; joint industry/ university laboratories; technology licensing and technological brokers; development of university extension services; university industrial associates; industrial parks; university business development centres; and the innovation centres. Examples of these mechanisms are provided in Appendix IV.

The most successful programs have been the Innovation Centres Experiment and the Cooperative Research Centres Experiment sponsored by the National Science Foundation[2]. Both initiatives have resulted in a significant increase in non-federal R&D investment and the direct application of university R&D results.

Innovation Centres Experiment

Commencing in 1973, Innovation Centres were introduced as vehicles within universities for stimulating technological innovation and for increasing the

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[2]These experiments were two of several initiatives sponsored under the Experimental R&D Incentives (RDI) program of the NSF which began in 1973. Other experiments included: Federal Laboratory Validation; Federal Specification and Testing; Federal R&D Applications; and R&D Linkages to State Government.

entrepreneurial inclinations of graduates as they pursued their careers. Using university business and engineering skills for training entrepreneurs and inventors, the centres were designed to evaluate ideas, technology and R&D results, develop new products and services, provide assistance to inventors, and establish new business ventures.

At present, there are four centres, located at the Massachusetts Institute of Technology (MIT), Carnegie-Mellon University (CMU), the University of Oregon, and the University of Utah. Each of the innovation centres has as a common objective the demonstration that university-based activities can stimulate innovation and entrepreneurship in the external business community.

In pursuing their common objective to stimulate innovation and entrepreneurship, the activities of these centres are geared to[3]:

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[3] See R.M. Burger, "An Analysis of the National Science Foundations, Innovation Centres Experiment", Research Triangle Institute, 1977.

- idea/invention evaluation;
- assistance for new business start-ups;
- development of new products for existing businesses;
- development of innovation/entrepreneurship education curricula; and
- research on the innovation/entrepreneurship processes.

In practice, each centre has a slightly different emphasis which gives it particular individuality[4]:

- At MIT, the focus is on a learn-by-doing research wherein ideas are generated and developed into new products or services that can be licensed to an existing company or become the basis of a new venture;
- at CMU, the focus is on new venture initiation and support to the stage where the business can qualify for venture capital assistance; and
- at Oregon, the focus is on idea or invention evaluation and upon transfer of technology from the independent to the entrepreneurial and corporate sectors.

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[4] No discussion in this report will be devoted to the Utah Innovation Centre since little documentation exists given that it was only recently established.

Each centre offers courses in entrepreneurship and innovation, exposes students to the entrepreneurial process and actively promotes innovation as an integral part of the academic regimen. The educational curricula of each centre varies in accordance with its special interests as well as its institutional setting[5]. The MIT Innovation Centre is based in the engineering school. Its aim is to provide an education and training in which various disciplines are linked to enhance the entrepreneurial ability of participating students. Direct involvement by students in innovation and risk-taking is actively encouraged. Typical courses offered include Introduction to Innovation, Invention, Entrepreneurship, Invention Development Laboratory, and Internship in New Enterprise Development. In contrast, the Oregon Innovation Centre concentrates upon invention evaluation. Its academic and educational programs are located in the College of Business Administration; most courses relate to the invention evaluation process

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[5] See, for example, R.M. Burger, "RANN Utilization Experience, Report to the National Science Foundation", Case Study No. 33, Research Triangle Institute.

which includes examination of factors such as, business risk, demand analysis, environmental impact and investment costs. More details on each of these institutes is contained in Appendix V.

In addition to educational activity, the centres have also provided facilities for the evaluation of ideas and inventions. In this they have been very successful. In the first year of operation, alone more than 500 ideas were brought to the centres. Although, only a few of these ideas were recommended for continued development, discussions with submitters of these ideas established that they were very satisfied with the services offered. Because of the evident need for such evaluation, and the apparently inadequate service provided by commercial firms, this aspect of the centres' work has received considerable public attention.

Although long-term results are not yet available, it is difficult to avoid the conclusion that thus far, this experiment has been a demonstrable success (see tables 1 and 2[6]. Each of the centres has established a supportive constituency; at Oregon, the independent inventor, at Carnegie-Mellon, the local business community, and at MIT, the university and participating industries[7]. All centres are attracting the attention of government mission agencies for their ability to respond to specific needs.

Participating students have shown considerable enthusiasm and satisfaction. The number of students enrolled expanded from 400 to 700 and the total number of courses offered by all centres increased from 14 to 30 in the first few years of operation.

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[6] The NSF is in the process of evaluating the long-term results. For example, prior to and after leaving the centres, each potential entrepreneur/innovator is surveyed/interviewed by the NSF. The results are being evaluated against those obtained from a comparison group which is also being surveyed for an equivalent period. These longer-term results will not be known for some time. See, Robert M. Colton and Gerald G. Udell, Ibid., pp. 11-12.

[7] See, R.M. Burger, Ibid., p. 26; and Robert M. Colton and Gerald G. Udell, "The National Science Foundation Innovation Centres: An Experiment in Training Potential Entrepreneurs and Innovators", Journal of Small Business Management, (April 1976).

According to the centres' directors, this trend is expected to continue. Furthermore, similar trends have also been reflected in the university community external to the NSF experiment. Upward of 80 schools in the United States now offer courses in entrepreneurship education as compared to only 10 a decade ago[8]. The effects are also spreading to the Small Business Administration where university-based small business centres are being developed for encouraging entrepreneurship.

In the short period of time since the program began the Centres have also been successful in stimulating the transfer of technological entrepreneurs from university to industry. For example, within the first 2½ years of operation 54 entrepreneurs had already moved out of the Centres into the economy[9]. It has also been reported by the NSF that students from the Centres become involved in entrepreneurial and innovative activity, approximately 3 years after graduation rather than the normal 8 to 10 years[10].

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[8] K.H. Vesper, Entrepreneurship Education - A Bicentennial Compendium, Society for Entrepreneurship Research and Application, Milwaukee, Wiscousin 1976 (sponsored by National Science Foundation).

[9] Robert M. Colton and Gerald G. Udell, Ibid. p. V-18.

[10] The Department of Industry, Trade and Commerce highlighted this aspect in the documentation of their recent site visits to the U.S. Innovation Centres.

This is further supported by a recent study of Oregon graduates which indicated that this Centre has been a significant factor in the number of entrepreneurs entering the economy[11]. From an economic standpoint, the centres are also demonstrating successful results. By the end of 1976, 23 active businesses were initiated or assisted by the innovation centres. Total sales (1975), and backlog (1976), of these businesses was in excess of $30 million. Direct taxes alone (estimated at $16 million) from these ventures already exceeds the total five-year cost to NSF. At Carnegie-Mellon, the centre director estimates that eight dollars in taxes have been created through new ventures for every tax dollar spent by the institute.

During the early stages of the centres development minor start-up problems were evidenced. The three major causes of these difficulties were:

1. A unique staff is required to deal with the large variety of inventors, students, consultants, and ideas coming to the centre. The atmosphere of

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[11] Gerald G. Udell, et al, "A Breeding Ground for Entrepreneurs and Innovators", a working paper in "Experiments in Invention and Innovation", University of Oregon, January 1976.

such an operation is charged with the pressures attendant to heavy work loads, high risks and opportunities. Finding staff members capable of working in this situation has been a challenge.

2. With the increased volume of inventors seeking the services of the centre, developing procedure has been a difficult problem. At this point, routines for handling inventions have largely been developed, but some matters still require further resolution.

3. Potential conflicts of interest have caused some preliminary problems. Ideas have come to the centre from university and centre staff members. Previous associates of centre personnel have negotiated for invention rights. These conflict-of interest possibilities are being removed through new centre policies prohibiting any past, present, or possible future financial involvement by centre personnel in any invention processed through the centre.

Despite these minor start-up problems, each centre in its own way has been demonstrating an encouraging efficacy in the academic environment. The most important factors contributing to this success are[12]:

1. A well defined experiment duration;
2. an initial commitment to full and sufficient funding of the program;
3. a multi-objective structure which permits program flexibility;
4. experienced and reputable centre directors;
5. early demonstrated success which has been instrumental in attracting a strong core of innovative expertise;
6. liberal patent policies established by the institutes.

The relative importance of these factors has been further documented in a recent NSF report[13]:

> The success (of the innovation centres) in no small measure stems from the fact that the experiment is funded at an adequate level and for an adequate duration; but other essential ingredients -- management flexibility, dedicated Centre Directors, competent participants, an enlightened patent policy, and early demonstrations of success -- have also been important.

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[12] A more detailed elaboration of these and other factors influencing the utilization of the Innovation Centres Experiment is contained in Appendix VI.

[13] R.M. Burger, Case Study No. 33, Ibid., pg. 33-34.

The conclusions of an independent review of the NSF Innovation Centre Experiment provide a useful synopsis of its relative success[14]:

> The centres seem to have gone well beyond their primary educational objective. Venture capital is being attracted to centre projects: ventures are being started; results of centre sponsored or conducted research is beginning to appear in the literature; new channels for transferring technology from the independent to the corporate sector are being developed; an increasing number of small businesses are seeking new products, business development and managerial assistance from the centres. A surprising number of large corporations have expressed an interest in the centres as a source of new products and insight into the innovation process; and an increasing number of universities and colleges have expressed an interest in this method of bridging the gap between classroom theory and the reality of the business world.

Cooperative Research Centre Experiment (CRCE)

This experiment was established in 1973 under NSFs Experimental R&D Incentives Program. At present, the NSF sponsors programs at three universities: Carnegie-Mellon University, North Carolina State University and MIT. This experiment is similar

[14] Robert M. Colton and Gerald G. Udell, Ibid., p. V-22.

to the Industrial Research Association Program of IT&C in Canada, in that the centres are designed to support R&D dealing with technological activities common to a specific industry and to be self-supporting within a specified period of time. It differs from the Canadian program in that the centres are located at universities with the further benefit of encouraging graduate students to work in problem-oriented research directly relevant to industrial needs. For example, the Processing Research Institute (PRI) at Carnegie-Mellon was funded by NSF mainly to develop a Master of Engineering program oriented towards the processing industries.

Unlike the NSFs Innovation Centres Experiment, a complete review of the CRCE has not yet been undertaken. However, the following more detailed discussion of the MIT Program (where some recent documentation exists) supplemented by recent discussions with the NSF should prove informative.

The Industry Polymer Processing Program at MIT was established with the purpose of identifying and testing federal incentives for improving technological innovation and transfer for public benefit. Although one of the principal goals of the program was to "recommend alterations in public policy which would result in increased R&D investments and efforts by small firms", the five initial industrial participants were large corporations with annual sales ranging from $40 million to over $10 billion.

The program began with a $100,000 grant from NSF in 1973 and by the 1977 fiscal year a total of $874,000 had been expended on the program ($446,000 by industry and $428,000 by the NSF). NSFs financial support is expected to terminate in the 1978 fiscal year. It is unknown whether the program can become self-supporting by that time.

As of 1976, the program was staffed by about 20 faculty, staff and student researchers. Eighteen projects had been initiated, of which 6 to 10 had been active at any given time.

One of the important by-products of the centre has been the development of student researchers. Particularly important is the experience gained from having to describe a research plan, the applicable theories, the work accomplished and implications of the results. From this experience, students are industry-ready and in demand on the job market.

There is some reason to believe that MIT has been reasonably successful in undertaking this program. "A great deal of informal interaction exists between the program staff and industrial members ... and a high degree of satisfaction with the program is indicated by member firms". The major reasons for this success are:

1. Before the program was instituted there was already some significant institutional or personal

contacts in existence. All companies who did join mentioned some form of previous connection. For example, most of the companies were associated with MITs industrial liaison program and had at least one MIT graduate among the two or three people who made the decision to join.

2. The establishment of a program organization which encourages and promotes interaction between the program staff, students, and industrial members. For example, a primary structural mechanism is the Industrial Advisory Committee. This group meets four times a year. In addition to developing rules on such commercial matters as patents and licensing, it provides a forum for an exchange of informal views and a mechanism for open and honest discussion. As a result, this rather unusual working group has developed considerable trust and ease of interaction. As well, students are given exposure to the whole R&D process (through the Bimonthly Meetings) which increases their perspective and prepares them for industry employment.

3. The entrepreneurial, innovative and administrative abilities of the program director have been crucial since the initiation of the experiment. For example, one of the industrial members said that while they were considering joining they received problem-solving help from the director which provided a concrete example of what might be expected.
4. The existence of an established industrial base where a few large firms control the industry market has been an unexpected but necessary criterion.

The MIT initiative represents a positive effort to use federal funds to reorient university research towards industrial interests. However, this is only one of the three CRCE university-based institutes. Final judgement as the usefulness of this type of cooperative approach will have to await a complete review of the other two experimental centres.

TABLE 1

SOME FACTS ON INNOVATION CENTRE PERFORMANCE

	1974	1975	1976 (EST.)
1) Students	400	565	700
2) Courses	15	25	30
3) Faculty	44	53	53
4) Professional	43	46	46
5) Ideas evaluated	542	625	650
6) Projects Initiated	37	55	60
7) New Products Developed	6	16	20
8) New Ventures Initiated	7	12	12
9) New Venture Employees (Entr.)	109 (21)	206** (33)	250** (40)
10) Private Venture Capital Invested in New Ventures	280,000	464,800	750,000
11) New Venture Sales	740,000	2,700,000	30,000,000
12) NSF Funding	670,000	715,000	845,000
13) Estimated Federal Taxes from 9 - 11	250,000	600,000	2,000,000
14) Estimated Federal Taxes from Distribution of Wages Under 9 (Multiplier Effect)	750,000	1,800,000	6,000,000
15) ROI***(Not Counting Return from Direct Expenditure of 12)	1.1	2.6	9.3

MIT — ** Does not include 400 employees at sub-contractor plants

CMU

ORE — *** ROI equals line 14 divided by line 12

SOURCE: National Science Foundation

TABLE 2

ACTIVE BUSINESSES INITIATED OR ASSISTED BY INNOVATION CENTERS

BUSINESS	PRODUCT	1976 SALES	1976 ORDER BACKLOG
Kemtech, Inc. (Executive Games)	TV Games	$5,000,000	$ 5,000,000
Transcomm Data Systems Corp.	Timesharing Computers	2,000,000	
Compu-Guard	Security Devices	1,000,000	10,000,000
Fisher Stoves, Inc.	Wood Burning Stove	400,000	1,000,000
Peoples Cab Co.	Transportation	250,000	
ECD Corp.	Capacitance Meter	200,000	1,500,000
Three Rivers Computer Co.	Computer Hardware	175,000	
Sun Publications, Inc.	Newspapers	135,000	
Transportation Concepts, Inc.	Three Wheel Car	117,000	2,000,000
Myers Motors, Inc.	Automobile	69,000	
Computer Controls Corp.	Control Systems for HVAC	50,000	
Peoples Travel, Inc.	Transportation Broker	50,000	
Rehabilitation Equipment, Inc.	Prosthetics Sales and Service	30,000	
MBA Consultants	Business Services	20,000	
Klein Corp.	Bicycle Framesets	15,000	
Richards Frames	Wood Picture Frame	12,000	
Wrench Knives, Inc.	Knives	12,000	
Royal Industries	Nite Trainer	10,000	
Redi-Grill	Wine Rack	10,000	
Vectran Corp.	Remote Control Devices	10,000	
Graphic Forms, Inc.	Wood Printing	2,000	
SICO	Folding Table	--	50,000
Health Spa, Inc.		--	250,000
TOTAL		$9,567,000	$19,800,000

SOURCE: R.M. Burger, Ibid., p. 19.

IV. OTHER COUNTRIES

In this section, a brief summary of some of the mechanisms for technology transfer is provided for a selected number of other countries; namely, France; Great Britain; Germany; Sweden; Switzerland; Norway and the Netherlands; and Japan.

a) France

Although several mechanisms for industry/university technology transfer exist in France, only two of major importance are noted here. First, the government encourages university and industry to submit joint proposals for research support by paying fifty percent of the industrial share of the project and one hundred percent of the university share. Second, when a majority of firms in a sector insist, the government will mandate the creation of an industrial research centre and a para fiscal tax is placed on all firms to support this centre. For example, the French centre for the study of plastic materials, which is similar to the MIT Polymer Processing Program of the United States, had a budget in 1972 of three million francs and employed forty-two people, including fifteen professionals. Although formally separate facilities are located at the Ecole National Supérieure des Arts-et-Métiers (ENSAM), the director of this program is a professor and three faculty members are active participants.

b) Great Britain

Many mechanisms for university/industry technology transfer exist in Britain. For example, numerous British universities have a formal policy to promote industrial consultation by staff members. The industrial liaison officers at some universities and many technology institutes, with the help of the Department of Trade and Industry (formerly the Ministry of Technology) have the function of promoting industry/university links in every possible way. Other types of liaison exist at many universities. For example, the industrial innovation centre at Strathclyde University carries out work for industry and keeps in continuous contact with 650 staff members in order to direct industry to the right scientists. This centre, being relatively new, has not as yet achieved full success.

Not unlike Canada, Great Britain has a policy of supporting research associations. Although this provides a potential for stimulating university/ industry technology transfer the extent of this interchange is limited since the associations are not located at the universities.

c) Germany

The tradition here, of appointing industrial scientists to university posts, would appear to be one of the main reasons why German universities are more industry oriented than either the French or British. These appointments form the bridge for technology transfer from university to industry by allowing these teachers direct contact with students thus enabling them to help industry find the right graduates. A secondary, but important, offshoot of this integrated approach is the fact that all chemistry teachers receive, at regular intervals, a sum of money from a fund financed by the chemical industry which they are expected to spend on research.

Another mechanism for stimulating industry/university technology transfer is known as the "teachersparty", whereby all newly appointed chemistry teachers are invited to industrial headquarters for a period, extending from three to four weeks. Here they are entertained, informed of company research being carried out and queried about their past and future plans. Other industries use similar mechanisms but not to the same extent as the chemical industry. The importance of this interaction should not be underestimated since this has proved to be a key mechanism responsible for the success of MIT's Polymer Processing Program.

d) Sweden, Switzerland, Norway and the Netherlands

The major thrust in Holland is the encouragement of industrial scientists to teach at the universities. This direct approach was developed in Holland but exists also in Germany, Belgium, Switzerland and Sweden.

Dutch senior researchers from every large industrial laboratory and many small companies spend approximately fifteen percent of their working time teaching at the university. This is done in full agreement with their companies who know that it is to the ultimate interest of industry to contribute to the universities. This institutional flexibility in higher education is rare elsewhere and is a modern expression of an old tradition for survival. Today one quarter of all Dutch university professors in science and technology are active industrial researchers, having found this to be one of the most important mechanisms for stimulating technology transfer.

Research in the technical universities of these small countries seems to have played a major role in increasing university/industry links. Unlike the elite schools in France and Britain (for example), the Ecole Polytechnique in Paris and Imperial College in London) these technical universities are geared directly to industrial research needs. Here there is close association between industrial research institutes and technical universities as the bulk of research in these universities is of direct interest to national industry. As a result, the universities train students for industry not only through their curriculum but also by giving them industrial attitudes and motivations. This concentration on industrial research needs is reflected in the policy of institutes which require new students to work approximately six months in industry prior to enrolment. Also, for teaching appointments, industrial experience is a definite asset and in some cases even a requirement.

Some institutional mechanisms created by governments of these countries towards support of industrial research are:

1- NETHERLANDS-TNO (Central Organization for applied research);

2- NORWAY-NTNF (Norwegian Council for scientific and industrial research; and

3- SWEDEN-STU (Swedish Board for Technical Development).

These government institutes are major clearing houses of industry and university knowledge and are important links for technology transfer. In all countries, these bodies which draw both sides together prove to be a very valuable mechanism for university/industry links.

Japan[1]

The most important and distinctive aspect of Japan's Science and Technology Policy is a well-defined consensus on an industrial or economic goal. This has resulted in clear guidelines in the development of criteria for technological innovation and the R&D process. Science and Technology is thus considered a tool for achieving a specified national goal.

The approach is pragmatic and directed - a goal is established, and when required, technology is imported and adapted through domestic R&D.

The universities and their research institutes, numbering well over 100, provide the major source for absorbing and integrating the transferred core technology into the total system of industrial production. A large proportion of university research activity is of the "basic" nature. However, this research is primarily directed towards satisfying the economic and social needs of the country. Thus, when foreign technology is imported, the university community has a base of potential expertise capable of adapting and improving this technology to suit domestic needs.

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[1] For a more detailed discussion, see "Japan's Economic Growth and her Science and Technology Policy"; Lecture given by Professor K. Oshima in Brussels on December 9, 1975, at a conference organized jointly by the Japanese Embassy in Belgium and by l'Office Japonais d'Etudes Economiques. This paper drew heavily from Professor Oshima's report. The other major source documents for this report were: Guide to World Science, Vol. 17 Japan, 2nd Edition, 1976; "Procedures of Distribution of Federal Funds for Science in Japan", Dr. M. Yoshiki, American Association for the Advancement of Science, 140th Meeting; and National Research and Development Program, (Background Information), Ministry of International Trade and Industry, Japan, 1975.

A more detailed discussion of Japan's approach follows.

In the 30 years since World War II, Japan has made remarkable success of reconstructing her industry and has achieved a high economic growth virtually unequalled by any other industrialized nation. Science and Technology policies have played a crucial contributory role in this development, the importance of which is reflected by the active involvement of the Prime Minister. For example, the two major contributors to science policy are the Science and Technology Agency (STA) and the Science Council of Japan, both of which are affiliated to the Office of the Prime Minister. As well, numerous other advisory organizations such as the Council for Science and Technology and Commissions such as the Atomic Energy Commission, report to the Prime Minister's Office.

The promotion of science is a significant part of Japan's Science Policy. The Minister of Science and Technology usually has two press conferences a week. As well, the STA provides lectures and films to many exhibitions and seminars, organizes conferences the aim of which is to improve communications between scientists and Governments, is responsible for a radio series "Science for Tomorrow" and special televised presentations.

There is also a "Science and Technology Week" annually involving schools, research institutes, government and industry. During this special week there are lecturers, films, exhibitions, open days and award-giving ceremonies honouring those who make conspicuous advances in science and technology fields.

Historically, the Japanese Government has considered science and technology as a tool or a means for achieving a well-defined national goal. The main features of this policy have been referred to as "absorptive". Core technology has been transferred from abroad in most cases; and local R&D has been essential in absorbing and intepreting the transferred core technology into the Japanese system of industrial production. Government policies have encouraged enterprises to take a progressive attitude toward introduction of advanced foreign technology and have promoted efforts for domestic R&D to bring this technology into commercialization rapidly. A few following examples will help clarify this philosophy.

During the second phase of Japan's industrial recovery, which was developed in the early 1950s, a national goal was to "strengthen Japan's competitive capacity in international trade", by transferring its industrial structure towards the heavy and chemical industries. The definition of "heavy and chemical industries" was somewhat arbitrary but it consisted of machinery, electronic machinery, metals, chemicals and included, in the later period, electronics. Researchers took the attitude that the government should encourage development of indigenous technology by protectionist policies. Industrialists insisted that there was immediate need to be competitive and that government policy should encourage the importation of advanced technology. On the whole, industry views pervailed and except for a few sectors most of the new technologies were imported. However, in giving approval for the import of technology, the Government gave priority to groups already developing technology on their own.

Japan is now in the third phase of its industrial policy, which is oriented to place more emphasis on knowledge-intensive industries. Japan has made it a national goal to gain dominance of the world's computer and electronics markets. They have thus established a $250 million joint government/industry Very Large Scale Integration (VLSI) program whose stated aim is to develop all the necessary highly advanced processes, manufacturing techniques, and components to reach this goal by the end of 1980. As a result, Japanese businessmen are agressively gathering information in the centre of the U.S. electronics industry. Samples of innovative tools and instruments are bought and sent back to Japan for further improvements through domestic R&D.

This unique feature of the Japanese R&D policy has resulted in a relatively high proportion of R&D expenditure being funded by industry. In 1973, R&D expenditures funded by industry were 66%. Figures for other countries were, 29% for Canada, 39.3% for the United States, 35.8% for France, 54.9% for West Germany, and 42.7% for the U.K. in 1971.

A second notable characteristic of Japan's R&D is the high proportion of support to basic research (23% of total R&D expenditures), most of which is performed by the universities. Even in industry, however, expenditures classified as basic research are relatively larger than they are in other countries (97% of its 1970 R&D expenditures, compared with 3% to 5% for Western countries).

The role of the universities in Japan is to improve the scientific and technological base through teaching, research training and basic research: "Basic research activities have been mainly to supply a scientific and technological soil of high standard to cultivate active technological innovations through transfer of technology from abroad". In essence, little effort by the universities is devoted to originating new technological development. This is evidenced by the contribution of universities to Japan's total basic research activities. Some 65% of the expenditures for basic research is spent by the universities. However, it should be noted that the strong influence of Japan's economic objectives is represented by the high proportion of basic research in the engineering field (42%), and the proportionately high number of engineering students (14%) which compares to 8% (1974-75) for Canada. In summary, the major research responsibility of the universities is to perform basic research of an applied nature; and thus, the extent of cooperative research between industry and universities in Japan is minor although industry does employ the services of universities from time to time.

V. OTHER FEDERAL PROGRAMS THAT INDIRECTLY STIMULATE TECHNOLOGY TRANSFER

Industrial Research Association Program (IT&C). This program was introduced to encourage industrial sectors to aid in support of establishing and maintaining R&D facilities dealing with technological activities common to industry. To date, their have been three associations, two of which are still being funded (see Appendix VII). Assistance for this program is similar to that of the Centres of Advanced Technology Program.

Enterprise Development Program (IT&C) 1977. Several of the Development incentive programs of the Department of Industry, Trade and Commerce (PAIT, PEP and IDAP) have been consolidated into this program. The program will provide financial support for product development, studies for pre-production design and engineering productivity and determine market feasibility and strategies. The program will cover up to 50 percent of eligible costs of specific innovation projects and assist firms when the project appears commercially viable and represents a significant burden on the firm's resources.

Defence Industry Productivity (IT&C) 1968. This program is the combination of the former Industry Modernization for Defence Exports Program and the Defence Development Sharing Program. Its purpose is to sustain the technological capability of the Canadian Defence Industry. The grant includes cost-sharing of up to 50 percent of current and capital R&D expenditures for defence-oriented R&D.

Pilot Industry-Laboratory Program (NRC) 1975. This program is aimed at accelerating the pace of transfer of technology into industry by contracting-out parts of NRC's research programs.

Industrial Research Assistance Program (NRC) 1962. This program is designed to encourage long-term applied research. Under this program, grants of up to 50 percent of salaries and wages for R&D staff and of the cost of certain fixed assets are available to all companies incorporated in Canada. The grants reduce both current R&D expenditures and the capital cost of fixed assets for income tax purposes. A group of companies may combine to select a project of mutual interest.

Cooperative Pollution Abatement Research Program. This is a government/industry cooperative program aimed to produce development standards for effluent control in the Canadian Pulp and Paper industry. Its intent is also to develop cheaper and more effective methods of dealing with water and air pollution control in this industry.

Industrial Energy Conservation Research and Development Program 1977. This program provides assistance for R&D aimed at new energy-conserving technology.

Program to Stimulate the Development and Demonstration of Pollution Abatement Technology (Environment Canada) 1975. This program is designed to stimulate the development and demonstration of new technology for the abatement of pollution in Canada. The level of cost-sharing by the government is negotiable. DPAT contracts require that any technology developed under this grant be made freely available to any other Canadian business.

PROGRAMS OF INDUSTRY, TRADE AND COMMERCE TO STIMULATE TECHNOLOGY TRANSFER FROM THE UNIVERSITIES TO INDUSTRY

The Industrial Research Institute Program Grants

University	Grant and Term	Termination date
Nova Scotia Tech.	$270,000 - 7 years	March 31, 1974
Windsor	$236,895 - 7 years	June 30, 1974
McMaster	$358,000 - 7 years	Sept. 30, 1974
Waterloo	$244,557 - 6 years	Nov. 30, 1973
McGill	$204,000 - 4 years	Aug. 15, 1975
Ecole polytechnique	$260,000 - 5 years	Sept. 30, 1976
Ryerson	$150,000 - 5 years	July 31, 1977
Universite du Quebec a Montreal	$300,000 - 5 years	May 31, 1978
University of Manitoba	$285,000 - 5 years	Sept. 30, 1978
Guelph*	$150,000 - 3 years	March 31, 1976

* This grant was terminated July 31, 1974 after payment of $65,383 and operation of the Food Industry Research Institute was discontinued.

Source - Dept. of Industry, Trade & Commerce, Office of Science and Technology "The Industrial Research Institute Program, The Centres of Advanced Technology Program, The Industrial Research Association Program", Annual Report 1975/76, Ottawa, December 1976.

The Centres of Advanced Technology Program

Grants

Name of Centre and Parent Institution	Grant, Term & Termination date		
Centre for Powder Metallurgy (Ontario Research Foundation)	$450,000;	3 years;	June 30/74
Systems Building Centre (University of Toronto)	$300,000;	3 years;	Sep. 30/74
Canadian Institute of Metalworking (McMaster University)	$830,000;	6 years;	Sep. 30/76
Centre for Ocean Engineering (B.C. Research)	$1,225,000;	3 years;	Mar. 14/76
Centre for Ocean Technology (Nova Scotia Research Foundation)	$875,000;	5 years;	May 31/79
Systems Analysis, Control and Design Activity (University of Western Ontario)	$875,000;	5 years;	Oct. 31/78
Centre de technologie de l'environnement (Universite de Sherbrooke)	$300,000;	3 years;	Oct. 31/77
Canadian Food Products Development Centre (Manitoba Research Council)	$550,000;	5 years;	Mar. 31/79
Biomedical Instrumentation Development Unit (University of Toronto)	$875,000;	5 years;	Feb. 28/81
Health Industry Development Centre (Manitoba Research Council)	$225,000;	3 years;	Dec. 31/79

Source - Dept. of Industry, Trade & Commerce, Office of Science and Technology "The Industrial Research Institute Program, The Centres of Advanced Technology Program, The Industrial Research Association Program", Annual Report 1975/76, Ottawa, December 1976.

UNITED STATES SELECTED PROGRAMS TO STIMULATE TECHNOLOGY TRANSFER

MECHANISM	EXAMPLES	COMMENTS
1) Direct corporate funding of University Research Projects	Harvard (Monsanto Biological and medical research program (1975)	This arrangement represents a long-term (12 years) high level committment ($23 million) to support basic research. It is hoped that it will result in improved interactions that favour technology transfer. However, it is too soon to judge on the relative success.
2) Cooperative Research Programs	Presently NSF sponsors cooperative research programs at Carnegie-Mellon, North Carolina State University and MIT	This program is designed to stimulate technology transfer for specific industries. It has been most successful in large industries where a few firms control the market.
3) University/Industry Research Consortia	- Department of Defence in the development of military technology - Clemson University experiment/Dept. of Commerce research on fabric flammability - Gulf Universities Research Consortium	A group of experts in the field defines the key research needs, selects proposals from both university and industry. The consortia are most productive when they are directed towards the achievement of a specific goal. As yet, it is too soon to comment on the relative success in stimulating technology transfer.
4) Joint Industry/University Laboratory	Fluid Dynamics and Energetics Laboratory of New York	Because of the basic differences between universities and for-profit organizations it has been extremely difficult to promote this type of activity.

MECHANISM	EXAMPLES	COMMENTS
5) Technology Licensing and Technological Brokers	New England Energy Development System (NEEDS) developed by MITRE Corporation funded by NSF (a component of NSF's Cooperative Research Program	An organization is established to coordinate university research with the needs of industry. In the case of the MITRE experiment, an attempt was made to "facilitate the flow of technology between the New England electric utilities and those universities/non-profit research groups capable of performing research needed by the utilities". Again, it is too early to evaluate the relative success of this mechanism.
6) Extension Services	Energy Advisory Service for Taxes (EAST) organized by Taxes A&M University	The University develops an extension centre designed to provide contacts and expertise on particular issues. In general, this approach appears to be most appropriate for fragmented industries where the cost of obtaining information about new developments is high.
7) University Industrial Associates	Successful Industrial Associates programs are operating at MIT, Stanford and California Institute of Technology	Member companies contribute an annual fee between $15,000 and $25,000. In return, they exchange research results in fields they are actively pursuing and receive intensive briefings in unfamiliar areas. Only a few of the nations most prestigious institutions have been able to achieve the appropriate number of corporate members needed to defray costs of running the program.
8) Industrial Parks near universities	- Stanford Industrial Park - Research Triangle Park (University of North California)	Since this requires strong political and financial commitments by universities and governments only a limited number of universities have been successful.

MECHANISM	EXAMPLES	COMMENTS
9) Innovation Centres Experiment	Presently there are three innovation centres supported by NSF at the University of Oregon, MIT and Carnegie-Mellon University	The program is designed to provide support for inventors and teach the necessary skills to move a new product from the laboratory to the market place. At present, it is too soon to evaluate the overall success of this program but preliminary evidence appears encouraging.
10) University Business Development Centres	University Business Development Centres (UBDC's) established by the Small Business Administration	These programs have had little direct effect on university research links with industry since the institutions carry out little on-going research. However, they may stimulate technology transfer indirectly by helping establish new firms that may then acquire technology from universities.
11) Federally Funded Research and Development Centres (FFRDC's)	- Applied Physics Laboratory (John Hopkins University) - Lincoln Laboratory (MIT) - National Astronomy and Ionsophere Centre (Cornell University)	There are approximately 21 FFRDC's located on university campuses. These institutes are financed exclusively or primarily by the Federal Government to perform R&D in relatively specific areas, or in some instances to provide facilities at universities for research and associated training purposes. The Centres usually have a direct and long-term relationship with their funding agency, making it possible for them to maintain instrumentation, facilities, and operational support beyond the capabilities of single educational or research institutions. These institutes primarily conduct basic research of the Nation's total basic research expenditures in 1975, FFRDC's administered by universities and colleges accounted for 7 percent of the total which amounted to about $300 million (current).

MIT INNOVATION CENTRE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

OBJECTIVE:	To encourage students with ideas to develop them into products with potential in the real marketplace and, thereby, to increase the supply and the quality of technical entrepreneurs through a supplementary education program. The Centre is also conducting formal research on the innovation process.
STRUCTURE:	The Centre is organized as a division within the School of Engineering with support from the Sloan School of Management.
PROGRAM:	Two programs are provided: - Innovation Education Program - An interdisciplinary program that provides two major parallel activities: a) a set of elective courses; b) a series of laboratory, workshop, office, and field activities relating to the generation of concepts, their subsequent evaluation and their development to a marketable stage. - Innovation Co-Op - An organization similar to a small R&D company wherein actual development and commercialization of inventions takes place. It provides a clinical environment in which students, with supervision and guidance, can undertake prototype development, experimental fabrication, patent application, market analysis, and promotion of new products, processes, and services.
ENROLMENT:	1974 58 students 18 faculty 1975 150 students 23 faculty
REVENUE:	Royalties on innovations developed in centre and industry project fees. ($33,000 from outside sources in 1974).
ACTIVITIES:	As of May 1976, 23 Co-op projects were listed, 9 funded with project funds, 10 with industrial funds, and 4 were unfunded.
EXAMPLES OF PRODUCTS:	Bicycle framesets, electronic games, current limiters, high efficiency bow, precious metal forgery detection system, small molecule detector, wide band electronic guitar.

SOURCE: R.M. Burger, RANN Utilization Experience, Report to the National Science Foundation, Case Study No. 33, Research Triangle Institute, pages 33-39.

EXPERIMENTAL CENTRE FOR THE ADVANCEMENT OF INVENTION AND INNOVATION

University of Oregon

OBJECTIVE:	To promote, encourage and stimulate technology transfer -- specifically from the inventor to the innovator to society. The Centre carries out education, public service, and research missions in support of this objective.
STRUCTURE:	The Centre is an entity within the College of Business Administration of the University of Oregon and is subject to normal University policies. The Western Inventors Council provides support to and participates in the Centre programs. Liaisons have been established with other universities and with public and private installations, agencies, and firms.
PROGRAM:	The Centre identifies its thrusts in three distinct activity areas: education, public service, and research. In education, a curriculum of nine courses is offered covering the full spectrum of entrepreneurship and innovation. At present, the thrust of public service is the evaluation of a large number of inventions that are brought to the Centre and the moving of worthy ideas to the marketplace. Finally, research is in two parts: the first relating to the Centre and the invention evaluation process, and the second consisting of faculty conducted, Centre funded research.
ENROLMENT:	1974 — 301 students — 8 faculty 1975 — 325 students — 10 faculty
REVENUE:	Fee of $25 required for each evaluation, but revenue is assigned to Western Inventors Council and is being accumulated in a trust. No revenue has yet been realized from the marketing of ideas and the NSF funding is the sole financial support for Centre operations.
ACTIVITIES:	A very large number of ideas has been received and over 500 have been evaluated. During the year ending June 30, 1975 alone, over 70 patents were issued on these ideas; and some 8 product efforts have been initiated.
EXAMPLES OF PRODUCTS:	Plumbing fixture to allow setting of bath temperature, wood burning stove, three-wheeled car, wine rack.

SOURCE: R. M. Burger, Ibid., pp 33-41, Case Study No. 33

CENTRE FOR ENTREPRENEURIAL DEVELOPMENT

Development of a Laboratory Experiment in Technology Transfer Via Entrepreneurship

Carnegie-Mellon University

OBJECTIVE:	To encourage and develop entrepreneurial activities and innovation through education, research, and support of new ventures.
STRUCTURE:	The Centre is a separately chartered tax exempt corporation with the University as residual beneficiary. The Board of Directors consists of the Executive Director and three CMU deans. Three components of the University -- Carnegie Institute of Technology, the Graduate School of Industrial Administration, and the School of Urban and Public Affairs, provide the academic base on which the Centre was created.
PROGRAM:	The Centre provides courses in the engineering and management disciplines, including a Master of Engineering degree in design. However, its primary focus is on entrepreneurial activities. For these, it directly participates in the development of new businesses, arranges community service seminars, stimulates related academic activities, and is a resource centre. It provides capital, where no commercial capital is available, and interfaces strongly with the small businesses that it spawns.
ENROLMENT:	1974 41 students 18 faculty 1975 90 students 20 faculty
REVENUE:	Efforts are made to obtain venture capital for small businesses. No revenue to date.
ACTIVITIES:	Three small businesses with 43 employees have been created. Others are in various development stages, and additional product ideas such as the oximeter are being considered.
EXAMPLES OF PRODUCTS:	Small businesses: Compu-Guard, Inc., The Pittsburgh New Sun, People's Cab Company, International Lamp Corporation, and Bactex, Inc.

SOURCE: R.M. Burger, *Ibid.*, pp 33-37, Case Study No. 33

FACTORS INFLUENCING THE UTILIZATION OF THE INNOVATION CENTRES EXPERIMENT

The experimental nature of the program--emphasis is on testing hypotheses on the education of entrepreneurs and on innovation, although in each centre, this is interpreted differently;

the well-defined experiment duration--knowing that NSF support of the centres terminates in five years places emphasis on creation of future income and causes some to view the centres as transient perturbations in the educational structure;

the multi-objective structure--the hierarchy of objectives creates options in approaches and products and permits commendable program flexibility. At the same time, the measures of performance are not well-defined and it becomes easier to "march to the sound of the drums" rather than follow a reasoned experiment protocol;

the calibre of the directors--through selection of strong Centre Directors, a strong measure of enthusiasm, competence, and zeal permeates the centres and bodes well for their success;

the importance of the subject--innovation and entrepreneurship are in the national spotlight, thus the Innovation Centres Experiment benefits from a large receptive audience, but must bear the burden of detailed scrutiny;

the quality of the work--each of the centres can enumerate significant accomplishment and an apparent concordance of support from those served. The early victories have aided greatly in attracting recruits to the centres;

the resistance to change--as innovations in the education process countering established academic patterns, the centres meet with resistance just as does any interdisciplinary program in a disciplined structure;

the block funding--the initial commitment to full funding of the programs has been important in allowing the centres to obtain institutional status and in avoiding the resource dissipation associated with renewal processes and the accompanying uncertainties;

the program management--although minor irritation was voiced relative to the documentation required for the experiment evaluation, no significant faults were attributed to NSF management in response to inquiries on this subject. All evidence points to an effective, flexible, and constructive approach to centre supervision by NSF;

the liberal patent policy--the agreements permitting the centres to develop through patents and other means, income that supports present and future operations, are a significant factor in the experiment design and are apparently an innovation in government policy that could have far-reaching effects;

the nature of venture capital--in the business world, venture implies levels of risks and rewards that are beyond the resources of the Innovation Centres Experiment. Thus it appears that the ventures being undertaken must be considered as small-scale laboratory experiments, and recognition must be given in the research to the factors involved in full-scale ventures.

SOURCE: R.M. Burger, RANN Utilization Experience, Ibid., pp 33-31 and 33-32

The Industrial Research Association Program

Association	Amount	Termination Date
Sulphor Development Institute of Canada	$ 1,400,000	June 30/76
Canadian Welding Development Institute	$ 875,000	July 31/78
Canadian Gas Research Institute	$ 875,000	Dec. 31/79

Source - Dept. of Industry, Trade & Commerce, Office of Science and Technology "The Industrial Research Institute Program, The Centres of Advanced Technology Program, The Industrial Research Association Program", Annual Report 1975/76, Ottawa, December 1976.

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