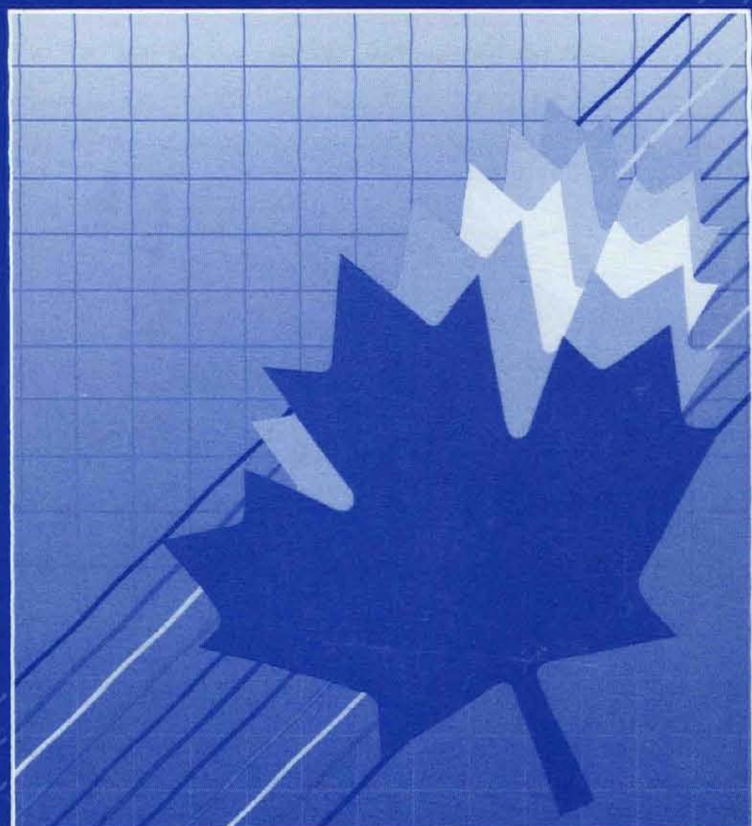
TECHNOLOGY DIFFUSION IN CANADA:

MYTHS AND REALITIES



Ministry of State
Science and Technology
Canada

Ministère d'État
Sciences et Technologie
Canada

Canada

TECHNOLOGY DIFFUSION IN CANADA:

MYTHS AND REALITIES

A Discussion Paper

by

A.D. Millington
Y. Van Ruskenveld

Ministry of State
Science and Technology

Industry & Trade Branch
September 15, 1986

EXECUTIVE SUMMARY

The Economic Council of Canada's 1983 report, "The Bottom Line: Technology, Trade and Income Growth" concluded that Canada was slow, compared to its industrial competitors, to adopt new technologies. However, evidence presented in this paper shows that the situation is evolving rapidly in Canada, though with considerable sectoral differences.

A myriad of factors affect the rate of diffusion of a technology. These include obvious financial variables, such as the level of investment required and anticipated return on investment, and variables relating to firm size, projected market size and stability, level of competition, level of R&D, and government tax and other direct incentives. One major influence in the Canadian context has been the intra-corporate transfer of technology to Canadian branch plants, though little is known of the costs and restrictions associated with such transfers.

It is clear that the importance of the factors varies from sector to sector, as does the rate of technology diffusion. A global technology diffusion strategy will therefore continue to be elusive.

Several recent studies, largely conducted in Ontario, have examined the diffusion of advanced manufacturing technologies. The results of these surveys tend to be inconsistent, but from the elements that might be compared Canada does not appear to lag behind Europe, except perhaps in the use of robots. We are, however, clearly far behind the Japanese in introducing new manufacturing technologies.

Improved technology diffusion into Canada has been suggested as an alternative to increasing domestic R&D. However, a number of studies have demonstrated that there is a close linkage between R&D and the diffusion of technology within a sector. For example, the Science Council has recently demonstrated a strong correlation between payments for foreign technology and domestic R&D expenditures, indicating the two are complements and not substitutes. As pointed out by a well-known U.S. economist, "later adopters face diminishing returns" - that is, many of the benefits of the technology have already been discounted through price reductions by the initial adopters. Adopting existing technology would not necessarily give Canada an advantage over other competitors unless the technology

can be further developed and improved. Also, independent Canadian firms may have difficulty getting access to the latest technologies unless they have something to trade in return.

A wide variety of federal and provincial government programs contributing to the diffusion of new technologies are identified in this report, and the role of technology centres is highlighted. Additional measures might be considered as follows:

- Small firms need more, direct advisory assistance, particularly with regard to selection and justification of equipment and its incorporation into the total manufacturing system of the plant. Such a consulting function could be provided through a further expansion of IRAP, through industry associations, or through groups based on local Chambers of Commerce, as in West Germany. Carrying the technology to the plant seems to be essential.

- In the case of larger firms, the industry associations should be encouraged to play a fuller role, though additional financial incentives may be necessary.

- A number of provincial governments, often supported by CEIC, have established training schemes to meet the needs for skilled personnel. However, the lack of such skills is identified in all surveys as a major impediment to technology diffusion. MOSST will explore the development of a program to introduce newly-graduated or unemployed engineers into small and medium-sized manufacturing firms to help identify applicable new technologies and overcome apprehensiveness towards their application.

- A greater appreciation of potential markets is a significant incentive towards the introduction of new technology. However, market information is often weak. The establishment of New Ventures Assistance Centres, supported by a central source of market data, could be of considerable value to the SMEs. (This has been proposed in a separate MOSST paper.)

- Greater attention should be given to promoting the publication in the media of success stories relating to the introduction of new technology. This would serve to increase awareness of the applicability of the technology to small firms, and to counteract "horror stories" circulating within the industry.

- It is evident that the technology diffusion situation in most OECD countries is evolving rapidly, and that better means of monitoring the situation in Canada are required. In conjunction with Statistics Canada, MOSST is considering undertaking surveys or other initiatives to better keep abreast of developments.

- In order to obtain leverage from the government's efforts special attention should be devoted to equipment and systems suppliers, since they are a major source of ideas for smaller firms, and to consulting engineers, who are designing facilities.

Technology diffusion is a complex topic demanding multi-faceted approaches.

TABLE OF CONTENTS

EXECUTIVE SUMMARY

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

In recent years there has been extensive interest and debate over the means of facilitating the more rapid diffusion of advanced technologies into the Canadian manufacturing sector and, to a lesser extent, into the resource and service industries. A number of specific sector studies related to technology diffusion were commissioned by the federal government in the 1970s, but the publication of the study "The Bottom Line: Technology, Trade and Income Growth" by the Economic Council of Canada([1]) in 1983 seems to have given greater emphasis and focus to the debate. The basic conclusion of the Economic Council's report was that firms and institutions in Canada are, for the most part, slower than their foreign counterparts in adopting new technologies, with consequent negative impacts on their productivity and competitive positions. Some exceptions to this pattern, for example Canadian libraries and to some extent the iron and steel industry, were, however, identified.

This issue will be addressed in some detail later in this paper, but before proceeding further a working definition of technology diffusion is required. For the purposes of this document technology diffusion is considered to be "the spread of a technology already put to use by at least one firm or public institution, either in Canada or elsewhere in the world." This serves to distinguish technology diffusion from technology transfer, which is seen as the transfer from laboratory to initial use, either for commercial or public purposes. The Economic Council study chose to differentiate between diffusion of a domestic technology and the adoption of a foreign technology, which they termed "adaptation". This distinction was made partially because of the overwhelming importance of intra-corporate transfers in the latter process. Otherwise the definitions in the Council's paper and this paper appear to be comparable.

Since Canada develops only a very small proportion of all technological innovations, the acquisition of foreign technologies and their diffusion throughout Canadian industry is critical to maintaining the competitiveness of the industry. There are a number of routes to acquisition, which include licensing, parent-subsidiary transfers, direct investment by foreign firms, the import of capital goods, and the exchange of technologies or joint technology development ventures.

Studies have indicated that imitation costs are, on average, less than 60% of innovation costs and the time to implementation is similarly halved.(2) It must be remembered, of course, that the benefits may also be lower than those gained by the initial adopter.

2. BACKGROUND AND ISSUES

The literature on the diffusion of technology is extensive. Most of the studies have been based on multivariate analyses of published data, occasionally supplemented by specifically designed surveys. A number of studies have been done on the diffusion of particular technologies in Canadian manufacturing industry and in the service sector, and it is upon these studies that the conclusions of the Economic Council are based.

For example, in one study(3) done for the Department of Industry, Trade and Commerce in the mid-1970s, it was shown that the diffusion of selected technologies in the pulp and paper, textile, and tool and die industries was slower in Canada than in the United States and Europe. In a more recent study for the Economic Council, Steven Globerman(4) found that, when compared to the United States, computer technology adoption levels in Canada were lower, at specific points in time, in hospitals and in the wholesaling and retailing sectors. Rates of adoption were higher, however, in Canadian libraries. The iron and steel industry in Canada was also shown to be technologically ahead of the U.S. industry in a study conducted in the early 1970s.

Even within Canada, significant differences in rates of adoption of new technologies from region to region have been noted.(5) For example, the Prairie and Atlantic provinces tended to lag behind Ontario in the adoption of computer technologies by about six years.

While many of these studies give credence to the idea that Canada is relatively slow to adopt new technologies, the majority were based on data collected prior to 1976, though a major study of five industrial sectors was undertaken by the Economic Council in 1980.(6) It is also interesting to note that a recent study by McFetridge (6a) showed that transfers of U.S. technology to Canada in the period 1960-1979, either through intra-corporate or arm's-length transfers, took place more quickly than such transfers to Europe or the rest of the world. With the increasing awareness of the

the importance of technology to economic competitiveness, an awareness enhanced by a wide range of federal and provincial government programs, the question arises as to whether the lags are still significant.

Secondly, the above studies would suggest that the situation varies widely from sector to sector. Indeed, Canada may be at the forefront of diffusion in some industries. The studies also show that the factors affecting diffusion rates differ widely from industry to industry, which may render general policy approaches inappropriate.

The measurement of diffusion rates is, in itself, a complex task, since technologies often undergo significant changes in being transferred from one firm to another, and after two or three steps in a chain the relationship to the original innovation may no longer be clear.

3. THE IMPACTS OF NEW TECHNOLOGY

The relationships between the introduction of new technologies and increases in productivity and general economic growth are now well established in the economic literature. Summaries were presented in the Economic Council report and have been discussed at length by Mansfield(7) and others(8). Two recent papers are worth comment, however, for they highlight the importance of the adoption of new technology and illustrate some of the complexities in the decision to introduce technology.

A recent study of some 500 manufacturing companies in Japan(9) related their actual performance in terms of sales growth and profitability to a range of 20 different factors. These included organizational and financial variables, technology development and new product strategies, and top management attributes among others. The overall results are given in the Figure 1. It is clear that technological factors had a profound impact on the performance of the firms, with the introduction of new plant and equipment being the most important, closely followed by the level of research as a proportion of sales. Managerial and organizational variables appeared to be of lesser importance.

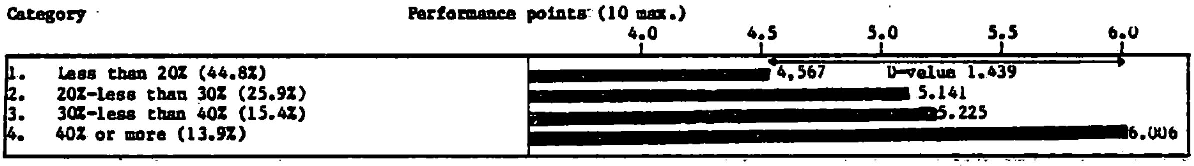
FIGURE 1

TWENTY MANAGEMENT FACTORS AFFECTING PERFORMANCE

Factor	Item	D-value	Rank
Top management	Company strength	0.874	11
	Business goals	0.844	12
	Overseas strategy	0.802	13
	Average age of top management	0.701	18
	Outlook on business development	0.675	20
Organizational	Average length of service of male employees	1.058	6
	Wage levels	0.878	10
	Human resources development	0.726	14
	Motivation	0.717	15
	Computerization	0.704	17
Technology development	Ratio of research spending to sales	1.384	2
	Level of applied research	1.092	4
	Level of basic research	1.042	7
Product strategy	Ratio of new plant and equipment	1.439	1
	Operating ratio	1.147	3
	Ratio of microcomputer-controlled equipment	1.066	5
	Ratio of new products	0.970	8
	Selling point of main products	0.707	16
Financial	Funding for fixed investment	0.953	9
Relation to outside firms	Dependence on outside contractors	0.682	19

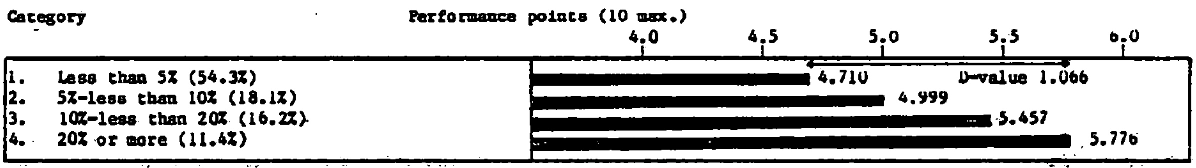
Note: Rank is descending order of D-value.

Ratio of New Plant and Equipment

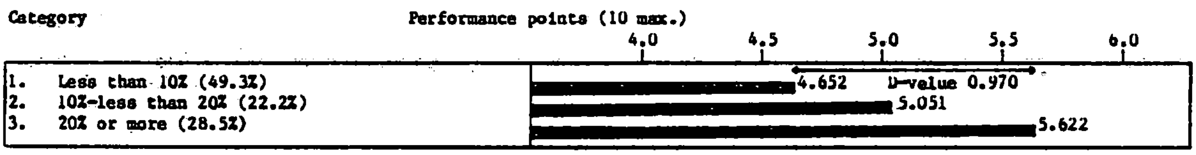


NOTE: Percentage of plant and equipment purchased in the past three years.

Ratio of Microcomputer-Controlled Equipment

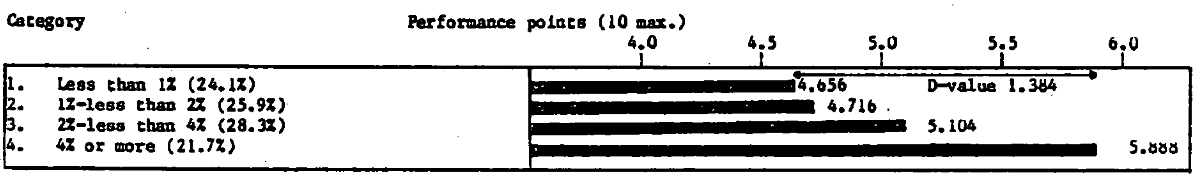


New Product Ratio



NOTE: The new product ratio is new products developed and sold during the past three years as a percentage of present total sales.

Ratio of Research Spending to Sales



Source: Journal of Japanese Trade & Industry, No. 6, 1985, Hiroshi Kasai

It is interesting to compare this result with that of a survey of opinions of chief executives of major European companies conducted by Booz, Allen & Hamilton Inc.[10]. These executives identified their own commitment to exploitation of technology and their involvement in the process as key, but gave a lower rating to technological factors such as R&D funding. Lack of senior managers trained in technology was identified as a problem and, in fact, a general lack of trained personnel was recognized as the most important problem faced. The survey report notes, however, that in similar Booz, Allen surveys, Japanese and U.S. executives had placed much higher emphasis on new product development. One interesting point from the survey indicated that 20% and 32% of the European firms were involved in co-operative projects with Japanese and U.S. competitors respectively and it was anticipated that these ventures would increase.

In a recent thought-provoking paper published in Scientific American[11], Wassily Leontief used an input-output analysis to examine the impact of the introduction of new technology on the U.S. economy. His study focusses on the introduction of computer-based automation, and he argues that, while recognizing the necessary trade-off between increased rates of return on capital and increased wage rates for a given level of technology, both interests would benefit from introduction of new technology as long as the overall rate of return on capital remains below 17.5%. He further argues, however, that decisions about the introduction of new technology within one firm or industry, without considering the ramifications of new technologies in other industries, will always be sub-optimal, i.e. a firm making decisions based on the assumption that technology in other industries will remain constant will usually under-estimate the benefits of introducing a new technology. The paper also suggests, as one explanation for the apparent readiness Japanese entrepreneurs to rapidly adopt new technology, the entrepreneurs' willing acceptance of a lower rate of return on capital, which, according to Leontieff's thesis, would be consistent with the introduction of new technology.

The examination is pursued further by examining which sectors of the economy would benefit most from the introduction of new technology, based on the assumptions of the model. While the computer/semi-conductor industry leads the list, it turns out that many of the sectors of importance to the Canadian economy - lumber, mining, petroleum refining, paper, iron and steel, transportation equipment, forestry and fisheries - are high on the list. The service sectors, on the other hand, are not favoured. The model certainly provides an interesting perspective.

Prior to reviewing the recent evidence with respect to rates of diffusion of technology in Canada, a brief overview of the literature discussing the myriad of factors which have been shown to affect the rates of technology diffusion is presented in the following section.

4. FACTORS AFFECTING THE DIFFUSION OF TECHNOLOGY

In the various studies that have been carried out, a broad range of factors has been identified as affecting the rate of diffusion of technology. A partial list of the more important variables is given in Appendix A. Unfortunately, there is little consistency either among studies or among industry sectors in the variables which appear to be important. Indeed, the same variable, for example industry concentration or firm size, often seems to have opposing impacts in different sectors. Only certain financial variables, such as project profitability and total investment requirements, showed up as having a consistent, and statistically significant, impact on the rate of diffusion.

The impact of organizational and managerial attitude variables has been largely neglected, probably because they are less amenable to quantitative study. There is some evidence, summarized in a recent paper by Donald Daly of York University(12), to suggest that in Canada these may be of crucial significance.

Bearing in mind the above-mentioned qualifications, some of the factors believed to be particularly significant in the Canadian context are discussed below.

One of the most effective ways of transfering technology is from parent company to subsidiary, and in this area Canada is a significant beneficiary of such transfers, though it is difficult to estimate the costs to Canada of these transfers. The subsidiary may, however, be less reliant on Canadian suppliers than would a Canadian-owned firm, and the impact of the new technology would thus be less readily transmitted through the manufacturing system. It may be noted also that multinationals will tend to automate their domestic plants first before their foreign plants. Thus, with a high proportion of foreign ownership of the Canadian economy, we are perhaps always going to be behind in adopting major new technologies or systems.

In general, large firms are more readily able to acquire external technologies. They more frequently have their own R&D group and, hence, a technological base and greater awareness of current developments; they would normally have access to greater financial resources; and, they may have technology of their own which can be traded. It would appear that this is often an important advantage in acquiring technology. Canadian firms, however, tend to be relatively smaller than their counterparts in other developed countries, and this may serve as an impediment to rapid diffusion of technology. It might be noted that larger companies are also of greater interest to potential suppliers of high-technology equipment.

Several of the previous studies show a strong correlation between the rate of diffusion of technology and the R&D expenditures in a particular sector. Canada's relatively weak industrial R&D expenditures, indicating a weaker technological base, would therefore be expected to inhibit diffusion.

In recent years, Canada has tried to stimulate additional industrial R&D through a variety of tax incentives, and it is generally believed that, overall, the R&D tax incentive system in Canada is more generous than that in other OECD countries. It is not clear, on the other hand, that the tax regime in Canada is more favourable in downstream activities relating to commercialization of new discoveries. For example, the U.S. has had a more beneficial regime with respect to capital gains, especially where venture capital companies are involved. Other countries have special provisions for writing-off capital equipment that may be more advantageous. These factors will affect the rates of diffusion.

Another major incentive to the adoption of a new technology is the likelihood of having access to a large and stable market. Thus, unless Canadian firms have ready access to the U.S. market, Canada will be at a disadvantage with respect to most of its OECD competitors, and again this factor may explain diffusion lags in some industries. The opening up of Canadian markets to external competition, for example through reduction of tariff barriers, would probably increase the rate of diffusion for most industries. In general, increased competition has been a positive factor for increasing the rate of diffusion. Of course, with reduced barriers there may be less incentive for foreign firms to create manufacturing subsidiaries in Canada, which would mitigate against more rapid technology diffusion.

The availability of capital is often a major constraint, particularly for the small- and medium-sized firms (SMEs). Venture capital markets in Canada are much less well developed than those in the U.S. This will affect both the SMEs which wish to upgrade their existing facilities or practices, and potential start-up companies, which might identify market niches and act as suppliers of new equipment, thus driving the diffusion of technology from the supply side. (Proximity to suppliers, who are able to provide information, servicing, etc., increases the rate of technology diffusion). The argument would not apply, however, in comparing Canada to the European countries, where venture capital markets appear to be at an early stage of development.

The diffusion of technology is also sensitive to the availability of trained personnel, and it has been suggested that a lack of engineers and technicians has had a serious restraining influence in Canada. Globerman's comparative study of the diffusion of computer technology in Canada and in the U.S.[4] indicated that this was a highly significant factor, and he linked the shortage to the lack of flexibility or adaptability of our universities. The diffusion of robot technology may have suffered for similar reasons. The argument is also extended to an apparent lack of entrepreneurial managers in Canada - it is hypothesized that this is because Canadian managers tend to be older and less well-educated than their U.S. counterparts. Related to this is the flow of personnel from one industry to another - this is perhaps the most effective way of diffusing technology.

One study by McMullen[13] of the Economic Council investigated the length of the time lags associated with adoption of innovations as influenced by various risk factors. Quantitative estimates were made of the average increases or decreases in lags that would be associated with given changes in the risk factor. While the innovation costs relative to firm size and perceived rates of return had considerable influence on the lags in adoption, the level of government funding of innovation had a smaller impact. Intercorporate transfers were also much more rapid than arm's-length transfers of technology.

There is little evidence to suggest that lack of information on commercially utilized technology is slowing the rate of diffusion. In fact, many studies show that this factor is not significant. Much of the government effort, however, is directed to this end.

The conclusion to be drawn from the studies is that technology diffusion is a complex process affected by a wide variety of factors, few of which seem to be any more important than others. Moreover, the importance of the variables will change depending upon the industry or sector being studied.

While these factors and issues have been discussed in the diverse studies on the subject of technology diffusion, the serious shortcomings of many of the studies have been identified by Bela Gold(14), a pioneer in the field, in a critical review article in 1981. He is particularly critical of the acceptance of the S-curve as a model of the diffusion process and of the estimates of diffusion rates based on a static model of potential adopters. Gold argues that innovations undergo continuous modification and adaptation and the range of potential adopters, whether they be different plants within one industry or different industries, is constantly changing. For these reasons studies should be done at a very disaggregated level, but should also take into account the impacts of adoption by one firm on its suppliers and customers among others.

He further argues that studies should be focussed much more on the firm's pre-decision environment as opposed to the post-adoption econometric studies that seem to predominate. These lead to "logically relevant but overly generalized criteria" which rarely apply to specific cases. The ex-post results are often quite different to what was expected ex-ante when decisions were made. In addition, one major criterion, the profitability of the invention, appears to be tautologous - i.e. a profit seeking enterprise would not invest in the absence of an expected profit. It should be noted, however, that in some cases firms are obliged to adopt innovations not to increase profit but to minimize reductions in profitability brought about by a competitor's pioneering efforts.

Specifically related to this, and of significance to Canada, it is pointed out that "later adopters face decreasing benefits as competitive efforts of early adopters tend to pass cost savings to purchasers through lower prices and as wage gains come to be enforced on an industry-wide basis". Thus, later adopters incur the costs but derive few of the benefits of innovation.

In examining the difficulties in evaluating the risks and potential profitability of an innovation prior to its adoption, Gold suggests that judgements of senior management probably overshadow any other factor in the decision process, and that in a manufacturing environment more predictable technical production criteria, e.g. increased production rates, will often override general economic criteria. There is an implicit assumption in the literature that faster rates of diffusion are necessarily better, but these assumptions are often based on an inadequate appraisal of the costs of innovation. Qualitative as opposed to quantitative factors also tend to be ignored.

5. A SUMMARY OF MORE RECENT EVIDENCE

The conclusions reached in the Economic Council report were, to a large degree, based on data collected during the late 1960s and the 1970s. One exception was the study of the application of microelectronics in certain service industries conducted by Globerman in 1982. There is some evidence, however, that the situation is changing extremely rapidly, particularly with regard to the application of microelectronics technologies in the manufacturing and service sectors.

This section attempts to summarize and compare the results of four recent (1984) surveys conducted in Ontario. Some comparisons are also made with European surveys conducted in 1983 and 1984. Subsequently, the imports of certain higher technology capital goods into Canada are examined to determine how the patterns have changed over the last decade. It was thought that this may provide a very crude indicator of the rates of change in technology in Canada. Domestic market data rather than imports would be preferable, but such data are not readily available.

Finally, we comment briefly on preliminary results from a study MOSST is carrying out of the diffusion of new technologies in the Urban Transit sector.

A. Survey Data

(i) Utilization of Manufacturing Technologies

A number of recent studies have investigated the extent to which manufacturing companies in Ontario are using modern manufacturing technologies in their operations([15,16,17,18]). Unfortunately, the studies address different groups of industries or firms of differing sizes and are not fully compatible in their definitions of the various technologies investigated. Comparisons among them are therefore difficult, and this is even more the case in trying to draw parallels with recent European studies looking at the employment of microelectronics in British, French and German manufacturing industries([19]). The most recent study ([16]) in Ontario focusses specifically on the use of NC machine tools and robots and provides detailed data which give a rather different perspective than the other studies.

As is evident from the British study, which surveyed respondants in 1981 and again in 1983, asking also for projections for 1985, the rate of change in the use of microelectronics is very high, though it varies significantly by industry. For example, the percentage of all processes controlled by microelectronics was 11% in 1981, 18% in 1983 and was projected to be 27% by 1985. While only 16% of smaller firms (100 employees) were using microelectronics in their processes in 1981, over 30% were doing so by 1983. Thus, comparisons made using data collected even 12 months apart must be used very cautiously.

Given all these caveats, some very general comparisons might still be examined. The Ontario Task Force Study (1984), covering nine of Ontario's major industries but excluding the automotive sector, indicates that at least 40% of firms with more than 20 employees use some form of advanced manufacturing technology (and the percentage may be significantly higher since it is not possible to derive it directly from the figures given). Indeed, the OCAM study conducted in early 1984 indicated higher levels of use, though Craig & Noori (1984) show only about 25% use among smaller firms.

These figures may be compared with a rate of use of microelectronics in manufacturing operations by 43% of all British firms employing more than 20 people in 1983. Comparable figures were 47% for Germany and 35% for France. When firms with less than 100 employees are compared, the proportion of firms using advanced manufacturing technologies in Ontario seems at least comparable to that in Europe. The OCAM study indicates that almost 60% of such firms had implemented some form of advanced technology, though the Craig/Noori study had a lower figure of 25% based, however, on a slightly smaller range of technologies. The Craig/Noori sample also displays a different distribution of firm sizes. In Britain, it was estimated that 32% of firms with 20 to 100 employees were using microelectronic technologies in 1983, with the figure for Germany 5% higher and for France some 5% lower.

Equally interesting are data given in the 1984 White Paper on Small and Medium Enterprises in Japan([20]), which show that in December, 1983 only 30% of SMEs (300 personnel) had introduced "mechatronics" technology into manufacturing. The comparable figure for large entreprises was 71%.

Data available at the level of industrial technologies are rarely sufficiently compatible to permit direct comparisons. The most recent Flexible Automation Equipment Survey ([16]) indicates that only 4.1% of Ontario manufacturing firms use NC machine tools while the OCAM survey gives a figure of 18%. The smallest firms (10 employees) are under-represented in latter survey, however, and correcting for this factor would probably reduce the figure to around 10-12%. The Task Force survey, which only considered firms with more than 20 employees in nine major manufacturing industries, indicates that 65% of such firms were using NC machines prior to 1985. Even were one to assume that no firms with less than 20 employees had NC equipment, the latter survey would still indicate that 25-30% of all firms in these industries had such equipment. The same holds true for the metalworking industry (SIC 301-309) for which specific results are given in the two reports. The figures are thus difficult to reconcile.

Comparisons with the use of NC machines in Japan show Canada at a very significant disadavantage - after adjusting for the relative size of the two manufacturing sectors Canada has apparently only 1/15 the number of NC machines.

It is also interesting to note that the introduction of NC machines in Canada has progressed more rapidly in small firms than in large ones in recent years. While in 1976, according to the Flexible Automation Equipment survey, large firms had 460 NC machines and small firms only 125, by 1984 both categories of firm had about 1350 units. This may explain some of the apparent discrepancies in Canada/Japan comparisons where the relative number of machines differs by a factor of 15, but the percentage of establishments using them by a very much smaller factor. The implication is that the larger manufacturing firms in Canada are not automating.

In a study of the use of CAD/CAM technology in manufacturing firms in Ontario and Western Canada, Wedley and Vergin[21] estimate that 25% of firms of firms are using such technology, though the definition of CAM is very wide. If firms with 25 employees or more are considered the figure rises over 30%.

From the few data elements that might be compared from the remaining surveys [15,17,18,19] for firms with 20 or more employees, for example those data with respect to use of CAD systems or CNC machines, Ontario would appear to be significantly ahead of the three European countries in the percentage of establishments using the technology.

In the case of robotics, Canada clearly appeared to be lagging behind other countries in the early 1980s (see Figure 2). The relative gap, at least between Canada and the U.S., may have narrowed since then. A recent report in Québec Science (Nov. 1985) indicates that Canada had 900 programmable robots (meeting a specific definition) in 1984 compared to 13,000 in the United States, though West Germany had 6,700 and Sweden 2,500. Comparable data, based on a strict definition, are, however, difficult to obtain. [It might be noted that figures for the number of robots in use quoted for various countries in the E.M.F. Foundation 1985 Report on International Competitiveness differ significantly from those in Figure 2.] Moreover, from a policy perspective it would be necessary to know in which sectors they were being employed, for which type of activity, by what type of firm, etc.

The general conclusion is that we do not have a good measure of the rates of diffusion of technology in Canada even for microelectronics, and our knowledge of the spread of other technologies is weaker. The number of firms using a technology is also less important from an overall economic point of view than the proportion of production being produced with such technology.

(ii) Obstacles to the Use of Advanced Technologies

The above mentioned surveys also investigated the major impediments to innovation and adoption of modern manufacturing technologies. (In addition, the Ontario Task Force study examined the use of new technologies in the service industries, but few comparable data are available for elsewhere.)

For the firms in the OCAM study which had not adopted any new technologies (i.e. 30% of all firms), the overwhelming majority believed that their companies were too small, that the technology did not apply to their situation or, alternatively, they simply saw no need to investigate the use of new methods. This apparent state of complacency among some smaller firms is highlighted in the Craig/Noori study, where responses showed that firms believed that automation was extremely important for industry generally, but much less so for themselves. Most believed they were as advanced as other firms in their industry. Over 60% of the firms in this sample (which was limited to firms with less than 100 employees) indicated that they were not considering automation in any form in the immediate future, a result consistent with the OCAM study. Financing difficulties were given as a reason by less than 10% of these firms. This seems to be in direct contrast to the Craig/Noori study, however, which identified availability of capital as a major barrier, as did the Wedley/Vergin study on the introduction of CAD/CAM technologies. The difference in the findings of the studies is not readily reconciled.

FIGURE 2

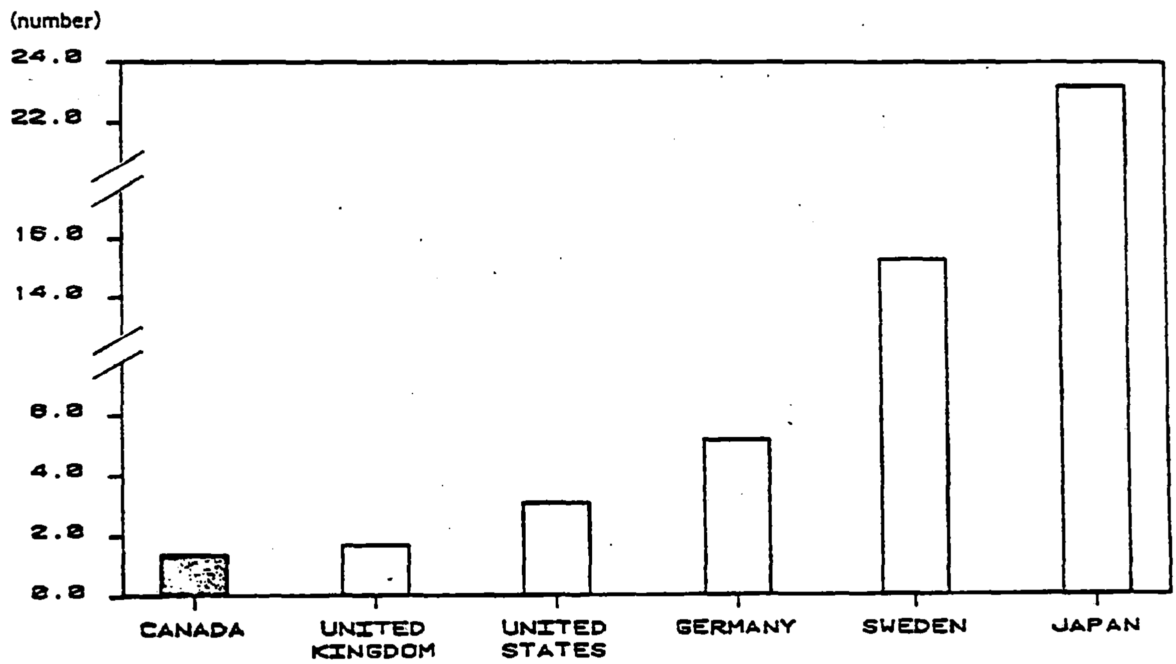
Number of Industrial Robots in Operation in the World (as of the end of 1982)

Japan	31,900		31,900	(56%)
U.S.	6,301	North America	6,574	(11.5%)
Canada	273			
Austria	50			
Belgium	305			
Denmark	63			
Finland	98			
France	9,993			
W. Germany	4,300	Western Europe	18,480	(32.5%)
Italy	1,100			
Netherlands	71			
Sweden	1,450			
Switzerland	73			
Britain	977			
Total	56,954		56,954	(100%)

Note: The survey was conducted for reprogrammable robots, servo-controlled and non-servo controlled.

Source: Robot Industries Association, U.S.A. 1983

Robots per 10,000 Employees in Manufacturing
1982



Sources: Robot Institute of America; U.S. Department of Labor.

The importance of the problems or difficulties encountered or anticipated in the introduction of new technology appears to vary by industry, but common themes arise from the various studies. High on the list of factors is finding qualified personnel/lack of in-house skills, which was identified by almost 50% of firms in the OCAM study and was a major factor in all the other studies, and indeed the major factor in Europe. Poor general economic conditions were also highlighted in several studies as an impediment, but the prominence of this factor may relate more specifically to the period when the studies were conducted, i.e. 1983 and early 1984. While financing appears as a significant factor, of equal importance to many firms is the ability to carry out cost justifications/feasibility studies and to understand and determine the optimum type of technology for a particular operation. Employee or union resistance to change appears to be relatively weak and is not cited as a significant factor by many firms in Canada or in Europe.

(iii) Factors Favoring the Introduction of Technology

In terms of factors which appear to drive the firms to adopt new technologies, increasing competitive pressures were clearly the most significant. Emphasis was placed on the potential of the technologies to reduce costs and increase productivity, with increased quality appearing to be a lesser consideration. Customer demands for changes were also recognized as an important factor in one study, but reduction of hazardous working conditions, which is reported to be one major reason for the rapid introduction of robots in Japan (though not as important as productivity and quality increases) was given a low rating.

The chief sources of information for most companies were trade magazines and trade shows, and the level of general awareness of the technologies was high. The smaller firms seem to have difficulty, however, in proceeding from this general knowledge to undertaking specific feasibility studies or studies at a sufficient level of detail to give them a full appreciation of the costs and benefits of specific technologies and to selecting the optimum types of equipment for their operations. Their familiarity with the Ontario technical centres was very limited, and the industry associations did not play a significant role for the smaller firms. Many firms would welcome outside assistance in determining needs, evaluating equipment and planning for its implementation.

(iv) Conclusion

While the fragmentary evidence available from these surveys indicates that Canada may not be significantly behind Europe in the application of microelectronic technologies, though lagging well behind Japan, a high proportion of smaller firms (i.e. those with less than 100 employees) are still reluctant to become involved with upgrading their manufacturing facilities and, indeed, see little need to do so. It should be borne in mind, however, that these firms account for less than 25% of manufacturing output.

There is an evident lack of current data which could permit a reliable comparison of diffusion rates in Canada with those in other countries.

B. Import Statistics as Indicators of Diffusion

The surveys discussed above indicate some of the difficulties faced in obtaining an overall appreciation of the levels of diffusion. In looking for alternatives, it appeared that one possible measure would be to examine the evolution of the domestic market for particular products, for example robots or CAD systems. Comparisons could be made over time and, potentially, with the evolution of markets in other OECD countries. Again, however, market data are not readily available. The current shipment data provided by Statistics Canada are in a form which makes comparison with export and import data for similar products extremely difficult.

Given the difficulties, it may still be possible to observe trends based on import data for selected products. In certain markets, for example scientific instruments, imports account for a very large proportion of the Canadian domestic market. Import data have the advantage that they are available for fairly discrete products and, also, that the latest data are quite current. Table 1 presents a picture of the growth in imports of selected products, which might reasonably be expected to relate to a country's level of technology, since 1971. The table aggregates the data into 5-year periods, 1971-75, 1976-80, and 1981-85. (The 6-month figure for 1985 has been doubled to give comparable statistics). Examination of this table shows a significant increase in activity in the latter two periods compared to the first period, and, in particular, a very large increase for many products in the 1981-85 period. This would suggest a very rapid increase in diffusion in the recent past, especially considering the serious recession in 1982/83 and the fact that for many electronic products prices have fallen dramatically and changes in volumes of equipment will therefore be grossly understated.

Of course, in principle, the data should be compared with market data for other countries to determine if Canada is exceptional in the apparent changes in activity levels. The only data we have to date relate to the machine tool industry and these are presented in Table 2. The figures given are for total domestic markets in each country in both current and constant U.S. dollars. (The data are based on statistics published in the American Machinist). A review of Table 2 indicates that Canada does indeed appear to be exceptional with respect to the 1980-84 period, showing a significant increase in spending while other countries' markets have been stable or declining. The United States showed a significant increase in the 1975-79 period.

The figures must obviously be used with caution, especially since the machine tool statistics show major declines in spending in some European economies. Nevertheless, they would appear to call into question the current dogma that Canada lags significantly, except with respect to Japan.

Further confirmation of this change comes from a survey carried out by Evans Research Corporation in 1984[22]. In a study of 450 manufacturing companies in Ontario and Quebec regarding capital expenditures on automated production and materials handling equipment, forecast expenditures for 1985 were $695 million compared to $195 million in 1984. Of the firms surveyed, about 40% already had some computerized production equipment, and 40% of the companies also indicated that they planned to introduce robots for materials handling.

C. Diffusion of Technology among Canadian Urban Transit Properties

As a case history of technology diffusion into a service industry, MOSST has undertaken, in conjunction with Transport Canada, a study of Urban Transit Properties in Canada, most of which belong to the Canadian Urban Transit Association (CUTA). This particular sector has a number of advantages. The potential market for transit equipment and control systems is large and, in fact, shipments of equipment have increased three-fold since 1980, with two-thirds of the production being exported, mainly to the United States. The transportation equipment manufacturing sector is not well developed in the U.S. and this may provide significant opportunities for Canadian firms, and especially for smaller firms such as Teleride, with specialized systems. Canada's particular advantage probably lies in its expertise in the operation of integrated urban transit systems.

Our initial surveys indicate, however, that implementation of systems or the use of new equipment by a number of Canadian transit authorities is essential to be able to market effectively elsewhere. To be able to demonstrate the equipment in actual use seems to be a sine qua non. The adoption of technology by a wide variety of transit properties is thus of importance to Canadian manufacturers. There are, of course, also significant benefits to the Canadian population as a whole, either in terms of reduced costs or improved levels of service, from the diffusion of these technologies as widely as possible in Canada.

While the study is only partially completed, the results of a CUTA survey of the use of computers and adoption of software systems for a wide variety of activities, from operations to marketing to finance, should be considered. The data are presented in Table 3 and indicate the very rapid adoption of these systems by all types of transit property in a wide range of activities. The Ontario government has undertaken a specific initiative relating to the introduction of computer systems into smaller properties.

The introduction of technology is not limited to systems developments, however. Trials are being conducted by a number of properties relating to the use of articulated buses, for example, and to the use of alternative fuels (propane, methanol, compressed natural gas). Traditionally, the Urban Transit sector has been extremely conservative, but it would appear from the above activities that these perspectives are rapidly changing, driven in a large measure by pressures from municipal authorities to cut costs and at the same time to increase ridership through more extensive marketing efforts. As might be expected, most of the trials are being conducted by the larger properties, but the informal exchange of information among properties, greatly facilitated by CUTA, is highly developed.

TABLE 1

Comparison of Imports for 5-Year Periods

	Code	Millions 1971 Dollars		
		1981-85	1976-80	1971-75
Automatic Metalworking Lathes	523-06	74.6	67.5	39.2
Machine Tools (N.E.S.)	523-29	191.8	173.9	142.8
Plastics Moulding Machy.	529-42	40.3	27.8	14.5
Electronic Ind. Machy.	529-50	125.7	94.8	65.2
Special Ind. Machy.	529-99	276.0	171.1	73.7
Commercial Communic. Equip.	634-99	402.6	202.3	130.6
Integrated Circuits	638-31	505.8	181.6	81.6
Semi-Conductors N.E.S.	638-39	734.2	207.8	62.2
Printed Circuit Boards	639-55	65.1	30.2	22.2
Electronic Equip. Components	639-99	567.9	482.2	295.4
Power Transformers (Large)	683-77	12.2	32.6	45.9
Industrial Control Equip.	688-59	181.8	181.4	176.5
Electronic Meas. & Test Inst.	702-90	200.2	299.0	93.6
Process Multi-Function Controls	703-78	83.9	26.1	19.1
Gas Chromatography Equip.	705-31	33.5	17.9	10.3
Scientific Instruments	709-99	75.6	56.3	46.5
Electronic Computers & Parts	771-22	5587.7	2334.6	1114.9
GROSS NATIONAL PRODUCT		686,376	630,524	527,186

Source: Statistics Canada.

TABLE 2

Domestic Market for Machine Tools

(Millions of U.S. dollars)

	Current Dollars			Constant 1975 dollars		
	1970-74	1975-79	1980-84	1970-74	1975-79	1980-84
U.S.	6496	14146	21530	7935	12274	13585
Japan	5788	5976	14186	7133	5174	8791
USSR	8094	14179	19654	9901	12470	12160
W. Germany	4864	6606	9524	6067	5695	6004
Italy	2429	3404	4263	2963	2995	2709
France	2620	3456	3921	3213	3075	2479
U.K.	2595	3650	4020	3229	3183	2568
Canada	834	1298	2499	1034	1145	1569
E. Germany	769	2551	1530	931	2183	977
Switzerland	632	1051	1414	776	922	891

Source: American Machinist - Various Issues

TABLE 3

CANADIAN URBAN TRANSIT PROPERTIES

STATUS OF COMPUTER APPLICATIONS

Application	1983-1984 Survey		1984-1985 Survey				Percentage Adoption		
	No of Systems Responding	No of Systems Computerized	No of Systems Responding	No of Systems Computerized	Expect to Computerize Within 3 Yrs	Computerization with in 3 Yrs	1983-1984	1984-1985	1985-1988
Word Processing	49	17	30	19	7	26	34	63	87
Payroll	49	32	27	20	6	26	65	74	96
Personnel Records	48	16	28	14	9	23	33	50	82
Absenteeism Records	49	13	25	9	14	23	26	36	92
Budgeting	50	30	26	16	9	25	60	61	96
General Ledger	49	34	29	23	5	28	69	79	97
Accounts Receivable	47	26	26	17	7	24	55	65	92
Accounts Payable	48	32	27	20	6	26	67	74	96
Fixed Assets Mgt.	-	-	21	3	10	13	-	14	62
Accident Statistics	-	-	23	4	11	15	-	17	65
Security Records	-	-	18	2	7	9	-	11	50
Scheduling	50	14	26	10	12	22	28	38	85
Run-cutting	50	13	26	10	12	22	26	38	85
Vehicle Assignment	49	7	24	7	10	17	14	29	71
Rostering/Bidding	49	4	25	4	18	22	8	16	88
Timekeeping	48	9	25	3	13	16	19	12	64
Auto. Vehicle Loc.	-	-	22	3	7	10	-	14	45
Passenger Counting	49	7	27	7	11	18	14	26	67
Fare Counting	49	3	24	7	7	14	6	29	58
Performance Monit.	49	6	24	5	11	16	12	21	67
Route Planning	49	5	25	4	5	9	10	16	36
Forecasting	47	6	25	6	7	13	13	24	52
Modelling	48	5	22	6	3	9	10	27	41
Materials Mgt.	48	14	26	9	12	21	29	35	81
Vehicle Maintenance	49	6	29	6	22	28	12	21	97
Work Order Process.	-	-	28	5	22	27	-	18	96
Vehicle Repair History	-	-	29	5	23	28	-	17	97
Fuel Control	-	-	27	10	14	24	-	37	89
Warranty Surveillance	-	-	22	2	12	14	-	9	64
Main. Empl. Perform.	-	-	24	2	16	18	-	8	75
Telephone Info.	48	4	26	4	11	15	8	15	58
Visual Displays	48	2	24	2	8	10	4	8	42
Passenger Rte. Plan	48	3	23	2	9	11	6	9	48
Timetable Prep.	47	5	24	1	11	12	10	4	50
Planning Surveys	-	-	24	8	7	15	-	33	62

6. RESEARCH AND DEVELOPMENT VERSUS IMPORTATION OF TECHNOLOGY

Canada spends a lower percentage of its gross national product on R&D than many of its OECD competitors. A number of economists have argued, however, that this is not a serious problem for Canada, that it derives in part from our industrial structure (i.e. Canada has heavy bias towards resources which are traditionally less research intensive), and that we benefit greatly from R&D conducted in the U.S. through intra-corporate transfers. The arguments are set out in a recent book by Palda(23). [It might be noted that even after "correcting" for industrial structure by assuming, as Palda does, that Canada had the same proportion of manufacturing industry as the average European country, Canada still trails well behind other major OECD countries in research expenditures. Indeed, when compared on a sector by sector basis, our industrial R&D expenditures as a percentage of output of that industrial sector are usually considerably lower than those of our major competitors (Appendix B).]

The argument has been extended to suggest that Canada should therefore focus its efforts on purchasing technology abroad and diffusing it among its industries as opposed to increasing domestic R&D expenditures. It is widely believed that this is the way in which the Japanese became successful. While the Japanese certainly purchased foreign technologies, what is perhaps less widely realized is that they significantly increased their R&D efforts in parallel to further develop these technologies. A recent article in Research Policy(24) displays the relationship between expenditures on industrial R&D in Japan and expenditures for the acquisition of foreign technology. Between 1966 and 1974, the period for which data are presented, the two types of expenditure were almost perfectly correlated, with R&D expenditures being almost nine times as great as expenditures for imported technology (see Figure 3). The relationship appears to hold also at the level of individual manufacturing sectors. Such figures would support the contention that a strong R&D base is necessary to effectively use, and further develop, imported technology. In more recent years, Japanese R&D expenditure has risen more quickly than payments for foreign technology, the ratio of payments to R&D falling to 5% in 1981.(25) In terms of new agreements entered into, Japanese receipts for sale of technology have exceeded its payments since 1975. The receipts were almost double the payments for agreements concluded in the 1979-83 period.(26)

Canadian expenditures appear to be similarly related, though the situation will be more complicated because of the high level of parent-subsidiary transfers, for which no royalty payments are necessarily made. Table 4 indicates the expenditures on industrial R&D in Canada since 1967 and payments for imported technology by those firms conducting R&D in Canada. The ratio of payments to R&D expenditures is relatively constant at around 15%. A similar pattern is observed if the total of royalties and similar payments (taken from CALURA returns) is used instead. The relationships are shown graphically in Figure 4.

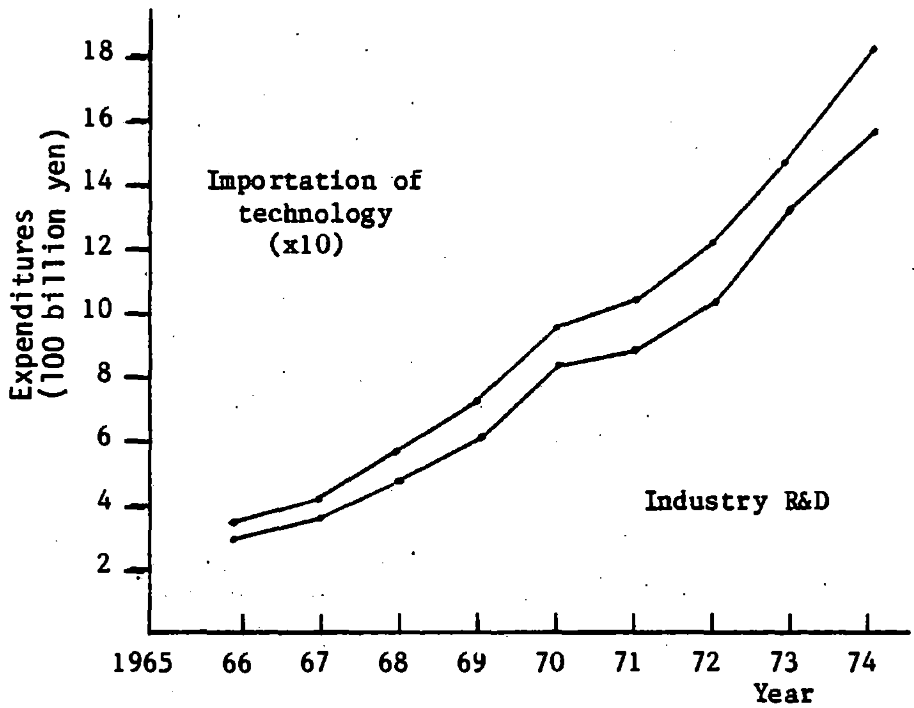
In support of this thesis, the recent study by Longo(27) using Statistics Canada's firm level data base, demonstrated a strong complementarity between a firm's R&D expenditures and its purchases of technology from elsewhere. These findings are also strongly supported by the OECD study conducted by Antonelli(28), who examined the relationships between R&D expenditures and technology acquisition for a number of European countries and, in particular, for Italy.

Rothwell(29) has examined the evolution of the semi-conductor industry in the United States, Japan and Europe. The initial inventive activity was largely a U.S. phenomenon and was concentrated in larger firms, though the later rapid diffusion was due to the entrepreneurial activity of smaller firms, often created by workers leaving the large firms. In Japan, in contrast, the semiconductor industry developed later, the technology being acquired by large R&D conducting companies. Its assimilation was aided by publicly-funded collaborative research, though the Japanese companies rapidly built up their in-house R&D capability in semi-conductors and have become major competitors to the U.S. firms. Based on this, and similar examinations, Rothwell goes on to conclude that "successful assimilation is a process of establishing technological complementarity between imported technology and in-house expertise. Attempting to substitute national capability through technology importation is not, in the long-term, a viable policy".

Finally, in one of the earlier attempts to quantify the relationship between diffusion and R&D expenditures, Mansfield and Schwartz(2), showed that for given industrial sectors, the rate of diffusion of a foreign innovation into a country was directly influenced by the level of R&D within that industry sector in the country. McMullan (13) also found a positive, through weaker, relationship between lag lengths and R&D intensity.

FIGURE 3

JAPANESE EXPENDITURES FOR R&D AND FOR IMPORTATION OF TECHNOLOGY



Industrial R&D in Japan and Importation of Technology by Sector (1974)

	Total R&D Expenditure 1589 billion yen	Fees and Royalties Paid 160 billion yen
	%	%
1. All manufacturing	91.8	96.7
2. Electrical Machinery	25.0	24.6
3. Chemicals	19.1	16.9
4. Transportation Equipment	15.2	16.7
5. Other Machinery	9.2	12.9
6. Iron and steel	5.1	4.2
7. Other	18.2	21.4
8. Non-manufacturing sector	8.2	2.8

Source: Research Policy 13, p.28, 1984, Oshawa Keichi.

TABLE 4

CANADIAN INDUSTRIAL R&D EXPENDITURES VS PAYMENTS FOR TECHNOLOGY

YEAR	1. INDUSTRIAL R&D EXP. (current $) (000,000)	2. PAYMENTS FOR TECHNOLOGY* (current $) (000,000)	3. 2 ÷ 1	4. ROYALTIES & SIMILAR PAYMENTS** (current $) (000,000)	5. 4 ÷ 1
1967	336	42	.13		
1968	342				
1969	394	62	.16		
1970	413			163	.40
1971	464	58	.13	193	.42
1972	462			221	.48
1973	503	90	.18	263	.52
1974	613			343	.56
1975	700	119	.17	408	.58
1976	755			435	.58
1977	857	154	.18	483	.56
1978	1006			578	.57
1979	1266	213	.17	632	.50
1980	1571			868	.55
1981	2082	307	.15	996	.48
1982	2381	354	.15		
1983	2551(P)				

* Excludes payments for R&D conducted abroad. Includes only payments for technology by firms conducting R&D.
Source: Statistics Canada 88-202, 1984, Table 40

** Sources: CALURA, Statistics Canada 61-210, Table 14.

FIGURE 4

INDUSTRIAL R&D EXPENDITURES vs PAYMENTS FOR FOREIGN TECHNOLOGY

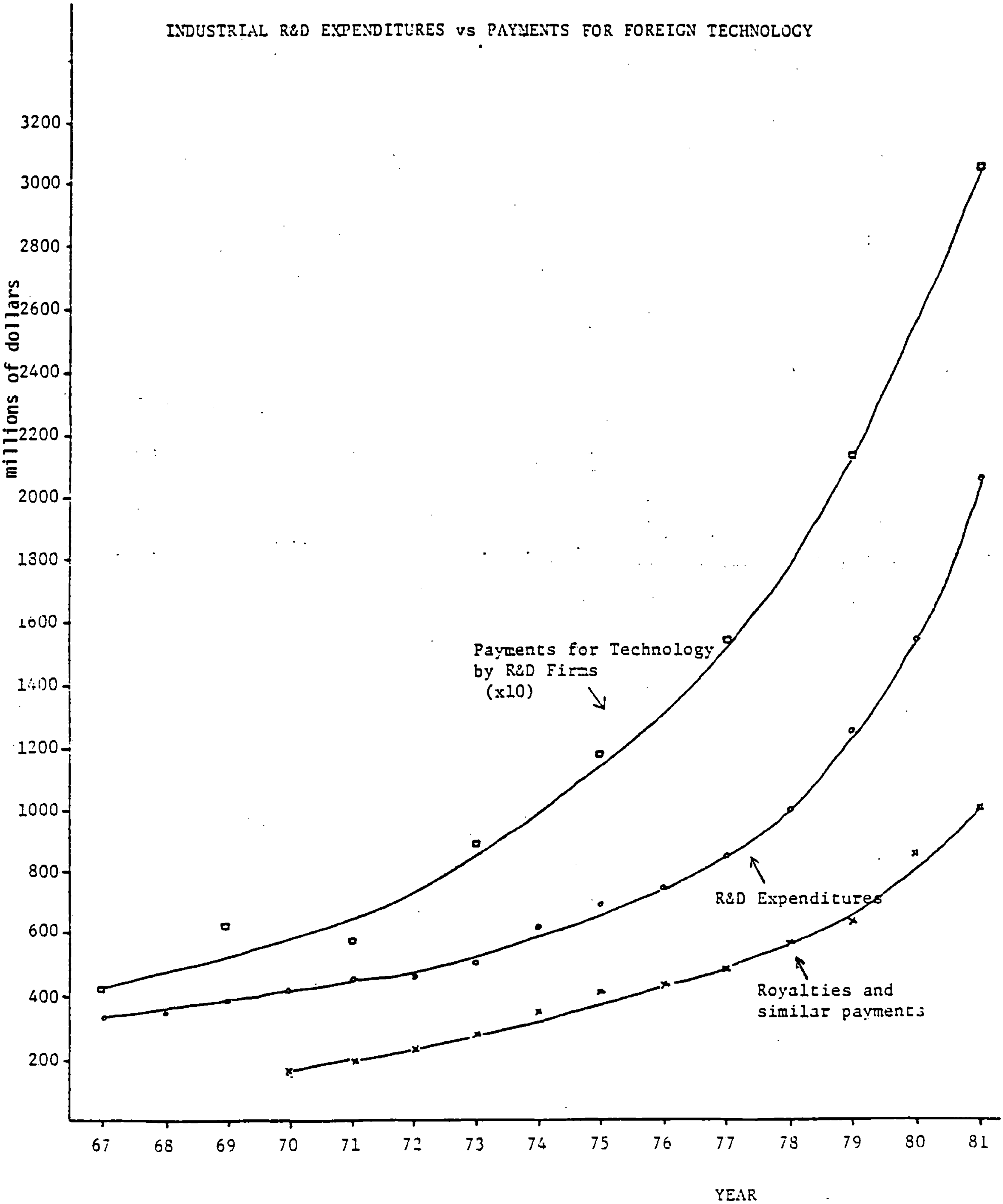
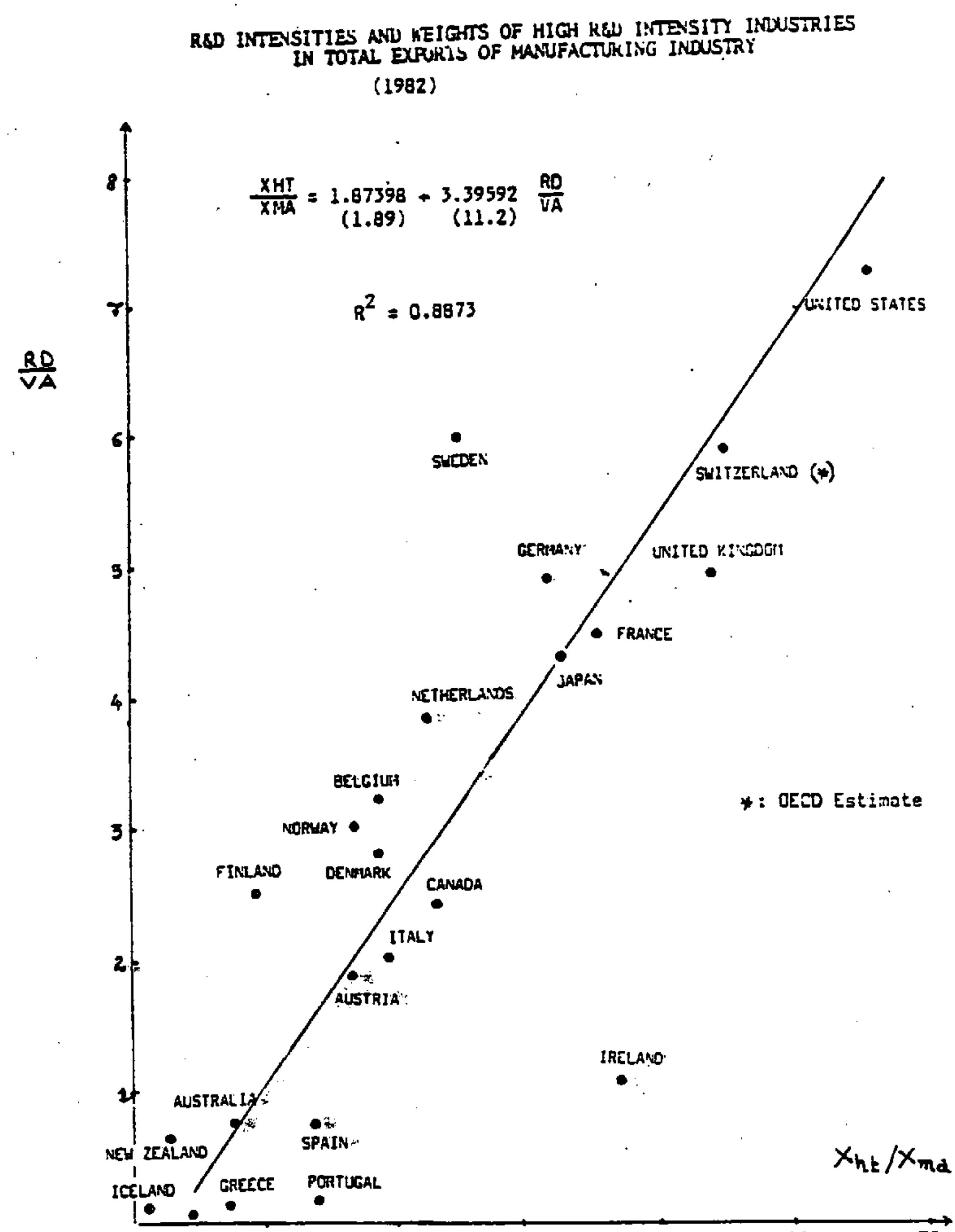


FIGURE 5



where VA: value added of manufacturing industries
RD: total R&D expenditure of manufacturing industries
Xht: exports by high-intensity industries
Xma: exports by manufacturing industries

Source: OECD DSTI/SPR/84.66 "Trade in high technology products".

In its latest annual review[30] the Economic Council, in dealing with the issue of diffusion, states that "the lack of close correlation between R&D intensity and success in exporting high technology could indicate that for many countries it is more important to follow the technical leader and adopt best-practice technology - which in most cases has been that of the United States - than to develop new technologies through R&D". The difficulty with this statement is that there is a clear correlation between R&D and exports of high technology as Figure 5 demonstrates.

For proponents of the view that Canada should simply purchase foreign technology at the expense of conducting domestic R&D, Gold's caveat that "later adopters face decreasing benefits" should be remembered. State-of-the-art or even best-practice technology may not be available to independent Canadian firms (cf. parent-subsidiary transfers) unless they have technology to trade in return. This may not apply, of course, to the purchase of up-to-date machinery and machine tools or similar equipment and systems. On the other hand, these would not necessarily provide a competitive edge since they are potentially available to all manufacturers in any country.

7. GOVERNMENT PROGRAMS FACILITATING DIFFUSION

A. Existing Programs

The Canadian government has developed an extensive array of programs to encourage industrial and regional development, many of which, although not designed specifically to support the diffusion of new technology, do so through providing funding and advice to firms engaged in modernization, innovation, expansion, R&D, and so on. A selected cross-section of these programs is described in Appendix C. The summaries give a brief description of the type of assistance, how it is being used and by whom.

The Federal government offers funding under such general programs as the Industrial and Regional Development Program (IRDP), and under more limited programs (that is, limited in terms of industry or size of client firm) such as the Defence Industry Productivity Program (DIPP) and the Small Business Loans Act (SBLA). R&D support programs such as the Industrial Research Assistance Program (IRAP) and the Program for Industry/Laboratory Projects (PILP), now merged with

IRAP, also contribute to technology diffusion by assisting Canadian companies to develop, adopt and commercialize Canadian technology. The new Technology Inflow Program (TIP), which includes the appointment of officers in a number of Canadian embassies or consulates with the specific function of identifying technologies of likely interest to Canadian industry, will help Canadian firms to acquire foreign technology. Other programs such as the Inter-Firm Comparison Program and the advisory service of IRAP encourage firms to at least investigate the potential for new technology use. These are, of course, only a few of the many government programs, some in specific subject areas (such as agriculture and energy), which offer support and advice to industry. The ones named above, however, do offer major opportunities for encouraging technology diffusion.

In addition to all of the programs, there is the growing network of technology centres across the country designed to support industry needs for new technology or specific technical skills. A MOSST study, completed in August, 1985(31), identified over 250 such centres, supported by the federal and provincial governments, universities and/or industry. Annual federal support for these centres amounts to about $455 million, though only about $100 million of this is identified as being in direct support of industry.

The major federal program for financial assistance to industry is the IRDP, which in 1985-86 has a budget of $240 million. Administered by DRIE, it is intended to promote industrial and regional development through supporting private sector initiatives which will reduce regional disparities and will offer economic returns, sustained growth, and international competitiveness. Assistance, in the form of outright contributions or contributions which are repayable, is provided in four categories: innovation, establishment, modernization/expansion, and marketing. While these elements support technology diffusion by financing new facilities and equipment, there is no specific focus on the use of new technology. As well, IRDP is a regional development program and the funding is structured in a "tier" system such that some of the most developed parts of the country are ineligible for IRDP funding under the Establishment and Modernization/Expansion Elements. Thus, the manufacturing sector in many parts of Ontario could not make use of IRDP funds.

With the planned devolution, through subsidiary agreements, of parts of IRDP to the Provinces, funds under the Establishment and Modernization/Element may be accessible to small and medium-sized enterprises in areas where the tier structure previously excluded them. The devolution is designed to improve the delivery of the Establishment and Expansion/Modernization elements to SMEs, focussing on projects with up to $2 million in eligible costs and businesses with up to 250 employees or $7 million in assets. Large projects and large companies will, however, continue to be subject to the limitations of the tier structure for the IRDP delivered by DRIE, preventing the use of the Program in support of technology diffusion for this segment of the population.

The various studies discussed earlier in this paper, (Section 5), have identified small companies as having greater difficulty than medium and large companies in adopting new technology. The difficulty for small companies arises from lack of knowledge and appreciation of the technologies most appropriate to their operations, lack of ability in undertaking feasibility/cost justification studies, lack of trained personnel and lack of funds for investing in new technologies. Many of the existing federal programs focus specifically on SMEs. In 1984-85 the largest number of offers under IRDP (84%) went to firms with revenues of less than $10 million, but 66% of the funds went to medium and large-sized firms, i.e. those with revenues over $10 million.

The R&D support programs (PILP and IRAP) have a special emphasis on small companies: in 1984-85 66% of PILP clients were firms with fewer than 200 employees. Under IRAP, 85% of the budget went to such small firms. IRAP in particular is popular with small companies because of the advisory services offered. Clients rated IRAP in a 1984 evaluation as "much better" than similar programs for speed of decision making, simplicity of procedures and quality of technical advice and assistance.

Another source of funds for small companies is the Small Business Loans Act, which offers loans at one per cent above prime rate through designated lenders. The loans are available to new or existing small businesses for a variety of capital purposes. Companies must have less than $2 million in annual revenue.

A program which could be useful in helping more firms to recognize the importance of new technology is the Inter-Firm Comparison Program, delivered by DRIE. At no charge to participating companies, DRIE will carry out an analysis of the companies and, using approximately forty productivity ratios, will assess the companies' relative standing against the industry median, and against each other. Strengths and weaknesses are identified and suggestions are made for improvements. At present there is no emphasis on the role of automation or other new technology, but that aspect of the analysis could be enhanced.

The Department of Consumer and Corporate Affairs has established a Patent Information Exploitation Program, which will make patent data more readily available to all sectors through provision of an "expert" interface, through progressive computerization of the system, and through a public education and awareness effort.

This is just a sampling of selected federal programs showing the range of financial support available to all sizes of firm interested in acquiring new technology. In addition, the provincial governments offer funding, advisory, and training programs to encourage the diffusion of new technology in industry. Many of these are listed in Appendix C. The major problems for firms, especially smaller ones, wanting to acquire and use new technology seem to be: how to use the right information to get the right equipment, and where to find the technical expertise to do so. A primary source of assitance in both these areas is the network of Technology Centres.

B. Technology Centres

Technology Centres, as defined in the MOSST review of August, 1985(31), are "organizations sustained through federal grants or contributions or operated by the federal government and which were designed to function predominantly in support of industry needs for new technology or specific technical skills". The centres may be operated by the federal or provincial governments, by universities, or by industry. The MOSST study identified almost three hundred such centres across the country, serving a wide range of clients in a variety of areas. During the past ten years, there has been a rapid growth in the number of new centres, especially in Ontario, Quebec and Nova Scotia. Major subjects covered include CAD/CAM, robotics, software computing technologies, and energy.

Many of the centres were set up to serve small and medium-sized companies which might otherwise have difficulty in acquiring and adapting new technology for their own use. The centres make available highly qualified engineers and scientists to many SMEs which may not have access to skilled personnel. A recent report for the Ontario Centre for Advanced Manufacturing indicated that approximately 80% of Ontario manufacturers have no registered professional engineers on staff.[32] Particularly in the high technology fields of microelectronics, informatics, CAD/CAM, robotics, flexible manufacturing and artificial intelligence, the MOSST study found that the centres "do not serve the large hi-tech industries in the communications, electronic equipment and computers sectors but they serve the smaller industries that need to use the hi-tech products, but are unable to develop the expertise to select and adapt commercial systems".

An example of this relationship between companies and centres was described recently in an article in the Globe and Mail of November 15, 1985[33]. On that date, Echlin Canada Inc., a company with 100 employees, unveiled two robots on its plant floor. Echlin has been making brake parts in Canada for about twenty years and had sales of about $30 million last year. The company first became aware of the possibilities of using robots in its operations two years ago, when its President attended an open house at the Ontario Robotics Centre, part of the Ontario Centre for Advanced Manufacturing (OCAM). The Robotics Centre, working with Echlin, contracted Numet Engineering to build the robotic work cell. The President of Echlin said in the Globe and Mail article that the company could not have automated without the Centre's help: "We don't have the expertise." Echlin spent more than $500,000 for the robots and OCAM spent about $70,000.

Another approach is taken by the Industrial Technology Transfer Centre of the Saskatchewan Research Council. The Council uses funds provided by DRIE and the provincial government to place CAD/CAM equipment on shop floors throughout the province, with training provided on site. The installed equipment is connected to a central Control Data computer in Saskatoon and the longer the equipment is in place the more the company must pay for its use. This allows companies to apply the technology at about one-quarter of actual cost, while gaining familiarity with it[34].

The technology centres form a valuable link between the vendors of technology and the companies purchasing it. The report for OCAM identified "inadequate support and services from vendors" as a major problem in the adoption of advanced manufacturing technologies. This lack of support was attributed to the "high rate of evolution in vendors' products and systems", steadily dropping prices, meaning vendors "cannot afford to spend as much time assisting or guiding the customer", and to "the growing need for integration of disparate products or systems which were previously operated independently". With the increasing need for integrating products from different vendors, the technology centres offer unbiased assistance and familiarity with a wide range of products, services especially useful to smaller companies on whom vendors may be unwilling to spend much time or effort.

But are the centres being used? The MOSST study found that the majority of centres were fully or over-utilized, according to their staff. In a detailed review of about forty technology centre projects, MOSST found that participating firms felt the centres had made strong contributions to the success of the projects. Many of the firms did not know of alternative sources of similar expertise.

The technology centre network has been variously criticized for duplication, fragmentation, and draining skilled personnel from industry. The findings of the MOSST investigation of the centres suggested that generally these concerns are overstated. With respect to duplication and overlap, even the most frequently-serviced fields of microelectronics, biotechnology and CAD/CAM, showed negligible overlap. The problem of fragmentation, however, does appear to be a real one. Over one hundred of the centres provide services to industry in one or more of twelve technology fields. In a majority of cases the amount devoted by any one centre to a particular field is less than $100,000 per year. This implies under-funding or fragmentation and indicates the need for more investment in the centres.

There does not appear to be a problem of skilled personnel being drained from industry. Rather, there is a high turnover of such personnel from the technology centres. Thus the centres seem to be a source of practically-trained scientific and technical staff for industry.

The network of centres continues to grow. Recent announcements have included the Canadian Workplace Automation Research Centre in Laval, Quebec, and the expansion of the Centre québécois pour l'informatisation de la production to at least ten locations in Quebec over the next two years. While the establishment of the centres in itself is an important step, efforts must be made to ensure that the companies which need their services most will know how to obtain access to them and use them to best advantage.

C. Other Countries' Experiences

Many of the OECD countries, particularly the more advanced European countries, have a panopoly of programs to assist in the transfer and diffusion of technology. Many of these efforts date from the late 1960s or early 1970s. A survey of the various transfer mechanisms adopted by different countries was prepared for the Ontario Ministry of Industry and Trade and published in July, 1984.(35) This report describes in some detail the wide array of government and industry programs which have been implemented in Britain, and these programs are replicated to a greater or lesser degree in other European countries.

Industrial research associations have existed for many decades and, in addition to providing R&D assistance to the industry, contribute significantly to keeping member-companies aware of technological advances. Many of these research associations now exist independently of government funding. Some permit foreign memberships and Canada, through NRC, has an associate membership of the Production Engineering Research Association (PERA).

In order to address the needs of small firms, which lack the technically trained personnel to evaluate and implement new technologies, Industrial Liaison Centres, attached to universities or technical colleges, were established and operated by Industrial Liaison Officers. They appeared to be successful in aiding small companies to adopt new technologies, but many were unable to survive once government funding was withdrawn. Their success was attributed largely to the fact that the industrial liaison officers spent much of the time visiting the companies, i.e. taking technology to the company rather than expecting a company to visit the centre. The current IRAP field staff perform a very similar function in Canada, though often attached to Provincial Research Organizations as well as to the universities.

Low Cost Automation Centres, also based on universities and technical colleges, were a parallel development and aimed at introducing automation to SMEs through demonstration projects, seminars and consultancy. The OCAM CAD/CAM and robotics centres and the robotics centres based on CEGEPS and universities in Quebec appear to be current Canadian parallels.

A third interesting initiative in Britain was a contract given to the Production Engineering Research Association to provide a production engineering advisory services. The service operated a number of large mobile units, comprising a lecture room and demonstration equipment, which would visit small and medium-sized enterprises. Initial visits were free and any subsequent consulting advice subsidized. Ex-post evaluations of the service indicated that high levels of performance improvement were obtained at relatively low cost. The idea has been adopted by other countries including France and Sweden.

In a change of policy in the early 1970s, it was decided that SMEs would be better served by providing general information and advice, and directing them to other specialists, rather then providing direct technical assistance as the above programs had done. After three years it became apparent that this was totally insufficient and direct technical assistance services were re-introduced. A large number of such programs have been initiated, often oriented to providing consulting assistance and aid in the conduct of feasibility studies. Initial consulting assistance, for 5 to 15 days, is usually free, with a range of fees being charged for additional assistance. This approach does, however, get SMEs into the habit of using such services and give them a certain degree of confidence in the use of outside experts. Many of the programs are oriented towards specific strategic technologies, and grants to partially cover the cost of new equipment and machinery are often available (up to one-third of capital costs).

One further scheme of note is the provision of grants to permit young industrial engineers to work for up to one year in Japan, and thus learn their technology at first hand.

While the above discussion relates specifically to British schemes, as previous noted many of them also operate in other European countries. West Germany, for example, has a highly active consulting service program based on local Chambers of Commerce. The costs are shared among industry, local and federal governments.

8. IS FURTHER ASSISTANCE REQUIRED?

As indicated in the previous sections of this report, there is a high level of interest and activity in the development and implementation of advanced technologies in many sectors. Both federal and provincial governments have a wide array of programs whose objective, at least in part, is to stimulate the use of "state-of-the-art" and "best-practice" technologies. Some of these initiatives, as exemplified by the robotics and CAD/CAM centres of the Ontario Centre for Advanced Manufacturing and the more recent robotics-oriented centres in Québec, are directed specifically to the introduction of advanced manufacturing technologies into Canadian industry. A number of direct advisory programs, which include portions of NRC's Industrial Research Assistance Program and the parallel mechanisms of the provincial research organizations, also exist to encourage manufacturers to adopt new methods. Most universities now appear to have established industry liaison groups to generate and encourage co-operative endeavours. The federal government, through DRIE, provides financial assistance to selected industries to upgrade their manufacturing facilities, while External Affairs is endeavouring to put into place a more effective system to identify and facilitate the transfer to Canada of new foreign technologies of interest to Canadian industry. Are further initiatives required?

The premise on which the present study was initiated was that Canada was much more reluctant or, at least, slower to adopt new technologies than its industrial competitors. Some evidence has been presented in this study to indicate that significant changes are now taking place in both the industrial and service sectors, particularly with respect to the introduction of microelectronics. Such changes are also taking place in other countries and it is not clear whether Canada is gaining or losing ground relative to these countries, though, at present, we appear to be at least on a par with much of Europe. The position with respect to adoption of new, non-microelectronic technologies is even less clear.

It has also emerged from the recent studies in Ontario that a high percentage of the smaller manufacturing companies, that is those with less than 100 employees, have little interest in upgrading their manufacturing technologies. Their familiarity with the technical centres and similar government initiatives was, in general, minimal. Where such companies did express an interest, they often were unable to conduct suitable cost-benefit analyses or feasibility studies, nor did they know how to go about selecting appropriate equipment.

UK

The major problem raised by firms, large and small, in Canada and in Europe, was the perceived shortage of personnel having the appropriate skills, with the concomitant problems of training existing staff. Resistance to change by workers or unions was given a surprisingly low rating in the surveys, though it was quoted as a more important problem by larger firms which had actually implemented some new technologies.

Given these perspectives a number of thrusts might be pursued by the federal government. In many cases they may be extensions and reinforcements of existing programs rather than new initiatives. Many of the studies of diffusion have emphasized the need to examine the situation at the sector or sub-sector level with new incentive programs tailored accordingly. Generalized programs may be less effective.

A. Assessment of Current Position

It would appear incumbent upon government to obtain a better perspective on just what changes are taking place at present and how rapidly.

MOSST, in conjunction with Statistics Canada, has prepared a draft proposal to conduct a survey relating to the use of robots in Canadian industry. Such a survey would be a pilot study, forming the basis for an on-going statistics program of Statistics Canada for monitoring the use of robotics and of other technologies. This initiative could be supplemented, in the short-term, with individual industry surveys or, at least, a monitoring of such surveys carried out by industry associations or other bodies.

A second approach that might be considered is to extend the present productivity studies being conducted by the Market Development Division of DRIE, to include an appraisal of the level of technology in use within a plant. In this program, as previously noted, consultants visit individual establishments, usually within one industry sector, to establish productivity levels. The data are published in aggregate form and permit individual plants to compare themselves with the average and best plants within the industry. Including some assessment of technology levels may permit some conclusions to be drawn as to the relative effectiveness of such technologies in increasing productivity. A recent study by Forintek of seven British Columbia sawmills indicates, however, the importance of ensuring that the technology is properly used. While one mill with advanced equipment did indeed achieve the highest lumber recovery rate from a standardized log, other mills with similar equipment were achieving lower rates than some mills without such equipment. A systems approach to the implementation of new technologies is essential.

MOSST will continue to examine aggregate measures, similar to those presented for imports, to determine their value in monitoring the progress of technology. One refinement of this process would be to use the Import Analysis capability of DRIE to determine the industrial sectors using each type of equipment and to obtain a finer breakdown of equipment types.

B. Consulting Assistance

There appears to be a consensus that the transfer of technology is, quintessentially, a "person-to-person" process. Information banks are an essential part of the diffusion mechanisms, but tend to be used by the expert who, in turn, interacts with the potential users, particularly where these are smaller firms. Additional dissemination of technical information in printed form may achieve little - a number of diffusion studies have shown that such information has little influence in diffusion rates. The British experience of the early 1970s, described in section 6.C of this paper, tends to confirm this thesis.

The surveys indicate that smaller firms are generally unaware of the technology centres and our discussions with IRAP field officers and others stress the difficulty of having managers of small firms leave their enterprises even for a few days. It appears that the technology has to be taken to the potential user and

UK

direct technical advice, in terms of analysis of needs and evaluation of appropriate equipment, is required. An expansion of this consulting type assistance seems therefore to be warranted. This could take a number of forms: an expansion of the IRAP field service; provision of assistance to industrial associations to set up or operate such a service for their members; or provision of assistance to local groups, such as Chambers of Commerce as in West Germany, to provide consulting assistance. Industry would be expected to share in the funding. Perhaps mobile demonstration units should also be considered, though in-plant demonstrations in firms of comparable size (i.e. not at General Motors) appear to be the most effective means of persuading managers to investigate the technologies.

An experiment along these lines was conducted by Forintek in conjunction with CRIQ last year. Teams of consultants visited a number of sawmills in Quebec and made recommendations as to how productivity could be increased, both with and without significant capital expenditure.

C. Financial Incentives

The above measures are suitable for SMEs but probably less applicable to the large firms. However, the larger firms produce most of the output of the Canadian economy and are where efforts to improve the rates of technology diffusion should, perhaps, initially be concentrated. MOSST is just completing a number of concurrent studies to examine the potential for new technologies in the primary resource sectors.

In the case of large resource based and manufacturing firms additional financial incentives related to investment in new equipment may be necessary. Certainly such incentives appear to be common in Europe(35). Gold(36) has suggested that progressively greater tax credits should be given for technology improvement projects which have long pay back periods. He also suggests that firms should be allowed to begin charging depreciation allowances at the same time as construction begins where such projects will not yield revenues for several years. These measures would, in part, address the problems faced by senior corporate managers of having to produce short-term results, whereas major technological changes are often long-term investments. Measures which simply increase a company's cash flow or profitability probably will not lead to proportionate increase in innovative efforts unless managerial perceptions as to their relative profitability are changed.

D. Industrial Associations

In some industrial sectors, notably in pulp and paper, industrial research associations have become very active in evaluating and promoting new technologies, though again there appear to be few formal studies of their success in inducing firms to implement such technologies. The approach has the merit of having a strong industry focus and industry support, particularly from large firms. In principle, such research associations should be of significant benefit to industry sectors comprising large numbers of smaller firms for they could supply the technology base and work on scaling down and otherwise adapting foreign technologies to meet Canadian conditions. The individual small firm may not have this capability.

In considering the promotion of the diffusion of foreign innovations in Canada, the Industrial Innovation section within DRIE has also suggested a much increased role for the industry associations, both in identifying their members' technological needs and in providing the necessary stimulus through seminars, demonstration projects, arranging foreign visits, etc. Support would be provided through IRDP and through External Affairs' trade programs. The DRIE regional offices, provincial research organizations and NRC would form an active network, dealing with individual firms and with the associations, performing a technology brokerage function as required.

E. Training

A major problem identified by most companies in almost all surveys of technology diffusion and innovation relates to the scarcity of appropriately-trained technical personnel and the need for assistance with in-plant training. These comments are, however, too general to permit an analysis of the real needs. The survey conducted annually by the Ministry of Colleges and Universities in Ontario indicates that many of the technical college graduates in the province have difficulty in finding employment in their field. Table 5 on the following page illustrates the problem, showing the number of graduates available for employment in selected technological fields and the actual number

TABLE 5

GRADUATES AVAILABLE AND SEEKING WORK VS NUMBER FINDING JOBS

	1983-84		1982-83		1981-82		1980-81	
	Available	Working	Available	Working	Available	Working	Available	Working
Biochem. Technician	15	7	3	0	7	4	8	5
Biochem. Technology	22	15	23	15	31	19	45	42
Biology Lab. Technology	18	12	12	8	21	9	19	17
Chem Eng. Technology	92	75	74	57	82	63	92	86
Comp. Sci. Technician	10	8	11	4	9	9	17	17
Comp. Sci. Technology	133	107	115	91	118	85	111	110
Comp. Systems Design	133	95	71	51	17	11	14	14
Comp. Systems Technician	16	8	-	-	-	-	-	-
Control Systems Tech.	10	10	15	8	20	14	32	32
Elec. Eng. Technician	96	42	71	34	105	67	73	70
Elec. Eng. Technology	89	46	70	37	59	48	68	66
Electronic Comm. Techn.	78	52	37	20	31	10	-	-
Electronic Controls Tech.	16	7	-	-	-	-	-	-
Electronic Technician	387	212	299	149	231	138	296	266
Electronic Technology	242	180	209	135	199	159	198	195
Industrial Microbiology	7	4	4	2	6	6	7	7
Instrumentation Technician	114	46	84	29	103	64	69	65
Instrumentation Process Control	1	1	4	3	5	2	6	4
Materials Science	31	18	22	11	9	5	14	14
Process Operations	14	5	50	2	102	24	54	42
Telecomm. Technology	24	18	18	16	17	14	13	13
Transport Technology	10	4	14	8	12	8	10	8
Industrial Robotics	36	15	-	-	-	-	-	-
Total	4458	2845	3889	2179	3820	2254	3703	3274
	63.8%		56.0%		59.0%		88.4%	

Source: Ontario Ministry of Colleges and Universities, Graduate Placement Report.

finding suitable work. Similarly, the Technical Service Council reports that there are several thousand unemployed graduate engineers seeking work in Canada. It would appear that companies prefer to re-train existing staff, but a comparison of the European and Canadian surveys indicates that it is perhaps a field in which Canada has been particularly weak in the past.

One approach to introducing expertise into a firm adopted in Britain in the late 1970s was the Teaching Company Scheme. It has gradually been expanded and is reported to be very successful. Under the scheme a recent graduate, usually from an engineering discipline, works with a company for two years and is jointly supervised by industry and university personnel. The main focus of the work of the Teaching Company Associate, as the graduate is known, is to upgrade the manufacturing capabilities of the company. The Science and Engineering Research Council and Department of Trade and Industry provide grants towards the basic salaries of the Associate and the academic support costs. Such a scheme would seem to be equally applicable and beneficial to Canadian industry. The IRAP H component, which supports the employment of undergraduates in smaller firms during vacations, performs a somewhat similar function but usually addressing projects of much smaller scope.

F. Marketing Assistance

One major stimulus to plant expansion and modernization is a perceived market opportunity. Many studies have indicated that SMEs in particular have difficulty in identifying new markets and, indeed, in conducting market research studies, and this may be even more of a problem for new, entrepreneurial firms. Few government programs support this step in the innovation chain. In a separate paper, MOSST is proposing the establishment of a number of New Ventures Assistance Centres which would be supported by a central source of marketing data. Such a source could also be of inestimable value to other more established SMEs. It might be noted that such a proposal was recently strongly promoted in the Economist in an article entitled "Into Intrapreneurial Britain"(37).

G. Other Suggestions

Given the resource intensive nature of the person-to-person contacts that seem to be required, government programs must seek to obtain some leverage if they are to have a wider impact. One way of achieving this may be to focus efforts on equipment suppliers, encouraging them to adopt foreign technologies to the needs of the Canadian market, stimulating their internal developments or assisting in arrangements for joint ventures with foreign machinery manufacturers. Studies have shown that suppliers are a major source of new ideas for a large proportion of firms and their proximity to the user is of significance.

The second group worthy of particular attention would be the consulting engineers, since they are designing installations for their clients. The consulting engineers are, however, operating under the same pressures as many small firms and will not normally take the time to upgrade their knowledge of new technologies. The government could grant financial assistance to facilitate their participation in intensive seminars on specific technologies. The engineering companies also run significant risks in recommending relatively new technologies to their clients - perhaps some form of insurance to reduce such risks could be devised.

Many managers are reported to be reluctant to consider new technologies because of "horror stories" circulating within the industry. Perhaps these attitudes can be offset by much greater use of local print media to portray successful implementations of technology. A recent example of this was a prominent article on the introduction of robots, facilitated by OCAM, into an Ontario plant, resulting in the increase of production and attraction of jobs from the United States[33]. Considerable scope for such promotions exists and the news stories probably reach a wide audience. The articles could be tailored specifically to the interests of the region or locality. Surveys indicate that there is a need to persuade small business owners to at least examine the potential of new technologies. A second approach along these lines could be to produce videotapes, showing in detail how a small plant was modernised and indicating clearly how problems were addressed. Such tapes could be made available to individual plant owners or managers through industry associations and local business groups.

9. CONCLUSIONS AND RECOMMENDATIONS

The preceding portions of this paper lead to the conclusion that technology diffusion is a multi-faceted problem requiring multi-faceted solutions. There is clearly scope for testing a wide variety of programs and ideas and, as the array of initiatives identified in this paper indicates, this is to a large degree already happening. There is an apparent failure, however, to establish such programs on a sufficiently rigorous basis that their effectiveness might be determined. Perhaps it is too optimistic to assume that in such a complex, interacting field the impacts of one program can be differentiated from the impacts of others, but a greater focus on analysing what works in different situations and different industries seems to be warranted. A wide variety of case histories might provide an understanding of the common threads.

While the rapid diffusion throughout Canadian industry of technologies already in use elsewhere would doubtless yield benefits over the coming years, our competitors will make further advances during this period. Diffusion of present technologies must be accompanied by a significant increase in our own ability to further develop and enhance the technologies we acquire and, indeed, to work with currently emerging technologies. There is a wealth of evidence to indicate that the development of a "technological capability is a cumulative learning process and new know-how cannot be picked simply off the shelf"(29). Purchase of technology is not a substitute for R&D, but rather a complement.

Federal and provincial governments have undertaken a wide array of initiatives to stimulate innovation and technology diffusion in recent years, but many firms and institutions still exhibit a reluctance to become involved. Section 8 of the report identified possible ways in which further assistance or stimulation might be provided. They focus essentially on the provision of increased advisory/consulting assistance, particularly for smaller firms; on means of increasing the availability of people with appropriate technical skills; on a greater role for industrial and business associations; and on trying to create a higher profile for and positive attitude towards technological change. In addition, government policy makers need to be more cogniscent of the rates at which technical changes are occuring and in which sectors, in order to better gauge Canada's competitive capabilities and the potential impacts on employment.

In view of these findings, and the already extensive activities of the provinces in promoting new technologies, it is recommended that MOSST proceed as follows:

- this report and its findings should be considered under the umbrella of the National Policy on Science and Technology in order to identify future actions by the two levels of government;
- MOSST must continue to emphasize the need for more research and development while also searching for means to stimulate technology diffusion;
- to address the perceived need for qualified personnel and to reduce smaller companies' apprehensivenes of new technologies, MOSST should promote a program to encourage these firms to take on a newly-qualified or unemployed engineers with the specific aim of upgrading the firms' technologies. Training to up-date the engineers' knowledge in specific fields would be provided as necessary by the technology centres;
- develop, in conjunction with DRIE, the new ventures assistance centres and an accompanying market information network, as described in a separate MOSST paper. This initiative could benefit many SMEs, increasing their knowledge of markets and stimulating the growth of suppliers of technology;
- develop suitable indicators or means of monitoring technology diffusion rates by sector in conjunction with Statistics Canada.

These activities will be the focus of MOSST's efforts with respect to technology diffusion.

key

BIBLIOGRAPHY

(1) Economic Council of Canada, "The Bottom Line: Technology, Trade and Income Growth", 1983.

(2) Schwartz, M.A., "The Imitation and Diffusion of Industrial Innovations" Ph.D. Thesis, University of Pennsylvania, 1978.

(3) Globerman S., "Technological Diffusion in Canadian Manufacturing Industries", Research Report No. 17, Technological Innovation Studies Program, Ottawa: Department of Industry, Trade and Commerce, 1974.

(4) Globerman S., "The Adoption of Computer Technology in Selected Canadian Service Industries", Economic Council of Canada, 1981.

(5) Martin F., Swan N., Banks I., Barker G., Beaudry R., "The Inter-regional Diffusion of Innovations in Canada", A Study for the Economic Council of Canada, 1979.

(6) DeMelto D.P., McMullen K.E., Willis R.M., "Preliminary Report: Innovation and Technological Change in Five Canadian Industries", Discussion Paper No. 176, Economic Council of Canada, October, 1980.

(6a) McFetridge D.G., "Recent Developments in International Technology Transfer: A Canadian Perspective", Workshop on International Technology Transfer, Ottawa, May 6, 1985.

(7) Mansfield et al., "Technology Transfer, Productivity and Economic Policy", W.W. Norton & Co., New York 1982.

(8) Gold. B., "Research, Technological Change and Economic Analysis", Lexington Books 1977.

Griliches Z., "R&D, Patents and Productivity," University of Chicago Press, 1984.

Rothwell R. and Zegveld W., "Industrial Innovation and Public Policy", Frances Pinter (Publishers) Ltd., London, 1981.

(9) Huroski Kasai, "What Makes a Company Perform Well? - A Recent Survey", Journal of Japanese Trade & Industry, No. 6, 1985, p. 66.

(10) Booz, Allen & Hamilton Inc. "Management and Technology: A Survey of European Chief Executives", 1985.

(11) Leontief W., "The Choice of Technology", Scientific American, June 1985, Vol. 252, p. 37.

(12) Daly D.J., "Technology Transfer and Canada's Competitive Performance", to be published in "Current Issues in Trade and Investment in Service Industries: US-Canadian Bilateral and Multilateral Prospectives", University of Toronto Press.

(13) McMullan K., "A Model of Lag Lengths for Innovation Adoption by Canadian Firms", Discussion Paper No. 216, Economic Council of Canada, April 1982.

(14) Gold B., "Technological Diffusion in Industry: Research Needs and Shortcomings", Journal of Industrial Economics, Vol. XXIX, 1981, p. 247.

(15) Government of Ontario, "The Ontario Task Force on Employment and New Technology", 1985.

(16) Ontario Ministry of Industry, Trade and Technology, "The Market for Flexible Automation Equipment in Ontario", November, 1985.

(17) Craig, R.G. and Noori, H., "Automation and Small Manufacturers", 30th Annual World Conference of the International Council for Small Business, Montreal, June 16-19, 1985.

(18) Ontario Centre for Advanced Manufacturing, "A Study among Ontario Manufacturers in regards to the Introduction of Advanced Industrial Technology and the Ontario Technology Centres", August, 1984.

(19) Policy Studies Institute, London, "Microelectronics in Industry - An International Comparison: Britain, Germany, France", 1985.

(20) Ministry of International Trade and Industry, "Small Business in Japan", p. 48, 1984 White Paper on Small and Medium Enterprises in Japan.

(21) Wedley W.C. and Vergin R.C., "CAD/CAM Technology in Canadian Manufacturing: A Study of Constraints, Incentives and Impacts", A study for the Department of Regional Industrial Expansion, Ottawa, April, 1985.

(22) Globe and Mail, August 24, 1984.

(23) Palda, K.S., "Industrial Innovation", The Fraser Institute, 1984.

(24) Oshawa Keichi, "Technological Innovation and Industrial Research in Japan", Research Policy 13, p. 285, 1984.

(25) Council for Science and Technology: Japan, "Current Status of Science and Technology in Japan", 1983.

(26) "Japan's Science and Technology Research Expenditure Now Level with USSR After USA", Technocrat, Vol. 18, No. 5, May 1985, p. 25.

(27) Longo, F., "Industrial R&D and Productivity in Canada", Science Council of Canada, 1984.

(28) Antonelli, C., "Technology Payments and Economic Performance of Italian Manufacturing Industry: An Empirical Analysis" OECD, DSTI/SPR/82.61.

(29) Rothwell R., "Technological Change and Re-industrialization: In Search of a Policy Framework", Symposium on Competitiveness Through Technology, York University, Ontario, April 24-25, 1985.

(30) Economic Council of Canada, 22nd Annual Review, "Strengthening Growth: Options and Constraints", p. 38., 1985.

(31) Ministry of State for Science and Technology, "Technology Centre Review Project: Detailed Volume (Volume II)", August 13, 1985.

(32) CAD/CAM Newsletter, June 1985, published by the CAD/CAM Technology Advancement Council Secretariat, DRIE.

(33) Globe and Mail, "Ontario's Stance is Revealed at Robot Unveiling", November 15, 1985.

(34) McMurdy D., "Technology Diffusion in Canada", Canadian Electronics Engineering, March 1985.

(35) Ontario Ministry of Industry and Trade, "Technology Transfer Mechanisms: An International Perspective", July, 1984.

(36) Gold B., "Strengthening the Technological Competitiveness of Industries: Potential Contributions of Government", Symposium on Competitiveness Through Technology, York University, Ontario, April 24-25, 1985.

(37) The Economist, "Into Intrapreneurial Britain", February 16, 1985, p. 19.

APPENDIX A

Appendix A

FACTORS KNOWN TO AFFECT THE DIFFUSION OF INNOVATIONS BY PRIVATE SECTOR FIRMS

1. Size of Firm affects likelihood of innovating (but not the success of innovations)

2. Firm's Understanding of User Needs (involves marketing, R&D and design integration)

3. Awareness of New Technology (from internal R&D and external sources) leads to early innovation.

4. Attitudes of Managers towards innovation.

5. Status of Innovator in Firm affects success of innovation.

6. Type of Industry affects the speed of diffusion within the industry.

7. Degree of Concentration of Firms in the Industry

8. Size and Sophistication of Available Markets, and Location of Firm with respect to urban centers and degree of initiative in the region

9. Availability of Risk Capital

10. Education Levels including number of scientists and engineers being trained, skill of general work force and knowledge of managers

11. Firms having No Strictly Defined Hierarchy tend to promote innovation diffusion. (Individuals performing tasks in light of knowledge of the whole firm)

Figure 1

Diffusion Process - Firm's Perspective

Is there a need? ⇄ Is information available on state-of-the-art? → What are the obstacles?

° Do firms perceive a need for new technology?

- Enhance competitive position
  - Price
  - Quality
  - Availability, through increased production
- Diversification strategy
- Meet regulatory requirements
- Entrepreneurial drive
- Meet customer requirements

Embodied Technology

Sources:
- Trade Magazines
- Suppliers
- Customers
- Trade shows
- Conferences
- Ind. Assoc.
- Innov./Tech. Centres
- Patents
- Govt. publ.
- Govt. personnel
  - IRAP
  - PILP etc.
  - Science Counsellors

Disembodied Technology

- Articles
- Trade Magazines
- Suppliers
- Govt. personnel
- Ind. Assoc. and Res. Instit.
- Demonstration projects
- Consultants

R&D Results

- Journals
- Conferences
- University faculty
- Res. Instits.
- PROs

. Technological risk
  - Downsizing of technology
  - Modifying to Canadian environment or firm environment
  - Inadequate technical base in firm. (New vs. improved technology)
. Market risk
  - Changes in tariff barriers
  - Competing new products/ technologies
. Financial risk
  - Long payback period
  - Low cash flow
  - Limited access to capital
  - High investment compared to firm's net worth
  - Low tax incentives (vis-à-vis competitors)
. Strong patent protection
. Lack of trained personnel
. Negative regulatory environment
. Low present capacity utilization
. Long useful life of existing equipment
. Requisite machinery not available locally - limited service/parts
. Conservative managerial attitudes
. Potential labour problems

APPENDIX B

R&D/Production

	1980 U.S.	1980 JAP.	1979 GER.	1980 FRA.	1978 U.K.	1980 ITAL.	1980 CAN.	1978 AUST.	1980 NETH.	1979 SWED.	1979 BELG.
Aerospace	.278	.014	.254	.168	..	.201(a)	.106(a)	..	..	..	..
Office Mach. & Comp.	.166	.051	..	.117	.140	.035	..	..	..	..	..
Electronic Components	.127	.052	.104(b)	.129	.133	.042	.104	.012(c)	..	.061(b)	.087
Drugs & Medicine	.094	.079	..	.057	.100	.062	.048	.023	..	.186	.099
Instruments	.092	.023	.026	.028	.018	.048	.010	.026	..	..	.098
Electrical Machineries	.065	.029	..	.019	.020	.006	.017	.017	..	..	.070
Motor Vehicles	.030	.023	.032	.026	.017	.019	..	.005	..	..	..
Chemicals	.017	.029	.050(d)	.009	.022	.009(f)	.008	.008(e)	..	.017	..
Other Manuf. Ind.	.019(g)	.013	.005	.006	..	..	.008	.008(h)	..	.0002	..
Non-Elect. Mach.	.014	.016	.035(c)	.007(a)	.010	.002	.008	.005	..	.027(i)	.032
Rubber & Plastics	.012	.012	.018	.018	.004	.008(j)	.004	.004	.005(k)	.010	.008
Non-Ferrous Metals	.006	.019	.007	.007(1)	.005	.005	.044	.002	..	.007	..
Stone, Clay, Glass	.009	.012	.009	.006	..	.001	.002	.001	.002	.011	..
Food, Drink, Tobacco	.002(m)	.004	.002	.001	.004	.004	.002	.002	.005	.004	.003
Ship Building		.033	.008	.002(1)	..	.005	..	.000	..	.006	..
Petroleum Ref.	.007	.005	.004	.006	.010	.003	.009	..	..	.001	.0004
Ferrous Metals	.005	.010	.006	.004(1)	.004	.001	.002	.006	..	.018	.007

R&D/Production (cont'd)

	1980 U.S.	1980 JAP.	1979 GER.	1980 FRA.	1978 U.K.	1980 ITAL.	1980 CAN.	1978 AUST.	1980 NETH.	1979 SWED.	1979 BELG.
Fab. Met. Products	.005	.004	.008	.005	.003	.000	.002	.002	..	.007	..
Paper & Printing	.004(n)	.002	.002	.001	.005	..	..	.002	..	.009	..
Wood, Cork, Furniture	.003	.002	.003	.001(1)	..	.00004(1)	.002(o)	.0009	.003(o)	.001	..
Wearing, Foot W., Leather	.001(p)	.003	.002	.002	.004	.001	.0001	.0006(q)	.001(p)	.005	..

Source: (1) OECD, International Survey of the Resources Devoted to R&D by OECD Member Countries, July 1984
(2) OECD, Science and Technology Indicators, Competitive Position Indications of Manufacturing Industries, March 1985

(a) includes missiles & rockets
(b) includes electrical - machinery
(c) includes office machinery & computers
(d) R&D includes drugs
(e) includes petroleum refineries
(f) R&D includes plastics
(g) R&D includes footwear and leather, tobacco, printing and publishing
(h) R&D includes leather
(i) R&D figure includes office - machinery and computers but the production figure is only for non-electrical machinery
(j) R&D does not include plastic
(k) includes footwear and leather
(l) 1979 figures
(m) R&D does not include tobacco
(n) R&D does not include printing and publishing
(o) includes paper and printing
(p) R&D does not include footwear and leather
(q) R&D does not include leather

APPENDIX C

Appendix C

AREAS IN WHICH GOVERNMENT POLICIES CAN AFFECT RATE OF DIFFUSION OF TECHNOLOGY

1. Support of R&D

2. Procurement policies

3. Stimulation of R&D spillover from government laboratories to the private sector

4. Education policies for increasing the level of education in S&T areas, increasing the number of scientists and engineers, and expanding the type of education provided (S&T and managerial)

5. Industrial competition vs. monopoly policies

6. Policies toward unions

7. Policies toward building codes and other devices that traditionally have obstructed the use of new technology

8. Tax laws, including import tax policies on licenses

9. Patent laws

10. Employment policies (e.g., personnel interchange, pension transferability)

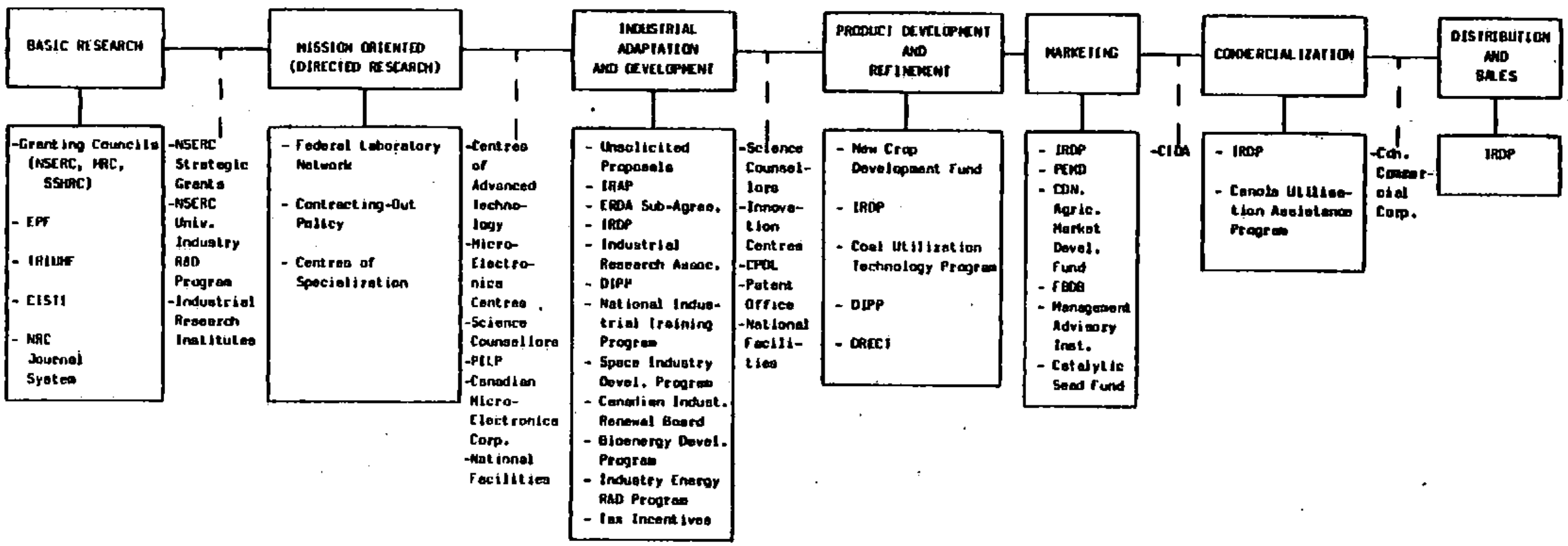
11. Policies that spread the social costs of technological change more equitably and reduce resistance to new techniques (e.g., retraining programs)

12. Creation of one coordinated and unified government agency to act as a broker and catalyst in the transfer process, to define the needs, markets and impact of implementing new technologies and to disseminate the technologies

13. Immigration Policies

14. Policies affecting the development of university spin-off organizations or university/corporate cooperative efforts.

MAJOR FEDERAL SCIENCE AND TECHNOLOGY INITIATIVES DIRECTED AT THE INNOVATION CYCLE



- Selected initiatives by the Federal Government in various phases of the innovation cycles: total Federal funds in the major industry support programs (e.g. IRDP, IRAP, PILP, UP, SDF, DIPP, IERD, Contracting-Out) amounted to approximately $660 million in 1984-1985, Granting Councils to approximately $507 million, and federal laboratories to $1.3 billion. Total $2.6 billion, not including tax expenditures.

¦ Indicates linkage program

TECHNOLOGY DIFFUSION
EXISTING FEDERAL GOVERNMENT PROGRAMS

Program: Defence Industry Productivity Program

Objectives:

1. To enhance economic growth through the promotion of viable defence or defence-related exports.
2. To provide a defence industrial base.
3. To maintain a defence technological capability.

Administered by: DRIE

Eligibility: Companies incorporated in Canada having an advanced technological capability in defence and defence-related products for export sales. Projects must be carried out primarily in Canada and must be within the applicants' capabilities.

Assistance: Assistance is offered in the following areas:

1. Product research and development.
2. Source establishment, i.e. contributes to the development of Canadian companies as quality suppliers to government of defence-related products.
3. Capital assistance for modernization of manufacturing capability.
4. Market feasibility, i.e. contributes to marketing feasibility studies or to determining market sector characteristics.

Budget:

$168.9 million in 1984-85
$175 million in 1985-86

Percentage Distribution by DIPP Element in 1984-85

1. Product R&D	48 %
2. Source Establishment	35
3. Capital Assistance	17
4. Marketing Feasibility Studies	1 (much less than 1%)

DIPP Distribution by Province in 1984-85
($ millions)

Funds were spent only in the following provinces:

N.S.	QUE.	ONT.	MAN.	ALTA.	B.C.	TOTAL
.12	114.34	29.20	1.50	.51	6.89	152.55

Clients:

Most of the active DIPP projects have begun since 1981, with the majority having started in 1983 and 1984.

Companies may benefit from more than one element of DIPP. About 143 companies are involved in DIPP, of which at least 38 receive support under more than one element.

The major users of DIPP are large multinational corporations:
For the R&D element, 2 companies have received over 30% of the funds. 7 companies (including those 2) have received over 40%.
For the Source Establishment element, 5 companies have received over 80% of the funding.

For the Capital Assistance element, 5 companies have received almost 50% of the funding.

Notes:

The R&D assistance under DIPP overlaps with other programs, such as IRDP, which offer similar support. For large projects, DIPP and IRDP are considered to be interchangeable.

5.12.85

TECHNOLOGY DIFFUSION
EXISTING FEDERAL GOVERNMENT PROGRAMS

Program:	Industrial and Regional Development Program
Objectives:	To promote industrial and regional development in Canada through assistance to the private sector for projects which will reduce regional disparities.
Administered by:	DRIE
Eligibility:	Individuals, associations, partnerships, cooperatives, corporate bodies, and non-profit organizations are eligible, depending upon the type of activity applied for. Projects or activities must be carried out in Canada.
Assistance:	Assistance is offered in the following areas:

1. Innovation, to encourage the development of new products and processes through support for research, development and demonstration: includes market research, venture capital search, and studies on technology transfer, and project feasibility; development of new products or processes; development of technological capability; industrial design.

2. Establishment, to assist in establishing new production facilities: includes studies and plant establishment.

3. Modernization/expansion, aimed at modernization and expansion of existing manufacturing and processing operations: includes studies, modernization/expansion of existing processes and services, industrial adaptation and installation of microelectronics technology.

4. Marketing, covers identification, development and exploitation of new domestic and international market opportunities, as well as enhancement of existing ones: includes market research and strategy studies, and assistance to non-profit organizations promoting Canadian products.

Budget:

1984-85	$346 million
1985-86	$240 million

1984-85 Distribution of IRDP Assistance by Program Element

Program Element	Number of Offers Accepted	%	Funding ($ millions)	%
Innovation	250	19	65	19
Establishment	171	13	39	11
Modernization/Expansion	764	57	216	62
Marketing	47	3	4	1
Industrial Development Climate*	104	8	21	6
Restructuring*	7	1	1	-
Totals	1343	100	346	100

* These two Program Elements were cancelled in November 1984.

IRDP funds are provided through a graduated scale of four "tiers", reflecting the differing economic regional needs. Thus, projects in the regions of greatest need (Tier IV) are eligible for maximum levels of support:

IRDP Element	Maximum Level of Assistance by Tier (% of eligible project costs)				
	I	Special I**	II	III	IV
1. Innovation	33.3	33.3	40	50	50
2. Establishment					
a) Studies	N.A.	30	30	37.5	37.5
b) Plant Establishment	N.A.	17.5	17.5	25	30
3. Modernization/Expansion					
a) Studies	N.A.	30	30	37.5	37.5
b) Modernization/ Expansion	N.A.	17.5	17.5	25	25
c) Microelectronics	N.A.	30	30	37.5	37.5
4. Marketing					
a) Non-profit organizations	45	45	45	45	45
b) Studies	25	25	30	37.5	37.5

** Short-term Adjustment Provision: For Tier I census divisions that find their economic and employment bases suddenly eroded due to a cyclical and temporary economic downturn.

<u>Clients</u>: In 1984-85 small firms accounted for the largest number of offers under IRDP, but the largest share of program funds went to medium and large-sized firms.

Sales per company	Offers No.	Offers %	Funds $ (in millions)	Funds %
Less than $2 million	752	56	62	18
$2 to 10 million	376	28	55	16
$10 to 100 million	175	13	163	47
More than $100 million	40	3	66	19
	1343	100	346	100

<u>Notes</u>:

1. Assessment of projects under IRDP is based on
   - incrementality, ie. projects are only supported if they would not proceed unless support was provided;
   - commercial viability, ie. the project and those carrying it out must be commercially viable within reasonable bounds of risk;
   - significant economic benefits to Canada.

2. Negotiations are now underway to transfer the delivery of parts of the Establishment and Modernization/Expansion elements to the provinces, through subsidiary agreements. Provincial delivery will focus on small and medium-sized enterprises: that is, eligible businesses would have up to 250 employees or tangible assets less than $7.5 million, and projects would have eligible costs of less than $2 million. The tier structure of assigning levels of assistance will not apply under the provincial delivery system. In any province where no agreement is signed, DRIE will continue to deliver the entire IRDP. In any case, large projects and other projects carried out by large companies under the Establishment and Modernization/Expansion elements will be administered by DRIE.

3. Under the Innovation element, small projects of less than $100,000 have been consolidated with NRC's Industrial Research Assistance Program - Contributions to Small Projects (IRAP-M).

4. The Innovation element, according to DRIE attracts projects from all manufacturing sectors and some service sectors.

TECHNOLOGY DIFFUSION

FEDERAL GOVERNMENT PROGRAMS

Program: Inter-Firm Comparisons

Objectives:

i) To help businesses improve their productivity and profitability and thus become more competitive.

ii) To promote the use of productivity measurement techniques at the firm or plant level and their integration with profitability measurement.

iii) To assist in the development of government policies by providing a better knowledge of the strengths and weaknesses of Canadian industry.

Administered By: DRIE

Eligibility: Any firm may request participation in the Program. Because of the limited resources available, selection of comparisons to be undertaken is made on the basis of a number of criteria, among which the following are especially important:

a) sectors identified as offering major policy opportunities;

b) sectors offering the greatest potential for productivity improvement;

c) the degree of interest shown by the industry association or other representatives of the sector.

Assistance: Firms manufacturing the same type of product or engaged in a similar type of activity are compared on a highly standardized, confidential basis in the most critical aspects of their operations.

Each participating firm is visited by a DRIE representative who collects the necessary financial and statistical data directly from the firms' officers. No questionnaires are sent out to the companies.

Between 25 and 40 performance ratios are calculated for each firm and median results are determined for the entire group of participants.

The overall group and individual firm results are analyzed and a separate confidential report is prepared for the management of the participating firms.

After these have received their reports, DRIE representatives visit each firm to interpret and discuss the results of the comparisons.

N.B. There is no charge for the Inter-Firm Comparison service.

Clients:

The focus in the past has been on the manufacturing sector, but other industries are also eligible, including service industries.

About 2,000 firms in over sixty industries have participated in the Program.

Each year approximately 200 firms are analyzed, of which about half are follow-up comparisons, used to check on progress made by the firms since the last comparison.

Notes:

1. The main ratio used is the return on assets invested, i.e. operating profit over operating assets, which shows how effectively the resources at the disposal of the enterprise are being used. This ratio is the product of the operating profit margin (ratio 2) and the turnover of assets (ratio 3) (see table). All the other ratios are used to explain these first three ratios and cover all major relationships of costs to sales, assets to sales, and productivity.

2. In any industry sector analyzed, only the participating companies are given the results of the comparison. The individual company report is shown only to the management of that company. No information on any company is provided to anyone without the written authorization of the management of that company. Overall industry results are used by DRIE in policy analysis.

3. Each company report contains:

a) A table of ratios for each participating firm, along with the group and sub-group results. Each company is identified only by a code letter.

b) A general section dealing with concepts and definitions, and describing the overall results for the group, emphasizing any striking features or correlations.

c) An analysis of the results for the company receiving that particular report. Strengths and weaknesses observed in the comparisons with competitors are identified, and the significance of these is interpreted. Suggestions are made for correcting weaknesses.

4. An example of the ratios used is given on the following page.

28.11.85

INTERFIRM COMPARISON

Five Competing Manufacturers

	A	B	C	D	E
Return on Assets					
1. Operating profit/ Operating assets (%)	9.7	9.6	9.3	4.5	3.2
Profit Margin on Sales and Turnover of Assets					
2. Operating profit/Sales (%)	7.6	8.3	8.9	4.3	3.7
3. Sales/Operating assets (times per year)	1.28	1.16	1.04	1.04	.86
Departmental Costs (as a percentage of sales)					
4. Production cost of sales	72.3	72.0	71.7	75.3	75.9
5. Warehousing & distribution	5.5	5.4	5.6	5.9	5.8
6. Promotion & selling	7.7	7.5	6.7	6.2	6.2
7. Administration	6.9	6.8	7.1	8.3	8.4
Production Costs (as a percentage of the sales value of production)					
8. Materials & components	49.3	49.1	49.4	50.2	49.7
9. Production labour	17.8	17.6	16.6	19.5	18.3
10. Other production costs	5.2	5.3	5.7	5.6	7.9
Productivity (dollars)					
11. Value added/Cost of materials and components	1.00	1.00	.99	.96	.98
12. Value added/Production man-hours	7.88	8.08	8.55	7.38	8.03
13. Production labour costs/ Production man-hours	6.85	6.90	6.89	6.98	7.01
14. Machinery and equipment/ Production employees	15,500	16,313	17,063	16,750	23,813
15. Value added/Other Production Costs	9.46	9.25	8.61	8.63	6.18
16. Value added/Floor area	16.40	16.01	15.30	15.19	10.84
Asset Utilization ($ per $1000 of sales)					
3a. Operating assets	784	862	961	961	1163
17. Current assets	409	471	552	559	591
18. Fixed assets	375	391	409	402	572
Current Asset Utilization ($ per $1000 of sales)					
19. Inventory of materials and components	82	94	111	112	118
20. Work in process	70	81	94	96	101
21. Inventory of finished goods	94	108	127	128	136
22. Accounts receivable	163	188	220	223	236
Fixed Asset Utilization ($ per $1000 of sales)					
23. Land and buildings	127	130	136	134	191
24. Machinery and equipment	248	261	273	268	381

Relationships between the ratios:

1. Ratio 2 multiplied by ratio 3 equals ratio 1.
2. Ratio 3a equals 1000 divided by ratio 3.
3. The sum of ratios 2, 4, 5, 6 and 7 equals 100%.
4. The sum of ratios 8, 9 and 10 equals ratio 4.
5. The sum of ratios 17 and 18 equals ratio 3a.
6. The sum of ratios 19, 20, 21 and 22 equals ratio 17.
7. The sum of ratios 23 and 24 equals ratio 18.

TECHNOLOGY DIFFUSION
EXISTING FEDERAL GOVERNMENT PROGRAMS

Program: Small Business Loans Act

Objectives: To provide new or existing small businesses with guarantees on loans for a variety of capital purposes.

Administered by: Loans are arranged through any designated lender, i.e. banks, trust companies, credit unions, etc. DRIE underwrites the loans, guaranteeing the lender for any losses sustained.

Eligibility: Manufacturing, wholesale or retail trade; service businesses; construction, transportation, communication, and real estate enterprises. Companies must have less than $2 million in annual revenues.

Budget: The Program was extended for another five years beginning in March 1985.

DRIE may underwrite loans up to a total value of $1.5 billion during the lending period 1985 to 1990.

N.B. No single loan may exceed $100,000. Loans are offered at one per cent over prime rate.

Clients: The major proportion (no figures available) of clients are in service industries because this is the only government support program available to them.

Similarly, many of the loans are for leasehold improvements, again because money is difficult to get elsewhere for that purpose.

Notes: 1. The Program was first established in 1961 and for many years existed at a low level of activity, as measured by DRIE in the number of claims for loss that they process. This number was about 100 claims per year. In recent years 5,000 to 6,000 claims per year have been made to DRIE, due, in part, to a large increase in program activity.

2. This is not a regional development program so no preference is given to funding in selected provinces.

3. The 1984-85 annual report for the Program will be issued by the end of December. No up-to-date statistics on the Program will be available to us until that time.

22.11.85

TECHNOLOGY DIFFUSION
FEDERAL GOVERNMENT PROGRAMS

PROGRAM: Technology Inflow Program

OBJECTIVES: To bring technology to Canada, which will be used to improve Canadian-made products, processes and services.

ADMINISTERED BY: External Affairs

ELIGIBILITY: Any company may apply, but must be sponsored by a federal department or agency which has an interest in the proposed activity.

ASSISTANCE: The Program is an amalgamation of the Catalytic Seed Fund (External Affairs) and the International Collaboration Assistance Fund (Communications). It will also include the six newly appointed Technology Development Officers (TDOs), at Canadian missions in the United States and elsewhere.

The Program offers financial assistance for international collaboration and for collecting information on emerging technologies of interest to Canada.

BUDGET: In 1985-86, it will be $1.3 milion.

Notes:

1. As of December 1, 1985, the funding of the two existing programs will be integrated. External Affairs will take over the management of ICAF, but the funds will be journal vouchered from Communications to External Affairs. An announcement of the new Program is expected around January 1, 1986.

2. The Industrial Technology Advisors in NRC's IRAP will be linked to the TDOs either through External Affairs in Ottawa or directly through the posts.

29.11.85

TECHNOLOGY DIFFUSION
EXISTING FEDERAL GOVERNMENT PROGRAMS

Program: Industrial Research Assistance Program

Objectives:

To assist Canadian firms to develop or acquire and make effective use of appropriate, up-to-date technology, in order to stay or to become internationally competitive.

Administered by: NRC

Eligibility:

1. PRINCIPAL SERVICE:

Professional technical advice and guidance delivered by a Network of some 200 Technology Advisors and Technology Transfer Specialists operating in 50 different cities across Canada and allied with technical officers at Canadian embassies abroad. These Technology Advisors and Technology Transfer Specialists are drawn from:

1) Federal technical departments
2) Provincial Research Organizations
3) Specialized Technology Centres
4) Canadian Universities and Colleges
5) The Association of Consulting Engineers of Canada
6) Industry Associations
7) Science and Technology Counsellors and Technology Development Officers in several Canadian Posts abroad.

2. NETWORKING SERVICE:

IRAP specialists work to connect every Canadian firm having a technical problem or technology-based opportunity with the best and most appropriate technical experts available in federal and provincial laboratories, universities, technology centres, consultants and technology resources abroad.

The National IRAP Network interconnects all these technical resources by placing members of the IRAP team within all the major technology organizations of Canada.

3. COST-SHARED SUPPORT:

IRAP will share the cost with a firm of undertaking an R&D project where the work is more advanced or more difficult than the firm is familiar with. IRAP will also support part of the costs of the technical investigations or developments carried out for the firm by competent laboratories in Provincial Research Organizations, specialized Technology Centres or in Universities.

Budget: 1986-87 estimated total budget is $66 million.

TABLE 1: IRAP PROGRAM EXPENDITURES ($ millions)

	Actual 1984/85		1985/86	
	$	No. of Projects	$	No. of Projects
IRAP-P & PILP*	40.7	419	43.6	391
Field Projects	18.0	4065	17.8	4300
Auxiliary Technology Advisors	8.2	(118)PY	7.8	(120)PY
TOTAL CONTRIBUTIONS	66.9		69.2	
Operations	4.5		4.8	
Paylist	4.9	(100)PY	5.7	(121)PY

Source: National Research Council Canada.

The distribution of IRAP resources by province is attached as Table 2.

Clients:

The emphasis in IRAP is on smaller firms: 85% of the total budget is for companies with up to 200 employees.

TABLE 2

INDUSTRIAL RESEARCH ASSISTANCE PROGRAM (IRAP)*

PROVINCIAL DISTRIBUTION OF CONTRIBUTIONS

(millions of dollars)

	ACTUAL 1984/85		ESTIMATED 1985/86	
	$	%	$	%
British Columbia	7.8	11.6	8.3	12.0
Alberta	4.1	6.1	3.8	5.5
Saskatchewan	2.1	3.1	2.1	3.1
Manitoba	2.2	3.3	1.7	2.4
Ontario	32.5	48.6	34.0	49.2
Quebec	11.8	17.7	13.5	19.5
New Brunswick	2.3	3.4	1.8	2.6
Nova Scotia	2.5	3.7	2.2	3.2
P.E.I.	0.5	0.7	0.8	1.1
Newfoundland	1.1	1.7	1.0	1.4
Other	0.1	0.1	0.1	0.1
TOTAL	66.9	100.0	69.2	100.0

* Including Program for Industry/Laboratory Projects (PILP)

TECHNOLOGY DIFFUSION
EXISTING FEDERAL GOVERNMENT PROGRAMS

Program: Program for Industry/Laboratory Projects

Objectives: To promote the application and commercial exploitation by Canadian companies of technology developed in federal laboratories.

Administered by: NRC

Eligibility: Canadian-based companies with the appropriate financial, managerial, technical, manufacturing, and and marketing capabilities.

Projects must:

a) be aimed at an important Canadian need or opportunity;
b) derive from federal research or be in an area of interest to federal agencies where their staff and facilities can make significant contributions;
c) give evidence of intent by the performer to commercialize the results by himself or with other identified parties in Canada;
d) identify the major barriers to commercialization and describe methods for overcoming these barriers.

Assistance: Financial assistance and scientific advisory services are available through contributions and contracts. These are provided on a project-specific basis that involves close collaboration between the recipient company and the government.

Projects are generally supported from the conceptual stage through to prototype or pilot-plant development within the company in order to provide a clear indication of whether the technology can result in a commercially viable product or service. Contribution arrangements involve cost sharing between PILP and the company.

Budget:	Expenditures ($ millions)	No. of Projects
1984-85	17,691	188
1983-84	14,395	144

PILP - Distribution by Province
FY 1984/85

PROVINCE	DOLLARS X 000s		PROJECTS		COMPANIES	
	84/85	%	NO.	%	NO.	%
British Columbia	1675	9	25	13	23	15
Alberta	166	1	5	3	5	3
Saskatchewan	195	1	4	2	4	3
Manitoba	-	-	-	-	-	-
Ontario	11808	67	107	57	83	53
Quebec	3089	17	29	15	26	17
New Brunswick	198	1	5	3	4	3
Nova Scotia	508	3	8	4	7	4
Prince Edward Island	11	**	3	2	3	2
Newfoundland	41	**	2	1	1	1
	17691	100	188	100	156*	100

* Total number of separate companies is 126, joint projects cause discrepancies in totals.
** Much less than 1%.

Clients: PILP is mainly directed at small Canadian companies of less than 200 employees and with less than $5 M in annual sales. 80% to 90% of PILP projects are carried out by such companies.

In 1983-84, 33% of PILP projects involved firms with less than 10 employees and 26% involved firms with between 10 and 49 employees.

Distribution of PILP Funds by Size of Company

	Small	Medium	Large
1984-85	66%	12%	22%
1983-84	66%	5%	28%

Small: Up to 200 employees
Medium: 200 to 1000 employees
Large: Over 1000 employees

The attached table shows PILP distribution by Standard Industrial Classification for FY 1984-85.

Notes:

1. In a 1983 client survey published in the evaluation of March 1984, 90% of PILP clients stated that their R&D capacity had been enhanced as a result of PILP. 51% cited improved production, marketing and sales capacity, and 61% reported "spin-off" effects.

2. Before 1981, PILP was more procurement-oriented, and commercial benefits were less than program costs. Major changes have since been made in criteria, procedures and contribution levels. As a result, five-year forecasts predict increased commercial benefits.

3. Firms receiving assistance under PILP frequently also receive help from DRIE and/or FBDB. In the survey of clients, it was found that 92% of PILP participants had access to government technology through other federal programs: 44% through Unsolicited Proposals, 44% through IRAP, and 23% through other programs.

4. A proposal has been made to consolidate PILP and IRAP-P, to form one, more extensive network of Industry/Liaison Managers who are expert in technology transfer between public sector labs and firms able to make use of the technology.

6.12.85

PILP

EXPENDITURES BY INDUSTRY SECTOR
FY 1984/85

STANDARD INDUSTRIAL CLASS	EXPENDITURES $000	EXPENDITURES %	PLACEMENTS No.	PLACEMENTS %	COMPANIES No.	COMPANIES %
Farms	463	2.6	8	4.3	8	4.7
Services Incidental to Agriculture	1,728	9.8	15	7.8	11	6.5
Fishing Industry	672	3.8	11	6.0	8	4.7
Food and Beverage Industry	1,257	7.1	17	9.0	15	8.9
Wood Industries	69	0.4	3	1.6	3	1.8
Primary Metal Industries	-	-	1	0.5	1	0.5
Machinery Industries	964	5.4	13	6.9	12	7.1
Transportation Equipment Industries	493	2.8	5	2.7	5	2.9
Electrical Products Industries	168	1.0	4	2.1	4	2.4
Electronic Instruments	1,033	5.8	15	7.8	15	8.9
Electronic Equipment	827	4.7	11	6.0	10	5.9
Communication Electronics	714	4.0	3	1.6	3	1.8
Electronic Sensors	1,667	9.4	14	7.5	14	8.3
Electronic Parts and Components	1,191	6.7	1	0.5	1	0.5
Non-Metallic Mineral Products	424	2.4	4	2.1	4	2.4
Petroleum and Coal Products	170	1.0	3	1.6	3	1.8
Chemical and Chemical Products	698	3.9	7	3.7	6	3.6
Manufacturing Industries	222	1.3	2	1.1	2	1.2
Communications	94	0.5	3	1.6	3	1.8
Services to Business Management (Software)	2,698	15.3	28	15.0	26	15.4
Health and Welfare Services	2,139	12.1	20	10.6	15	8.9
TOTALS:	17,691	100.0	188	100.0	169	100.0

TECHNOLOGY DIFFUSION

FEDERAL GOVERNMENT PROGRAMS

Program: Technology Centres

Objectives: Technology centres are "organizations sustained through federal grants or contributions or operated by the federal government and which were designed to function predominantly in support of industry needs for new technology or specific technical skills." (MOSST report on technology centres, August 13, 1985)

Administered By: The Federal government, industry, provinces, or universities.

Assistance: Technology centres offer a range of services:

- dissemination of technical information and advice on new products and process developments;
- demonstrations of products and processes;
- provision of research and testing facilities for client use;
- performance of prototype evaluations and equipment testing;
- assistance with patents, licensing, and grant applications;
- training of technical and management staff;
- performance of R&D in support of or for subsequent transfer to industry.

Budget: The federal government supports over 250 technology centres for a total annual expenditure of about $455 million.

The centres have annual budgets between $1 million and $5 million and employ from 5 to 25 engineering staff.

Federal Support for Technology Centres
Distribution by Performer

Performer	Numbers	%	Federal Grants $ Millions	%	Operating Budget $ Millions	%
Federal Govt.	109	43	416.25	92	422.13*	64
Industry	18	7	4.23	1	34.41	5
Province	33	13	3.31	1	112.42	17
University	96	37	31.62	7	98.84	14
Total	256	100	455.45	100	662.79	100

* $102.5 million of this has been identified as being in direct support of industry. The balance supports long term research for industry, mission research, and statutory or regulatory activities.

<u>Clients:</u> Number of Client Organizations Served by Size of Firm (Employees)

Size	1-50	51-100	101-500	500+	Total
Total No.	3862	2018	1313	682	7875
Total %	49	25	17	9	100

If the percentage distribution of client size is first calculated for each centre and these percentages are then averaged, the average for all centres is 37% small-sized firms, 17% each for medium and large firms, and 29% for very large firms (500+ employees). The implication is that many centres serve a few client firms, most of which are very large.

It should be noted that the distribution of manufacturing establishment size in Canada is approximately 82% small (1-50 employees), 8% medium (51 to 100), 8% large (100-500), and only 1% very large (500+ employees). Thus, technology centres tend to serve medium, large, and very large firms rather than small ones.

Notes:

1. Distribution of Technology Centres by Province

Nfld.	N.S.	P.E.I.	N.B.	Que.	Ont.	Man.	Sask.	Alta.	B.C.	Total
8	17	2	13	34	111	13	17	18	23	256

2. Distribution of Technology Centre Effort in Direct Support of Industry (DSI)*

Performer	Low DSI	Medium DSI	High DSI	Total
Federal	80	23	6	109
Industry	4	1	13	18
Province	8	9	16	33
University	35	29	32	96
Total	127	62	67	256

* The DSI index reflects the percentage of time and effort spent by the centre in making the client aware of, and familiar with, a new technology, and in assisting the client with the adoption process.

3. During the last ten years there has been a rapid increase in the rate of formation of technology centres, with the majority of the new centres in Ontario, Quebec, and Nova Scotia. The main subject areas have been energy, computing technologies, informatics, and CAD/CAM.

4. The centres make highly qualified engineering and scientific personnel available to many small and medium-sized firms, which would not normally have access to them.

6.12.85

All this information is drawn from the MOSST study entitled "Tech Centre Resource Review", August 13, 1985.

ORGANIZATIONS INCLUDED IN THE TECHNOLOGY CENTRE STUDY

(High Direct Service to Industry)

LIST OF TECHNOLOGY CENTRES		GROUP
ACOUSTICS SECTION	NRC	F
AUTOMATED FORMING PROCESSES	INDUSTRIAL MATERIALS	F
Biological Production of Fuels Unit	Division of Biological Sci.	F
Biotechnology Research Institute		F
CERAMICS AND COATINGS	INDUSTRIAL MATERIALS	F
Chemical Physics Unit	Division of Chemistry	F
Computer Technology Unit	Division of Electrical Eng.	F
DAVID FLORIDA LABORATORY	CRC/DOC	F
Division of Building Research		F
Engine Laboratory	Division of Mechanical Eng.	F
Gas Dynamics Laboratory	Division of Mechanical Eng.	F
High Speed Aerodynamics Unit	National Aeronautical Est.	F
Hydraulics Laboratory	Division of Mechanical Eng.	F
INDUSTRIAL RESEARCH ASSIST. PROGRAM	NRC	F
Information Science Unit	Division of Electrical Eng.	F
INSTITUTE FOR MARINE DYNAMICS	NRC	F
Low Speed Areodynamics Unit	National Aeronautical Est.	F
Low Temperature Laboratory	Division of Mechanical Eng.	F
Manufacturing Technology Centre	Division of Mechanical Eng.	F
MECHANICAL R&D OPTICAL PHYSICS SECT	NRC	F
Metallic Corrosion and Oxidation Un	Division of Chemistry	F
METALLIC MATERIALS	INDUSTRIAL MATERIALS	F
POLYMER AND COMPOSITE MATERIALS	INDUSTRIAL MATERIALS	F
Power Engineering Unit	Division of Electrical Eng.	F
Program for Industry/Lab. Projects	NRC	F
Railway Laboratory	Division of Mechanical Eng.	F
CARTOGRAPHIC SERVICE	DEPT. OF ENERGY, MINES ET RES.	F
Wastewater Technology Centre		F
BREWING & MALTING BARLEY RES INST		I
CANADIAN GAS RESEARCH INSTITUTE		I
CANADIAN INSTITUTE OF METALWORKING		I
CANADIAN PLASTICS INSTITUTE		I
CANOLA COUNCIL OF CANADA		I
COFT R&D LABORATORY		I
COMPUTER INTEGRATED MANUFACTURING		I
FOREST ENG RESEARCH INST OF CANADA		I
FORINTEK CAN CORP EASTERN LAB		I
FORINTEK CANADA CORP WESTERN LAB		I
Industrial Applications of Microele	University of Manitoba	I
PETROLEUM RECOVERY INSTITUTE		I
POS Pilot Plant Corporation	University of Saskatchewan	I
Pulp and Paper Research Institute	McGill University	I
WELDING INSTITUTE OF CANADA		I
Air Pollution Centre	Ontario Research Foundation	P
Industrial Technology Centre	Manitoba Research Council	P

APPLIED SCIENCES DIVISION	ALBERTA RESEARCH COUNCIL	P
Biotechnology and Chemical Engineering	Ontario Research Foundation	P
BIO-ENGINEERING/FISHERIES TECHNOLOGY	BRITISH COLUMBIA RESEARCH	P
Canadian Food Products Development	Manitoba Research Council	P
Centre for Alternate Fuel Utilization	Ontario Research Foundation	P
CHEMICAL TECHNOLOGIES DIVISION	BRITISH COLUMBIA RESEARCH	P
ENVIRONMENT AND HEALTH DIVISION	BRITISH COLUMBIA RESEARCH	P
Glass and Ceramics Technology Centre	Ontario Research Foundation	P
Industrial Technology Transfer Sector	Saskatchewan Research Council	P
MANUFACTURING TECHNOLOGY CENTRE		P
New Brunswick Research and Production	(PRO)	P
Nova Scotia Research Foundation Corp.	(PRO)	P
OIL SANDS RESEARCH DEPARTMENT	ALBERTA RESEARCH COUNCIL	P
Ontario Auto Parts Centre		P
Ontario CAD/CAM Centre		P
Ontario Centre for Farm Machinery		P
Ontario Centre for Microelectronics		P
Ontario Robotics Centre		P
PHYSICAL TECHNOLOGIES DIVISION	BRITISH COLUMBIA RESEARCH	P
Services Sector	Saskatchewan Research Council	P
Applied Microelectronics Institute	Technical University of N.S.	U
ATLANTIC ANALYTICAL SERVICES		U
Atlantic Industrial Research Institute	Technical University of N.S.	U
BC MICROELECTRONIC SOCIETY		U
Bras d'Or Institute	University College	U
Canadian Institute of Fisheries Tec --	Technical University of N.S.	U
Canadian Institute of Guided Ground	Queen's University	U
Centre de développement technologiqes	Université de Montréal	U
CENTRE DE RECHERCHE INFORMATIQUE	DE MONTREAL	U
Centre de recherche sur les transpo--	Université de Montreal	U
Centre de recherches en nutrition	Université Laval	U
Centre d'analysé service pour l'ind --	Université de Moncton	U
Centre d'Innovation Industrielle	Université de Montréal	U
Centre for Advanced Technology Educt'n	Ryerson Polytechnical	U
Centre for Building Studies	Concordia University	U
Centre for Cold Ocean Resources Eng	Memorial University	U
CENTRE FOR FLEXIBLE MANUFACTURING	MCMASTER UNIVERSITY	U
Centre for Industrial Development	Ryerson Polytechnical	U
Centre for Marine Geology	Dalhousie University	U
Centre for Regional Development	Lakehead University	U
Centre for Research in Engineering	University of New Brunswick	U
Centre for Resource Studies	Queen's University	U
Computer Communications Network Group	University of Waterloo	U
Computer Systems Group	University of Waterloo	U
Dairy Herd Analysis Centre	McGill University	U
Department of Mining and Mineral Pr --	University of British Columbia	U
Edmonton Radiopharmaceuticals Centre	University of Alberta	U
Energy Research Institute	Simon Fraser University	U
Energy Research Institute	University of Regina	U

Geotechnical Research Centre	McGill University	U
Group for Computing Research	University of Western	U
GROUP POUR L'AVANCEMENT PRODUCTIQUE	LAVAL UNIVERSITY	U
HYBRIDOMA CENTRE	UNIVERSITY OF WINDSOR	U
INRS Telecom Centre	Université du Québec	U
Institute for Coal Research	University of Alberta	U
Institute for Groundwater Research	University of Waterloo	U
Institute of Oceanography (Aquatron	Dalhousie University	U
Laboratory for Communications and C --	Simon Fraser University	U
McMaster Institute for Polymer Prod--	McMaster University	U
MECH ENG CAD & ROBOTICS GROUP	MCGILL UNIVERSITY	U
Microelectronics Centre	Dalhousie University	U
Microelectronics Centre	Université de Sherbrooke	U
Microelectronics Centre	University of New Brunswick	U
NB MANUFACTURING TECH CENTRE	NB COMMUNITY COLLEGE	U
Northeastern Ontario Occupational H---	Laurentian University	U
NS Computer Aided Design Centre	Technical University	U
C-C Research Institute	Carleton University	U
Piez Electricity Research Laboratory	York University	U
Science Industrial Research Unit	Concordia University	U
Surface Physics Laboratory	Simon Fraser University	U
Surface Science Centre	University of Western	U
Systems Analysis, Control and Design	University of Western	U
Textile Testing Service	University of Manitoba	U
The Atlantic Coal Institute	University College	U
The Carbohydrate Research Institute	Queen's University	U
The Manufacturing Technology Centre	University of New Brunswick	U
Transport Institute	University of Manitoba	U
Transportation Group	University of New Brunswick	U
University of Toronto Microelectron	University of Toronto	U
Water Analysis Facility - Department	Memorial University	U
Waterloo Centre for Process Develop	University of Waterloo	U
Waterloo Polymer Research Institute	University of Waterloo	U

ORGANIZATIONS INCLUDED IN THE TECHNOLOGY CENTRE STUDY

(Low Direct Service to Industry)

		GROUP
River Road Environmental Centre	Environment Canada	F
Atlantic Region	AGR CAN	F
Experimental Farm (6 sections)	AGR CAN	F
Sen. Herve J. Michaud Experimental	AGR CAN	F
Quebec Region	AGR CAN	F
Ontario Region	AGR CAN	F
Food Research Station	AGR CAN	F
Animal Research Centre	AGR CAN	F
Ottawa Research Station	AGR CAN	F
Research Centre	AGR CAN	F
Smithfield Experimental Farm	AGR CAN	F
Research Branch Headquarters	AGR CAN	F
Institute Headquarters	AGR CAN	F
Biosystematics Research Institute	AGR CAN	F
Chemistry & Biology Research Institute	AGR CAN	F
Engineering & Statistical Res. Instit.	AGR CAN	F
Food Research Institute	AGR CAN	F
Land Resource Research Institute	AGR CAN	F
Research Program Services	AGR CAN	F
System & Consulting Directorate	AGR CAN	F
Libraries Division	AGR CAN	F
Canadian Grains Commission	AGR CAN	F
Animal Diseases Res. Institute	AGR CAN	F
Animal Pathology Laboratory	AGR CAN	F
Animal Diseases Res. Institute	AGR CAN	F
Laboratory Services Division	AGR CAN	F
Prairie Region	AGR CAN	F
Pacific Region	AGR CAN	F
25 Research Stations	AGR CAN	F
CANADA CENTRE FOR MINERAL AND --	Western Laboratory -	F
ELECTRICAL AND TIME STANDARDS		F
Electron Physics Unit	Division of Electrical Eng.	F
Electronics Engineering Unit	Division of Electrical Eng.	F
HEAT AND THERMOMETRY SECTION	DIVISION OF PHYSICS	F
LASER AND PLASMA PHYSICS SECTION		F
Molecular Genetics Unit	Division of Biological Sci.	F
Molecular Spectroscopy Unit	Divisionof Chemistry	F
PHOTOGRAMMETRIC RESEARCH SECTION		F
PHOTOMETRY AND RADIOMETRY SECTION		F
Plant Biotechnology Institute		F
STRUCTURES AND MATERIALS LABORATORY	NRC	F
Technical Research Division	Office national du film	F
Textile Chemistry Unit	Division of Chemistry	F
ALBERTA MASONRY INSTITUTE		I

ALBERTA SULPHUR RESEARCH LTD		I
SULPHUR RESEARCH GROUP		I
ADVANCED TECHNOLOGIES DEPARTMENT	ALBERTA RESEARCH COUNCIL	P
CAD/CAM Centre	Saskatchewan Research Council	P
Centre for Powder Metallurgy	Ontario Research Foundation	P
EXTRACTIVE METALLURGY	BRITISH COLUMBIA RESEARCH	P
INDUSTRIAL DEVELOPMENT DEPARTMENT	ALBERTA RESEARCH COUNCIL	P
INSTITUTE OF MAN AND RESOURCES (PEI)		P
NATURAL RESOURCES DIVISION	ALBERTA RESEARCH COUNCIL	P
RESOURCE DIVISION	SASKATCHEWAN RESEARCH COUNCIL	P
Resources Sector	Saskatchewan Research Council	P
The Canadian Centre for Advanced In --	Saskatchewan Research Council	P
Aerospace Medical Research Unit	McGill University	U
Alberta Microelectronics Centre	University of Alberta	U
Bamfield Marine Station	University of Victoria	U
Building Engineering Group	University of Waterloo	U
Cancer Research Laboratory	University of Western	U
Centre de recherche en pates et pap-	University of Québec	U
CENTRE DE TECHNOLOGIE MANUFACTURIER		
Centre for Earth Resources Research	Memorial University	U
Centre for Energy Studies	Technical University	U
Centre for Remote and Offshore Medi-	Memorial University	U
Centre for Water Resource Studies	Technical University	U
Computer Systems Research Group	University of Toronto	U
Department of Mining and Mineral Pr-	University of British Columbia	U
INSTITUT D'ORDINIQUE DU QUEBEC	COLLEGE LIONEL GROULX	U
Institut national de la recherche s-	Université du Québec	U
Institute for Computer Research	University of Waterloo	U
Institute for Environmental Studies-	University of Toronto	U
Institute of Bio-Medical Engineering	University of Toronto	U
Institute of Materials Research	McMaster University	U
ISOTRACE Laboratory	University of Toronto	U
Marine Sciences Research Laboratory	Memorial University	U
MINING DEV & MINERALS EXPLORATION	LAURENTIAN UNIVERSITY	U
Newfoundland Institute for Cold Oce-	Memorial University	U
O-C Centre for Geoscience Studies	Carleton University	U
Statistical Laboratory	University of Western	U
Taiga Biological Station	University of Manitoba	U
The Canadian Marine Transportation	Dalhousie University	U
The Fire Science Centre	University of New Brunswick	U
The Industrial Research Institute	University of Windsor	U
Veterinary Infectious Disease Organ	University of Saskat	U
Westwater Research Centre	University of Britis	U
YIOO	University of Toronto	U

OTHER FEDERAL GOVERNMENT PROGRAMS RELEVANT TO TECHNOLOGY DIFFUSION

Program Name	Objective
Canadian Institute for Scientific and Technical Information (CISTI) - NRC	To provide Canadian researchers, technologists and managers in industry, universities and government with scientific and technical information.
Consulting Innovation Managers Assistance Program (CIMAP) - NRC	To help small and medium-sized enterprises to identify technology-based commercial opportunities for new products and markets.
Development and Demonstration of Resource and Energy Conservation Technology - Environment Canada	To encourage the development and demonstration of prototype systems and new technology designed to recover or recycle wastes.
Federal Business Development Bank (Crown Corporation)	To assist and promote most types of businesses in Canada, with particular emphasis on small and medium-sized firms, through three main services: financial services (loans, loan guarantees, and financial planning), investment banking, and management services, such as counselling, training and information.
Industry Energy Research and Development Program - EMR	To provide funds (up to 50%) to enable industry to develop new technologies in the field of energy conversion. The sharing ratio depends on the degree of technical risk, the magnitude of potential energy savings and the degree to which the technology developed can be used by other companies.

Patent Information Exploitation Program - CCA	To provide an "expert" interface to permit firms to access the patent literature.
Unsolicited Proposals Program - DSS	To encourage R&D in the private sector in support of departmental programs.
Western Transportation Industrial Development Program - DRIE	To provide industrial development assistance to firms in Manitoba, Saskatchewan, Alberta and B.C., in the manufacturing, processing and related service industries. The Program augments the assistance already available under IRDP. The establishment or expansion of facilities to manufacture new products in western Canada is a priority of the Program.

13.12.85

PROVINCIAL GOVERNMENT PROGRAMS FACILITATING TECHNOLOGY DIFFUSION

Name of Program	Objective	Type of Assistance
NEWFOUNDLAND		
Newfoundland and Labrador Development Corporation	To provide financial assistance for establishment, expansion and/or modernization of manufacturing and process industries.	Term loans and equity financing.
PRINCE EDWARD ISLAND		
Market, Research, Information and Education - PEI Development Agency	To stimulate sales of manufactured and processed products in local and international markets.	Financial and technical assistance for studies, market information, training and acquiring fulltime qualified personnel.
Small Business Equity Program	To provide improved opportunity for small business through supporting expansion, modernization, restructuring, or establishment of a new business.	Financial assistance: 40% equity through purchase of redeemable preferred shares.
Manufacturing and Processing Term Loan	To provide long term financing for acquiring capital assets. To provide bridge financing related to approved federal incentives.	Financial assistance up to 100% of costs at 1% above long term interest lending rate to PEI.
Product Development	To assist in the development and evaluation of new and improved products or processes in order to expand products and markets. (A "new" product need only be new to the company requesting assistance).	Cost-shared assistance.
Joint Venture and Licensing	To assist PEI processors and manufacturers to secure licensing agreements, joint ventures or the technology needed to develop and produce new products.	Cost-shared to include legal and financial expertise and royalty guarantees during first year of the agreement.

Name of Program	Objective	Type of Assistance
NOVA SCOTIA		
Business and Technical Services Division-Ocean Industries Innovation Centre	To assist small business to establish or expand in innovative directions that relate to ocean industries other than fishing, primary fish processing and boat/ship building.	Advice and guidance to entrepreneurs in medium-high tech ocean industries; cost-sharing also up to 70 percent of project costs.
Small Business Development Corporation (SBDC)	To assist business in start up, expansion or modernization.	Loans at fixed interest rates with flexible terms.
Product Development Management Program (PDMP)	To support product development.	Grant 75 percent of costs to a maximum of $15,000 per project. Marketing, design, production engineering.
Consulting Assistance Program	To provide professional advice by qualified advisors.	Up to 75 percent of study costs maximum $2,000.
Co-op Program: CAD/CAM Training	To provide on the job experience to engineering students.	Summer employment with McDonnell Douglas Automation Co. of St. Louis, Missouri.
NEW BRUNSWICK		
Small Industry Financial Assistance Program	To assist the establishment, modernization and expansion of industry.	Financial 30% of all approved capital costs 30% - maintenance and repair 50% - new industries capital cost maximum - $150,000
Research and Productivity Council (RPC)	To assist industry in the development and transfer of new product, and processes.	Technical assistance.
Manufacturing Technology Centre	To transfer CAD/CAM technology to the manufacturing sector.	Technical assistance.

Name of Program	Objective	Type of Assistance
CADMI	To transfer microelectronic technology to the manufacturing sector.	Technical assistance.
QUEBEC		
Quebec Industrial Research Centre - Centre de Recherche Industrielle du Quebec (CRIQ)	To contribute to the economic development of Quebec by promoting innovation.	Technical services on a cost free or cost shared basis.
Technology Transfer and Information Services	To provide technological, industrial and commercial information.	The "800" telephone number provides rapid access to information on a variety of services including products, market studies, invention evaluation, and other technical knowledge including industrial application of inventions developed by industrial, university and private sources.
Financing Program for Manufacturing Companies (Part II)	To enhance industrial development.	Financial assistance: - purchase of shares - shareholder loans - loans convertible into shares.
Investment Assistance Program for Manufacturing Companies	To encourage manufacturing companies incorporating modern technology and dynamic enterprises to invest in Quebec.	Acquisition of non-voting shares, non-interest bearing loans, interest rebates.
Modernization Program for the Textile, Knitwear, Clothing Firms	To contribute effectively to modernizing and consolidating these industries.	Financial: - grants and loans - maximum grant $450,000 - maximum loan 70% of fixed assets.
Technological Assistance Service for Businesses	To make available modern food processing techniques.	Technical, financial, marketing and export assistance.

Name of Program	Objective	Type of Assistance
Five-year Assistance Program for Companies in Wood Products Industry	To assist manufacturers to become more productive, improve profitability, and optimize plant.	Financial assistance
ONTARIO		
Small Business Development Corporations Program	To direct funds and managerial expertise to eligible small businesses (manufacturing and processing)	Individual shareholders in a SBDC receive a rebate equal to 30% of amount invested, corporate shareholders receive a 30% tax credit.
Manufacturing Productivity Services	To provide advisory services to small manufacturing firms.	Advise on a marketing, plant layout, material handling, work measurement, low cost automation, cost reduction methods, incentive schemes, productivity and possible equipment improvements, handled through publications and seminars.
Ontario Research Foundations (ORF)	To provide advisory and assistance services in the fields of science, engineering.	• Identify technological and operational problems • Locate appropriate information and identify and adopt new or better technologies • Optimize the use of energy, material, financial and human resources • Increase the level of technology and innovative capability • Transfer technology from laboratories to industry, promote the use of research results and develop the new products and processes • Prototype development and product testing

Name of Program	Objective	Type of Assistance
Sector Import Replacement	To encourage import replacement	Services are organized to encourage joint venture and licencing arrangements.
Ontario Centre for Resource Machinery Technology	To promote the development and use of high technology equipment by Ontario resource industries.	Financial: - equity stakes
Ontario Centre for Microelectronics Technology	To assist manufacturers to obtain the essential custom "chips" for new product innovations. To promote an awareness of the potential of microelectronics and their application.	Chip designs, production application, and testing assistance.
Ontario Centre for Advanced Manufacturing (OCAM)		
a) CAD/CAM	a) to specialize in promotion, applications and development of CAD/CAM technologies	Advice and assistance in application.
b) Robotics	b) to specialize in robotics applications	Advice and assistance in application.
c) Autoparts	c) to assist autoparts manufacturers	Advice and assistance in application.
Biotechnology (Allelix Inc.)	To develop industrial applications in biotechnology	Joint ventures in experimental areas - renewable cellulose - chemical feedstocks - waste product treatment - fixing in plant life
Ontario Centre for Automotive Parts Technology	To help firms to keep pace with the rapid evolution of parts technology both within North America and abroad.	Information and assistance concerning modern technologies and management techniques in automotive parts production.
Ontario Centre for Farm Machinery and Food Processing Technology	To promote the use of modern technology.	Test the operation and safety of equipment and provide information to industry.

Name of Program	Objective	Type of Assistance
Innovation Centres (22)	To commercialize university research. To act as a broker between the private sector and university researchers.	Marketing and technical assistance.
Ontario Research Foundation	To create new products, and processes and assist industry	Advisory and technical assistance.
MANITOBA		
Manitoba Research Council (MRC)	To stimulate the application of technology.	Fee for service consulting.
Industrial Technology Centre	To promote the adoption of new technology.	Fee for service.
SASKATCHEWAN		
Product Development Program	To develop new products for manufacture.	Product design assistance, information on plant layout and production control, special advice on welding problems, welding metallurgy courses, update on technological changes, line access to major North American computer centres and lists of technical articles.
Product Development	To aid clients in developing and improving products.	On a fee-for-service basis SRC provides technical expertise in mainly agricultural and mechanical engineering(CAD/CAM) sector projects.
Manufacturing Process and Technological Assistance	To provide in-plant services to manufacturers.	No charge, in-plant engineering assistance and advice on production, layout, machinery, quality control, welding and vendor sources. Information on processes, materials and developments throughout the world.

Name of Program	Objective	Type of Assistance
Technology Transfer	To provide information to introduce significant new technologies.	Cost-shared or at no charge: consulting services for clients to implement new technology systems (design of MRP, Quality Circle, Group Technology or CAD/CAM systems) on a pilot demonstration basis.
Assistance to Business Associations	To provide speakers and seminars on business topics.	Provides speakers on topics related to industrial technology. Also contractual seminar resource persons and materials.
Management Consulting and Industrial Engineering	To provide comprehensive industrial engineering and management services.	On a contractual basis various services to industry on a broad range of topics (e.g. business plans, market research, MRP, risk analysis, evaluation of new product ideas, economic development studies and exports).
Assistance for Inventory and Manufacturing Expansion (AIME)	To help small businesses remain operational during adverse economic times.	Loans up to $25,000.
Manufacturing Process and Technological Assistance	To provide in-plant services to manufacturers.	Financial - under NRC-IRAP. - cost shared or no charge for hiring science and engineering students for a semester/summer; - Grants for analysis, R&D and industrial problem solving.
Management Development Program	To encourage firms to become more competitive.	Seminars and courses on market development.
Marketing Benefits Branch	To increase the markets for Saskatchewan goods and services.	- Give buyers comprehensive information on products, services, capabilities and plant capacities of Saskatchewan suppliers;

Name of Program	Objective	Type of Assistance
		- Collect and distribute information to Saskatchewan suppliers on market opportunities in the province; - Organize seminars, shows, and individual meetings between buyers and sellers to discuss opportunities; and - Advise suppliers on how to secure contracts, interpret specifications, and prepare bids; - Help winning bidders gear up for production, and losing bidders evaluate why they lost sales opportunities; and - Respond to enquiries, requests, problems, and suggestions from all Saskatchewan buyers and sellers.
<u>ALBERTA</u>		
Product Development Program	To assist Alberta manufacturers to increase their inhouse design management understanding and capability.	Financial assistance up to 75% of eligible project costs.
Alberta Research Council (ARC)	To assist in the utilization of natural resources and the development of industry.	Provision of technical assistance, information services, contract research, licensing of ARC inventions, and undertaking joint projects with firms.
<u>BRITISH COLUMBIA</u>		
Industrial Training Activities	To respond to the shortages of skilled and semi-skilled workers in the province.	Financial assistance wage subsidy ($2.50/hr.).
B.C. Development Corporation (BCDC)	To assist businesses to expand existing operations or to create new economic activity within the province.	Financial assistance, long-term financing at BCDC prime rate plus 1½-2%.

Name of Program	Objective	Type of Assistance
Low Interest Loan Assistance (LILA)	To enhance the economic base of B.C.	Financial assistance: loan maximum $200,000 at low interest rate for a term of 3 years.
B.C. Small Business Development Fund	To enhance the economic base of B.C.	Financial assistance, loan maximum $1 million with fixed interest rate 12%/year for 3 years.

Source: DRIE

9.12.85