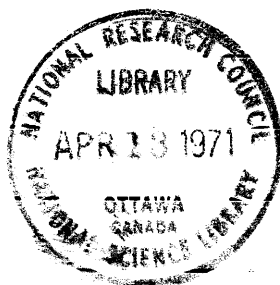


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# Background Study for the Science Council of Canada



March 1971  
Special Study  
No. 20

## Prospects for Scientists and Engineers in Canada

by Frank Kelly

ANALYZED



# Prospects for Scientists and Engineers in Canada

**ANALYZED**

Lopakhin:

You'll have to pull down all the old buildings...and cut down the cherry orchard—

Mme. Ranevsky:

Cut it down? My dear man, forgive me, you don't know what you're talking about. If there's one interesting, in fact quite remarkable, thing in the whole country, it's our cherry orchard.

Lopakhin:

The only remarkable thing about that orchard is its size. It only gives a crop every other year and then no one knows what to do with the cherries. Nobody wants to buy them.

Anton Chekhov,  
The Cherry Orchard

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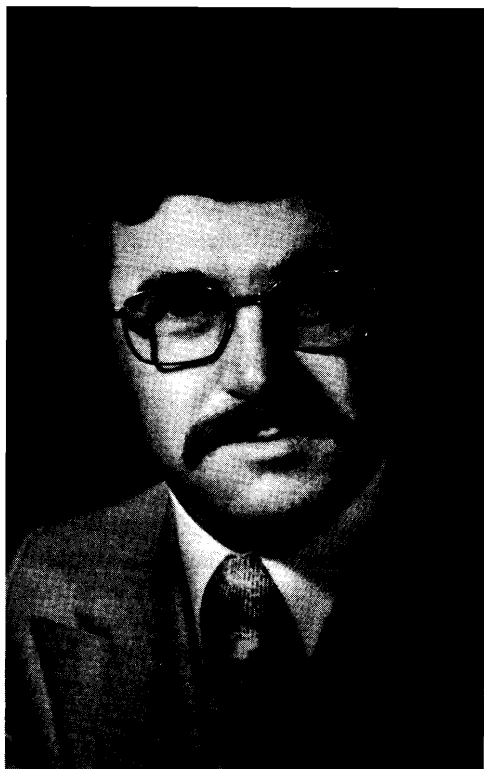
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## Frank Kelly

B.Sc. (University of Sydney), Ph.D.  
(University of New England), F.C.I.C.

Frank Kelly was born and educated in Sydney, Australia. He taught physical chemistry, and performed research on molten salts, in the United States for several years, then moved to Canada in 1964 to establish and direct a power sources research laboratory for the Mallory Battery Company of Canada at Sheridan Park, Ontario. He joined the staff of the Science Council in 1970.



## Foreword

The seriousness and importance of the debate in Canada on the need and demand for highly qualified manpower, on the one hand, and the supply, on the other, is undoubted. Both the nation's leaders and the students are calling into question the relevance of all our post-secondary educational institutions.

This country-wide debate will almost certainly go up many blind alleys before finding its true course to a logical solution.

The Science Council of Canada is studying these many-sided problems, and will publish the results of these studies as quickly as possible as aids to reaching the best possible short-term accommodations and long-term solutions to the problems.

This present publication is a background study by Dr. Frank Kelly of the Science Council staff. As with other background studies published by the Council, it represents the opinions of the author; the Council does not necessarily share any of them, but it is of the opinion that the points raised are supported by the data presented or are logical deductions or projections. Through presentation of Dr. Kelly's paper at this time, the context of the public discussions will be broadened and the new data he presents will hopefully bring new dimensions of understanding to those seeking solutions.

Perhaps even more important are the many gaps in the supply of data needed to make the discussion objective. The existence of these gaps is a serious impediment to a proper understanding of our problems with regard to highly qualified manpower and to arriving at the best possible solution, and indeed, to placing this part of the overall manpower problem in Canada in its proper perspective.

It is hoped that Dr. Kelly's clear identification of these gaps in our data requirement will stimulate those whose responsibility it is to assemble these data to immediate and effective action.

The opinions of those who disagree and agree with Dr. Kelly's dissection of this problem will be most welcome, and will be valuable contributions to the Science Council's ongoing consideration of the total family of problems to which Dr. Kelly's paper is addressed.

P.D. McTaggart-Cowan  
Executive Director.  
31 January 1971

## Acknowledgements

This is the first Science Council Special Study that is mainly about people. There are no authorities on this subject—or rather, we are all authorities. The whole staff of the Science Council has been involved in the preparation of this report, and all have tried to make sure that it presents a balanced statement of the issues involved. Any residual imbalance in the report represents a well-nigh incorrigible bias in its author.

In particular, I want to thank Drs. A.D. Boyd, R.W. Jackson and P.D. McTaggart-Cowan, to whose perceptions and experience this report owes a great deal. Dr. Boyd also served as a guide through the thickets of official and semi-official statistics.

I also want to thank in advance those people who will provide more accurate statistics than this survey has been able to uncover, and those who will carry on this debate in the public arena.

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# Introduction

For the first time in its history Canada faces the prospect of an abundant supply of highly trained people. As we approach this widely sought goal, however, widely divergent reactions have begun to appear. Many see the battle as only partly won, and contend that the proportion of highly educated people in our population is still inadequate to meet the challenges this decade will bring. However, they anticipate that rapidly increasing costs in the educational system will soon produce a systematic examination of all the competing claims upon our national budget, and are concerned that our inability to demonstrate the direct benefits produced by higher education may lead to arbitrary cutbacks in spending.

On the other hand, many people view the educational system as an increasingly inflexible kind of social imperative; they speak of the growth of "credentialism" and of the "educational lock-step".<sup>1</sup> Other critics contend that higher education should now be regarded as a sophisticated form of consumption rather than as a public investment, and should be subject to some of the same discipline of choice as other consumer spending. This attitude has been termed "anti-education backlash"; in fact, however, it is often the public expression of doubts held privately for some time.

Students and graduates occupy the middle ground. They can appreciate both sides of the public investment versus private consumption debate. Immersed in the educational system, they are inclined to defend the scope and direction of university and college teaching, while at the same time seeking to make their instruction more responsive to the social problems they perceive in the outside world. They are, however, aware that university education produces graduates who are information-rich but experience-poor, and are open to changes in the university system.

Post-secondary students are united on

one issue. The theme throughout their years of education has been *preparation*: this they have interpreted to mean preparation for personally and financially rewarding, and socially useful, employment in later life. To an extent, they regard the issue as a social contract: those who respond to the increasing pressures to enter post-secondary education are to be rewarded with more satisfying employment than those who do not. It is easy to understand the growth of this sentiment; it has, after all, been the experience of most graduates to date.

In point of fact, our educational system has always operated with a built-in conflict of values, a conflict that has not been apparent—or significant—until recently. A policy of admitting to universities and colleges all those who are able to benefit from further education carries with it the implication that the size of this year's undergraduate class ought not to be influenced by our projections of the job market four years hence.

Only in special circumstances, such as in time of war, have national need and demand been closely related in the past. At any other time, it has been expected that a nation's aspirations would exceed its willingness to pay. Nevertheless, our social policies would be regarded as more successful if demand in 1971 were more clearly related to national objectives than is presently the case.

Any discussion of highly qualified manpower must take into account both educational policies and the process of creation of employment. Much of the present conflict can be traced to too great an emphasis on one or the other of these issues. The confusion is compounded by inadequate, out-of-date information and a lack of crucial data; it is, for example, impossible to determine with a sufficient degree of precision the number of scientists and engineers employed in Canadian industry. Specific information gaps will be pointed out in the course of this report. We also include some new data which have had only limited circulation; some of these have been gathered by trade and educa-

<sup>1</sup> See, for example, Edmund K. Faltenmayer "Let's break the go-to-college lock-step". *Fortune*, p. 98. November 1970.

tional associations, others have been collected in the course of studies performed for the Science Council Committee on Industrial Research and Innovation.

This report deliberately focusses on certain pivotal aspects of supply and demand. There is widespread unemployment in Canada at this time, and it is frequently concluded that the overall supply-demand imbalance for graduates is a reflection of the current level of activity in the economy. Even so, the potential surplus seems greater for technical graduates (especially for those with advanced degrees) than for non-technical.<sup>2</sup> This is partly a matter of attitude: technical graduates tend to regard their training as specifically vocational, a point of view that was confirmed by the ready availability—until recently—of vocational employment opportunities.

Certain disciplines, such as chemistry and physics, have traditionally been regarded as approximate indicators of future prospects for science graduates in general. If this still holds, continuing study of these early-warning areas should reveal whether our present difficulty is structural (and unlikely to be influenced by increased economic growth) or merely a short-term, cyclical effect. Some authorities now contend, however, that chemists and physicists are inadequate indicators of employment prospects, partly because of their relatively small numbers and specialized employment, partly because of rapidly changing trends in the composition of industry in North America.

Until fairly recently, our educational and employment systems were largely self-governing, and detailed planning and policy decisions were almost unnecessary. Short-term imbalances occurred from time to time, but were rapidly corrected by immigration or emigration. Trends in rising enrolment patterns, in career choices, in public and private support of research and development, continued steadily from

year to year. In the last year or two, however, discontinuities began to appear: student interests began to change, government in-house research ceased to grow, federal incentives failed to further stimulate industrial R & D growth, international decisions produced rapidly changing markets for technological products.

It is now time to re-examine some of the cause-and-effect relationships that were established during the long period of graduate scarcity. This report is a first step in that direction.

## Plan of the Report

The main purpose of this report is to provide information on how Canada's 1971 stock of science and engineering professionals is utilized. This is a subject of interest to a sizable proportion of the population; in fact, it is a crucial aspect of a larger topic, the utilization of Canada's labour force. To place the topic of highly qualified manpower in perspective, we begin with a brief summary of past and future labour force trends. The growth of the science and engineering work force is reviewed in this general context.

On the principle that those who fail to heed history are doomed to repeat it, we next retrace the expansion of the nation's university and college system over the last fifteen years, and the growth of governmental and industrial investment in scientists and engineers. Certain policies, either deliberate or implicit, have guided us along the way; their relevance to today's conditions and aspirations is briefly reviewed.

Information on the demand for university graduates is no less sketchy this year than in previous years. However, at a time in which employment opportunities and graduate output are moving in opposite directions, it is a subject of greater importance than ever before. To clarify the situation, this report gathers together what limited information is available, in an attempt to estimate the employment outlook for this year's graduates. Appendices provide more detailed information

<sup>2</sup> The term "technical graduate" in this report includes all graduates in physical and life sciences and engineering from all post-secondary institutions. "Scientists and engineers" is reserved for university graduates in these disciplines.

from recent surveys, and include hitherto unpublished studies by Science Council staff.

One thing is clear about this decade: it will not be an extrapolation of the sixties. Changes in individual and national aspirations are already beginning to appear, new international coalitions of power are emerging, transnational activities and isolationist policies compete in the same area. The final section of this report examines some trends likely to influence policies for the effective use of our scientific and technological work force.

# The Last Fifteen Years

## Some Background Information

One of Canada's advantages in the post-war years was its plentiful supply of workers. In fact, since 1955 the annual rate of growth of the Canadian labour force exceeded that of any other sizeable Western nation. Over these 15 years the labour force increased about 2.7 percent annually. This is almost twice the rate of growth in the U.S. (1.5%) and over six times that of France (0.4%) or the U.K. (0.4%). In the decade ahead, these annual growth rates are expected<sup>1</sup>:

Country	Average Annual Growth of the Labour Force
Canada	2.5 %
U.S.	1.7 %
France	0.9 %
U.K.	0.3 %

Four separate elements are now at work to maintain Canada's rate of growth. Large numbers of young people are seeking work<sup>2</sup>; immigration continues at relatively high levels (1 immigrant out of 2 enters the labour force, increasing it 0.8% each year); the proportion of women entering the labour force continues to rise (the proportion of women in the labour force rose from 20% in 1950 to 32% in 1970—in fact, half the increase in the force during this period was accounted for by women); and finally, agricultural workers are still seeking work in the cities. Never before, in the 115 years for which statistics are available, have these four influences worked in the same direction.<sup>3</sup>

As a result, although employment is expected to grow faster than population (for which a 1.5% annual increase is expected), the proportion of the population that wants to work is expected to grow faster still.

Canada's labour force now stands at just over 8 million people. Of this number about 159 000 are graduate scientists or engineers. The proportion of scientists and engineers has grown from 1.1 percent of the labour force in 1961 to 1.9 percent in 1970, an achievement paralleled by few other nations.<sup>4</sup> As far as we can tell, the science and engineering work force is continuing to grow 9 percent each year, almost 4 times faster than the population.

At this stage we begin to discern gaps in available information. The 159 000 figure is derived from a previous Special Study<sup>5</sup>, and is probably an upper estimate. When allowance is made for graduates undertaking further education, the size of the operational work force is reduced to about 145 000.<sup>6</sup> No comparable figure is available for the work force of science and engineering graduates from other post-secondary institutions, such as technical and community colleges. This is a serious gap, since the size of this work force may be expected to grow relatively faster than the university graduate work force. There are also indications that the two are beginning to compete for certain technical positions.

There is no easy way of determining how many of the professional work force were educated as chemists, or physicists. Even more difficult is the task of finding how many people, educated in one scientific discipline, are working in another scientific field, or how many work in essentially non-technical areas. Occupational mobility of this type has a considerable bearing on planning how much flexibility should be built into educational policies; we return to this topic later.

At this time more than 6 percent of the overall labour force are unemployed. The

<sup>1</sup> Dorothy Walters, Canadian growth revisited. Staff Study No. 28. Economic Council of Canada, 1970.

<sup>2</sup> This is largely a result of the growing proportion of young people in the population. Over the next 15 years, the size of the 20 to 24 age group is expected to increase an average of 2.2 percent each year, or about 50 percent faster than the total population.

<sup>3</sup> Frank T. Denton, The growth of manpower in Canada. Dominion Bureau of Statistics, 1970.

<sup>4</sup> Estimates of the 1970 proportion of graduate scientists and engineers in the labour force: U.S., 1.5 percent; U.K., 0.9 percent.

<sup>5</sup> This, too, is an upper estimate. The operational work force may be as low as 115 000 scientists and engineers.

<sup>6</sup> Science Council of Canada. Special Study No. 6. Background studies in science policy: projections of R & D manpower and expenditure, by R.W. Jackson, D.W. Henderson and B. Leung. Ottawa, Queen's Printer, 1969.

incidence of unemployment in the science and engineering force is certainly far lower, although specific figures are unavailable. It seems likely that unemployment is greater in the work force with non-technical degrees than in the force with technical degrees. The question is, will this continue to be the case?

A recent report from the U.S. College Placement Council underlines this question.<sup>7</sup> It notes that in 1970, a year in which recruiting levels dropped generally, greater decreases in job offers were recorded for technical graduates than for non-technical graduates. The actual figures are:

**Percentage of Decline in Job Offer Volume (1969-70)**

	Technical	Non-technical
First Degrees	40.0	14.0
Masters Degrees	30.0	2.5*
PhDs	45.0	45.0
* MBAs with non-technical BAs		

A similar message is conveyed by increases in starting salaries. These increases were smaller overall in 1970 than in recent years, but larger gains were reported by non-technical than by many technical graduates.

## Post-Secondary Education

During the period immediately following the Second World War, Canada, which was at the time in full economic development, encountered difficulties in meeting its needs for highly qualified manpower. These needs were partly filled by immigration, thereby reinforcing a long-standing pattern that has persisted to the present day. (By 1961, for example, about one quarter of Canada's professional scientific manpower consisted of postwar immigrants.<sup>8</sup>) Faced with the prospect of continuing manpower shortages, and in response to social demands, both federal and provincial governments undertook a deliberate policy of expanding the post-secondary educational system.

<sup>7</sup> Chemical and Engineering News, page 27. July 27, 1970.

The success of this policy is particularly evident in university education. In the last ten years enrolment has tripled (to 350 000), as has the annual number of degrees awarded (to 60 000). In addition, a whole new system of community colleges has been created, with a total enrolment (150 000) already nearly half that of the universities.

This vast expansion in higher education initially produced an acute demand for teachers with advanced degrees; thus, despite increases in domestic production, Canada found itself more dependent than ever on highly qualified immigrants.<sup>9</sup> Two other changes increased this dependence: greater Canadian "brain drain" to the U.S., and increased academic requirements for university faculty, particularly in engineering.

In order to resolve this dilemma, Canada's universities began to prepare a large proportion of their graduates for a career in the education system. In a sense, curricula and courses were shaped to produce teachers, research supervisors and professors. The other purposes of the educational expansion—supplying educated people to take their place in government, industry and other parts of the private economy—were temporarily forgotten.

In the meantime, population growth continued on its inexorable course. The proportion of 22 year-olds in the Canadian population (the age group demographers consider most likely to achieve a first degree) recently reached a new peak, and will not fall back to 1968 values until 1985.<sup>10</sup> We are thus faced with an *increasing* number of graduates who consider education the employment sector of choice,

<sup>8</sup> Overall, the postwar immigration program has materially improved the educational content of Canada's labour force. Forty percent of postwar immigrants have completed high school, and 9 percent have attended university; the comparable figures for the native-born labour force are 32 percent and 5.6 percent.

<sup>9</sup> The immigration of professors increased from 540 in 1963 to 2 400 in 1969, for example. During this period university teaching staff rose from 11 700 to 19 500.

<sup>10</sup> Z.E. Zsigmond and C.J. Wenaas. Staff Study No. 28. Economic Council of Canada, 1970.

coupled with *decelerating* rates of employment in education.

To compound this dilemma, an increasing number of graduates now have higher degrees. As a result, while a rapidly declining proportion of those with higher degrees are likely to find employment in the education system (for which they may be particularly well qualified), a rapidly rising proportion still need to find employment in government, industry and elsewhere in the private economy (for which they may not have been as adequately prepared).

Examination of university enrolment and graduation statistics shows that science and engineering have fully participated in the overall university expansion. While enrolment has tripled, the proportion of undergraduates choosing science or engineering has increased slightly since 1960. This year about 53 000 students are enrolled in courses leading to a first degree in science (pure or applied) or engineering.

Similarly, the number of bachelor's degrees awarded in science and engineering has increased in almost fixed proportion to the total number of first degrees. At 17 percent of the total, almost 11 000 first graduates in science and engineering were produced in 1970.

Over the years, however, an increasing proportion of the graduating class has enrolled in graduate schools. The result of this practice has taken a little longer to be perceived, but first became apparent in the latter half of the sixties. During this period, the annual output of science and engineering PhDs began to increase about 23 percent each year, over one and a half times faster than the annual increase in first degrees. Between 1 100 and 1 450 science and engineering PhDs may be expected to graduate in 1971; precise estimation is hampered by uncertainty about deferred graduations and unsubmitted dissertations.

This phenomenon shows no immediate signs of changing. More than 11 000 graduate students (9 950 of them full-time students) are currently enrolled in science and engineering faculties; sooner or later,

with greater or lesser qualifications, they will appear in the employment market.

About one half of these graduate students (and about one third of each year's PhD output) are foreign students who, technically, have to apply for landed immigrant status before staying to work in Canada. Little information is presently available on the proportion choosing to remain in this way. No information exists on the numbers who leave Canada upon graduation and subsequently return.

On the other side of the coin, the considerable number of Canadians studying abroad (about 15 000) can be considered as potential additions to our working force. About one half of them are graduate students, but there is no way of determining how many of them are scientists or engineers.

Although immigration has become less important a factor than it was in building up Canada's scientific work force, it remains a significant influence, and its potential is even greater. From 1960 until recently, rather more than one thousand scientists and engineers emigrated each year, principally to the U.S. Each year this loss was more than recouped in the form of immigrants, chiefly from Europe and the U.K. In the last decade Canada has probably lost 11 000 graduates, but has gained about 24 000, for a net gain of 13 000.

There is no sign of a slackening in this trend. In fact, in 1969 professional and technical workers formed the largest single segment (26 900 persons) of the 84 300 workers entering Canada.

Emigration of scientists to the U.S. need not be permanent. The "Operation Retrieval" campaign seeks to reverse this flow; at this stage, however, its success is difficult to gauge. The return of Canadians from the U.S. might be expected to increase our scientific work force considerably, for Canada has contributed to the U.S. a higher proportion of its graduate stock than have most other countries.<sup>1</sup>

Throughout most of this analysis we have spoken of the scientific work force as though it consisted solely of university



graduates. Supporting this force, of course, is a group of technicians, technologists and other supporting workers as least double the size of the professional work force. Very little reliable information is available on its exact size, its rate of growth, its distribution of educational qualifications, or the demand for technicians in various employment sectors. There is little doubt that this information will be required very soon. The rapid growth of the community college and CEGEP systems is beginning to blur operative distinctions between graduate and non-graduate scientific personnel, and it may soon prove impossible to consider educational and employment policies for one group in isolation from the other.

Doubling the scientific work force in the last twelve years has not been easy. Highly trained professionals have come to Canada in response to employment opportunities; at the same time, massive educational expenditures have been made to ensure that Canadians would have adequate and growing opportunities to participate in Canada's development.

Before attempting to decide at what level this increase will be maintained, it is appropriate to look at the way in which this work force has been used in recent years.

## Deployment of the Scientific Work Force

Table 1 summarizes what little we know of the distribution of the work force; it accounts for barely 15 percent of the total. Educated guesses can be made about some of the unknown quantities, but others (the number of scientists and engineers working in non-R & D functions in the private service industry, for example) remain totally unassessable.

Data for scientists and engineers working in R & D (including university teaching)

<sup>1</sup> For example, if one ranks countries by native-educated PhDs working in the U.S. as a proportion of the domestic stock of post-secondary students, the list runs: Switzerland 8.6 (Swiss-educated PhDs in the U.S. per 1 000 Swiss post-secondary students); Austria 5.3; U.K. 2.9; Canada 2.8; Cuba 2.6. (H.G. Grubel, *Bulletin Atomic Sci.*, April, 1970).

are fairly well documented, and indicate that about 15 percent of the total are employed in this capacity. Data for non-R & D functions are so sparse that it is impossible to guess which sectors can effectively make use of the forthcoming supply of scientists and engineers. This is, in a sense, the crux of the problem; we have been so preoccupied with R & D over the last ten years that we have lost sight of the considerable numbers of scientists and engineers otherwise engaged in keeping the country running.

It is possible, however, to make a very rough estimate of the distribution of scientists and engineers in the three major employment sectors. This estimate is given in Table 2, with comparable distributions in the U.S. and the U.K.

## Universities

Throughout the sixties, science and engineering faculties grew in size at an average rate of 13 percent per year. In 1968 this growth began to decline more rapidly than most planners had anticipated, and by 1970 had dropped to 5 percent or less. At the present time universities employ about 9 000 science and engineering faculty members. Almost 6 000 of these have PhD degrees.

During the period of rapid university growth the number of faculty employment opportunities each year amounted to about 80 percent of that year's PhD output; this proportion now stands at 35 percent or less.

Universities employ scientists and engineers other than in faculty positions. Post-doctoral fellows form the largest single group, and presently number almost 2 000. Besides engaging in research, a substantial number of them assist in teaching, and serve as demonstrators, as sessional lecturers and in similar functions. In some cases they occupy junior faculty positions. Post-doctoral fellows are the fastest-increasing group at universities (20% per year in recent years), but it is not clear what standards of "effective utilization" should be used to determine the optimum size of this group.

Table 1—Employment of Scientists and Engineers (1970 workforce estimate: 145 000)

	Education			Government		Industry		
	Univer- sities	Other post-sec- ondary	Primary and sec- ondary	Fed- eral	Provincial and other	Manufac- turing	Service	Self- employed
R & D (or teaching)	9 000 +	na	na	4 600	500 +	7 500	200 +	na
non-R & D (manufacturing, administration, other duties)	na	na	na	2 800p	na	na	na	na
+ indicates minimum estimate								
na not available								
p provisional figure								

Table 2—National Differences in Employment of Scientists and Engineers

Employment Sector	Canada (1970)	U.S.* (1966)	U.K. (1969)
Education	40 000	194 900	32 500
Government	20 000	219 500	52 500
Industry	80 000†	997 600	115 000
Total	140 000	1 412 000	200 000
* The U.S. data includes a group of perhaps 300 000 “engineers” who do not hold degrees; most of them are employed in industry.			
† The industry figure was obtained from differences, and is possibly an overestimate.			

Industry

Canada is a comparatively young country, and the origin of its industrial activities in the exploitation of natural resources is evident in the composition of Canadian industry today. During the postwar years, an increasing degree of emphasis was placed on the development of industries based on the application of technology. These efforts have been successful, but perhaps not successful enough to take advantage of the impending supply of technically trained people.

One measure of the degree of technological intensity of a country’s industry is the proportion of the total stock of scientists and engineers that is employed by industry. As we have seen, this requires guesswork, but it is likely that in this respect Canada ranks only slightly lower than the U.S. or the U.K. However, the ratio of scientists to engineers seems rather higher in Canadian industry than in the industry of many other countries.

There are now indications that no further sizeable increase in industrial use of scientists and engineers can be expected in the immediate future. Many “high-technology” industries, which have since 1960 claimed

a large proportion of each year’s university output, now appear to be reaching a state of limited growth, with a corresponding decline in new employment opportunities. Some technology-based industries have experienced similar saturation levels in the past; it is highly unusual, however, for industries in such diverse fields as aircraft, electrical components, and chemical products to reach this stage at the same time.

The reasons for this slackening in demand for graduates vary from industry to industry; in most cases, however, the main factors are limitations of market size and accessibility, and raw material costs, combined with increasingly severe economies-of-scale competition. Many companies regard the stringent financial climate of 1970 as only a minor consideration, compared with the structural changes now occurring in world trade.

The chemical industry is a case in point. In Canada this industry, though it employs relatively few people (81 000), sells \$2 billion worth of products annually. This is achieved by a combination of capital investment (about \$2.5 billion) and the use of technology: the chemical industry employs about 20 percent of all the engineers in

Canadian industry, and uses four-fifths of these engineers in functions other than research and development. Over the next few years this industry expects to be able to provide employment for barely 6 percent of our chemical engineering output; these projections are summarized in Appendix D.<sup>1</sup>

A number of other industries that depend on the use of technology have apparently reached the same conclusion: increased employment of scientists and engineers is unlikely to yield proportionately increased profits. There is in many of these industries a resurgence of interest in the exploitation of natural resources, for which the size of the potential market seems less constricting a factor.

Similar conclusions have been arrived at independently in a number of industries, and serve to focus attention on the economic framework within which these decisions were made. Generally, industry believes that an immediate re-examination of regulatory and other policies affecting market access is essential to the continued growth in Canada of technology-based industries, and to the continuing employment of graduates in these industries.

### **Employment in Industrial R & D**

Over the last fifteen years, research and development has become an increasingly significant activity in established Canadian industries. During the same time, many industries which formerly saw no need for technological innovation have established, and profited from, R & D laboratories. Federal and provincial governments have materially promoted the rapid growth and pervasiveness of industrial research.

There are now clear indications of a levelling-off in the rate of growth. The annual rate at which new laboratories are established, which rose from 19 in 1955 to 63 in 1965, has dropped sharply: no net increase in the number of laboratories occurred during 1969, and the number decreased during 1970. Canada now has

about 640 industrial R & D establishments, and few additions can be expected.<sup>2</sup>

Appendix C provides additional details.

Although the number of establishments became fixed around 1965, each laboratory continued to grow in size for several years. The rate of growth during 1965-67, although smaller than in previous years, averaged almost 5 percent in new employment opportunities each year.

Since 1968, no net growth can be detected in industrial R & D. Individual laboratories continue to fluctuate in size, but staff decreases now almost exactly balance increases. R & D expenditures have continued to increase; the rate of increase is considerably less than in previous years, however, and can be accounted for largely by inflation costs and the increasing sophistication of research techniques.

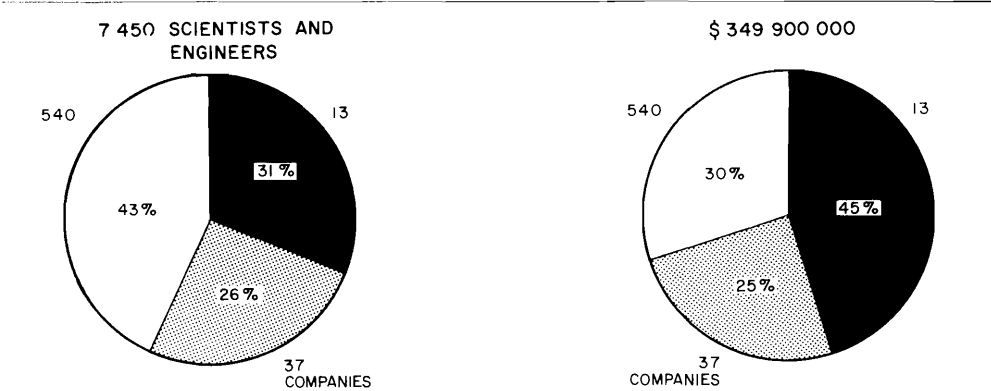
Canada's 640 industrial R & D laboratories have a total budget around \$424 million, and employ about 7 600 scientists and engineers. (As shown in Figure 1, there is an appreciable concentration of this effort. In fact, 50 of these companies employ 57% of industrial R & D professionals, and spend 70% of the total industrial R & D budget. Figure 2 shows that 450 of these laboratories employ 5 or fewer graduates.) No change is foreseen by industry in the near future. About 300 employment opportunities for graduates may be expected to occur annually through retirement and other forms of attrition—a negligible proportion of the 14 000 science and engineering graduates now produced each year by Canadian universities.

It seems likely that more than 600 of the 34 000 manufacturing companies in Canada could benefit from performing research and development. Existing incentive programs, however successful they have been over the last ten years, have failed to interest the great majority of companies, and stand in need of further revision. Other forms of incentive might well be tried; for example, government contracts and other

<sup>1</sup> From 1965 to 1968, the chemical industry employed 24 percent of each year's chemical engineering graduate output.

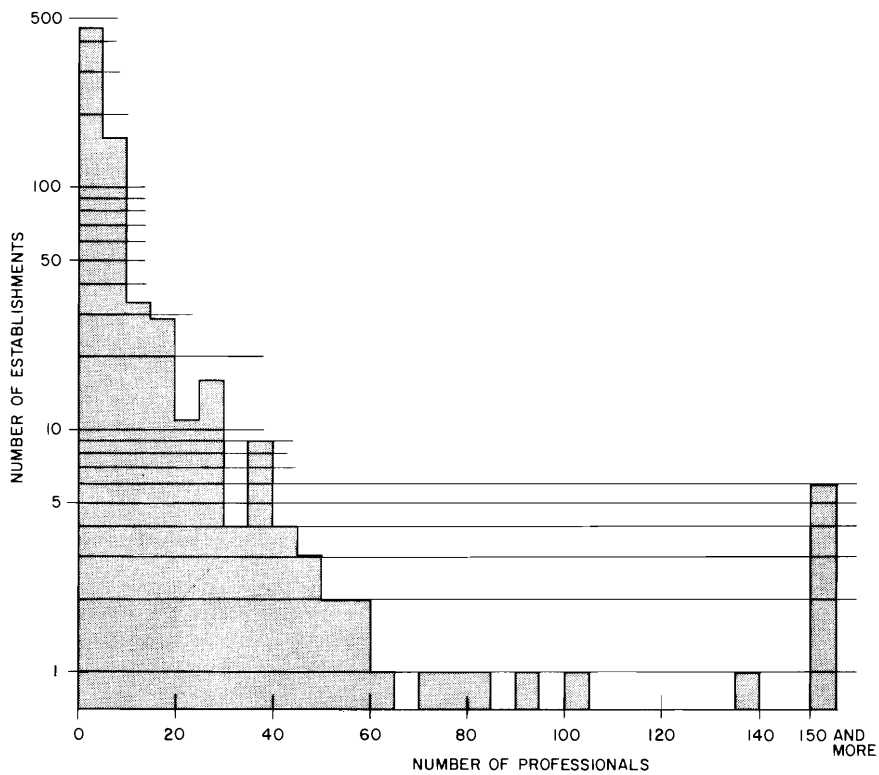
<sup>2</sup> In fact, during the latter half of 1970 several laboratories were closed: whether this will lead to a domino-like collapse of laboratories in competing companies is still open to question.

Figure 1—Distribution of Professionals and Funds in Industrial R & D, 1968



Sources: DBS 13-532 and Science Council survey—See Appendix C.

Figure 2-Size Distribution of Industrial R & D Establishments, 1968



Source: Directory of scientific research and development establishments in Canada. Department of Industry, Trade and Commerce, 1969.

purchasing agreements might more commonly include provision for R & D expenditures as a means of obtaining improved supplies or services.

There is a tendency in industry to regard the R & D laboratory as a training ground from which graduates are drawn for other functions, such as production or marketing. This avenue now seems to be narrowing. There is unquestionably a need to encourage employment of science and engineering graduates in a wider range of industrial functions.

### **The Service Industry**

In Canada service industries, defined as industries other than those producing physical goods, now provide two-thirds of all paid jobs outside of agriculture. The term "service industry" cuts across all three employment categories shown in Table 1; it includes all forms of education, a substantial proportion of governmental work, and many private or semi-private enterprises in the fields of communications, transportation, recreation, and wholesale and retail trade.

Despite its importance as a source of new employment opportunities, the service sector has long been a neglected field in economic research. Even today, opinions are sharply divided on how best to measure productivity or output.

If there is one issue on which forecasters are agreed, it is that the seventies will see a continuation of the rapid growth of organizations that provide individual and communal services, and relative stabilization of companies that make tangible consumer products. Service, or "communal goods", industries have always been labour-intensive. Whether they will become increasingly scientist- and engineer-intensive during their period of rapid growth is quite another question.

The heterogeneous nature of the service sector complicates this issue. Certain public and crown corporations are obviously very dependent on continuing technological advances. Our air and rail transportation systems, and especially the communications and computer businesses, are cases

in point. At the other end of the scale, it is doubtful whether the continuing expansion of the recreation and tourism industry will depend on increased participation by scientists and engineers with advanced degrees.<sup>1</sup>

In between, we can distinguish many industries to which technology has made substantial contributions over the last decade, but in which the rate of continuing innovation seems to be levelling off. In the educational sector, while audio-visual devices have come into widespread use, the use of computer-aided instruction seems hampered, at least for the moment, by the capital costs involved. Law enforcement (especially crime detection and road safety) has made use of advances in chemistry and systems analysis, but the current rate of application of new technology is disappointingly low. Retail trade, health care, information services—all seem, for the moment, to have reached a technological-economic impasse.

At the same time, there are many services for which a widespread, but unfocussed, demand can be detected in the nation. Frequently these are services which the increasing urbanization of our population makes both more feasible and more urgently wanted. Examples range from day-care centres and taxi-bus systems to the provision of clean air and potable water supplies. All require a combination of private entrepreneurial initiative and legislative definition of the market, a combination slowly beginning to emerge. These "new service industries" represent a major source of new employment, and new tasks for science and technology.

### **Government**

The federal government employs about 7 500 scientists and engineers to perform scientific work. About 4 700 of them are engaged in R & D; Tables 3 and 4 indicate their distribution among various departments and agencies. The supporting staff, containing a high proportion of technicians and technologists, is over

<sup>1</sup> Except, of course, in the resource management and environmental quality aspects of recreation and tourism.

**Table 3—Employment of Scientists and Engineers in Federal R & D Activities, 1969-70**

Department or Agency	Scientists and Engineers
Agriculture	847
AECL	591
Energy, Mines & Resources	732
Fisheries and Forestry	844
National Defence	396
National Research Council	720
Other	524
<b>Total</b>	<b>4 654</b>

**Table 4—Federal Personnel Engaged in Science, 1969-70**

Department or Agency	Total Scientific Personnel	
	R & D	Other Scientific Activities
Agriculture	3 891	287
AECL	3 199	85
Energy, Mines & Resources	1 821	1 898
Fisheries and Forestry	2 753	351
National Defence	1 864	63
National Research Council	2 378	498
Other	1 390	3 020
<b>Total</b>	<b>17 296</b>	<b>6 202</b>

twice as large, and currently stands at about 16 000 for all scientific activities.

From 1960 to 1968 the size of this scientific force grew at a rapidly accelerating rate. (Its total cost, growing more rapidly still, increased from \$179 million in 1960 to \$418 million in 1968.) In 1968 staff increases began to decline rapidly, and the size of the total work force has remained essentially constant for the last eighteen months. Federal expenditures on in-house scientific work continue to increase gradually, however; these expenditures in fiscal 1969-70 stood at \$486 million.<sup>2</sup>

The federal government's measures against inflation, though essentially they stabilized the public service at 1968 levels, have had a number of beneficial effects, and it is likely that more efficient use is now being made of the fixed scientific workforce than was formerly the case. An increasing number of governmental agencies began changing their organizational structures to permit their embarking on intermediate-

scale projects meeting the criteria of timeliness and relevance. A system of standing interdepartmental committees rapidly grew; while in some cases these committees further obscured issues, and prevented effective action being taken, in others they rapidly eliminated duplication of scientific activities. Some agencies demonstrated their potential for effective action when assigned the authority and responsibility which was formerly divided between several departments.

At the same time, it began to be clear that the federal government, during the long period of graduate shortage, had virtually monopolized certain scientific fields (agricultural research, for instance) which might more profitably be shared with universities and with industry.

In short: a number of federal government departments, while leaner than they expected to be, are probably now better organized to take on new challenges when inflationary pressures permit.

It is difficult to ascertain the state of scientific readiness in provincial governments. For one thing, they rely on federal scientific resources to markedly different degrees. There is also a lack of overall consistency in their manner of reporting scien-

<sup>2</sup> The steady year-by-year increase in the cost of scientific activities attributed to price inflation and increasing sophistication of scientific techniques is usually termed the inflation-sophistication factor. This year the factor has increased to 7.5% from the 6% estimated in 1968, mainly as a result of rapid price increases.

tific and engineering manpower inventories. Provincial non-profit research organizations employ more than 500 professionals in R & D; many provinces also conduct R & D in fields such as water resources, power generation and transmission, and fuel and mineral resources. No general information exists on the utilization of professionals in non-R & D activities.

Information is just as sparse on the scientific and engineering activities of municipal and city governments. With few exceptions, they tend to use mainly civil and mechanical engineers, and (in some large cities) systems engineers.

One observation is applicable to all three levels of government: they appear to hire graduates for their very specific professional skills. As a result, few scientists or engineers are found in departments that do not have a strong technological component. Industry has been criticized for this failing, but has on the whole a better record than government: scientists and engineers are far more frequently found in plant administration, in marketing, in corporate planning and in general management than in analogous government departments.

This is a potentially serious failing. Technology now influences the course of government policy more than ever before, and no department can afford to ignore the implications of new technology in domestic issues. There is also the international aspect: science (and the technology it produces) is increasingly a supernational activity, and a country's health now seems to be determined by the speed with which it can react, to weigh, absorb and diffuse new technology. Many countries now have an extensive system of scientific attachés for this very purpose. Canada does not.

## Government-funded Activities

Governments have never had a monopoly on technological progress towards national goals. Involvement and contributions by the other sectors of the economy are regarded as essential to such progress. To this end, the Federal government disburses about 30 percent of its total an-

nual budget for scientific activities to universities and industry; funds are shared about equally by the two recipients.<sup>1</sup>

To date, the industrial sector has felt that it should engage only in those activities likely to produce a profit over a relatively short term. The time scale inherent in many of the tasks now facing us is longer than industry is usually prepared to consider; furthermore, the magnitude of the potential return, both social and economic, seems sufficiently imprecise to deter totally private industrial involvement. In a sense, the problem is that of persuading industry to use its talents to complement the main governmental thrust. One likely, but as yet largely untried, technique is the use of contracts for specific projects. Despite excesses, the contracting system worked well in the most complex task any nation has yet set itself—the U.S. space program. In Canada there has always been a tendency for the government to perform in-house any work related to national goals. It may be that the seventies will see a modification of this viewpoint, with increased contracting-out to industry.<sup>2</sup>

These considerations apply equally well to universities, which are—as a potential source of technological skills—probably more significant than either government or industry. Universities contend, with some justification, that research activities are an essential concomitant of teaching. The type of research performed by professors and students has usually been phenomenon-oriented, and has—often by default—been chosen by researchers (or groups of peers) on the basis of personal inclination. There is no reason to suspect that the quality of teaching will suffer if a larger proportion of this research becomes mission-oriented; in fact, it now seems likely that a satisfactory degree of mission-orientation can be achieved without conflict. There is every reason to hope that a coherent, directed scheme will produce greater returns on investment in university research.

<sup>1</sup> The university allocation, however, is now growing more rapidly than the industry allocation.

<sup>2</sup> See the discussion on this topic in *A science policy for Canada*. Report of the Senate Special Committee on Science Policy, vol. 1. Ottawa, 1970.



# The Immediate Future

As we have seen, our state of ignorance about the present deployment of the scientific and engineering work force makes it very difficult to predict where this year's crop of graduates will most likely find employment.

Furthermore, rapid changes are now occurring in demographic and economic patterns, causing saturation in some employment markets and increasing opportunities in others. As a final complication, community college graduates are now seeking jobs in areas formerly regarded as the preserve of university graduates; the converse process has also begun, with university graduates accepting positions that (in their opinion) underutilize their skills.

Nevertheless, it is important to try to estimate the employment prospects of this year's graduating class. Two approaches are used below. The "holistic approach" makes a rough assessment of present employment sectors, and attempts to predict the rate at which these various subforces will increase over the coming year. Its disadvantage is that the overall demand estimated in this way will likely prove greater than the sum of the interdependent parts: for example, the number of BScs proceeding to graduate school is likely to drop during a period of massive industrial demand; this approach makes no allowance for this effect.

The "key area approach" selects three areas that have in the past been regarded as indicators for the employment prospects of graduates in general. They are: employment of PhDs, employment in industrial R & D, and the employment of graduates in the chemical industry. The disadvantage of this approach is that the key areas are almost abnormally sensitive to changing conditions; during periods of economic difficulty they are likely to predict unrealistically low demand levels for all graduates.

## The Holistic Approach

We begin by assuming no distinction between various levels of university degrees.

At a very conservative estimate, the total number of science and engineering degrees to be awarded in 1971 is 14 000 (11 000 bachelors; 2 000 masters; 1 000 PhDs).

The total scientific and engineering work force is, at most, 145 000. This force is subject to attrition (through death, retirement, and transfer out of the labour force) at 2 percent per annum, at most. (There are indications that 1.5% or less is more applicable: a substantial proportion of the force are now less than thirty years old.) This attrition may be expected to create 2 900 replacement positions each year.

If recent trends continue, about 20 percent of the bachelor graduates will enter graduate school: we count this as 2 200 (temporary) employment opportunities.

We now turn to conventional employment positions, and consider various sectors.

a) Universities employ 9 000 science and engineering faculty members. We assume a 5 percent annual increase in faculty (corresponding roughly to enrolment increases) will produce 450 new positions in 1971.

b) Other post-secondary educational institutes (technical and community colleges, CEGEP) employ about 11 500 teachers. We assume that 4 000 (or about 35%) of them teach courses with a scientific and engineering content, and that this number is increasing at 5 percent each year<sup>1</sup>: this provides 200 new positions.

c) There are about 90 000 secondary school teachers in Canada. We assume that the same ratio applies as at universities, and that one-fifth (or 18 000) of them teach courses with a scientific content. We further assume that the number of teachers is increasing at 4 percent per year, and that all the new teachers have university degrees. This calculation yields 700 new jobs for graduates in 1971. (In this connection it is worth noting that secondary school enrolment is expected to increase for a few years only, reaching its peak in 1975.<sup>2</sup>)

<sup>1</sup> This corresponds to enrolment (in colleges, about half that in universities) corrected for the colleges' more rapid rates of increase.

<sup>2</sup> Z.E. Zsigmond and C.J. Wenaas. Staff Study No. 25. Economic Council of Canada, January 1970.

d) No sizeable increase is foreseen in the numbers of elementary school pupils or teachers. There are indications that the long postwar rise in elementary education has now come to an end.<sup>2</sup>

e) We assume that about half (or 500) of the newly graduated PhDs will accept newly-created post-doctoral fellowships, either academic or industrial.

f) No allowance is made for increases or decreases in industrial R & D.

g) We assume that government policy will remain the same as in 1970, and that only replacement hiring will occur.

h) Despite our experience in the last decade, it is assumed that immigration and emigration will be approximately equal, so that university graduations will be our sole source of supply.

i) Industrial employment of graduates in non-R & D functions is difficult to assess. We assume that industry employs 80 000 scientists and engineers, and that this number will increase by 4 percent (or 3 200 new positions) in 1971. This is probably the most optimistic projection of all.

Table 5 summarizes these postulates. Several observations can be made:

1. The same kind of calculation, applied to 1969 figures, shows a balance between supply and demand: graduate supply was considerably less, but university and college hiring was higher, than is expected in 1971.

2. No allowance is made for the inroads community college graduates may be expected to make in industrial hiring.

3. These figures need not be interpreted to mean that 4 000 graduates will be unemployed. It can be expected that certain

job qualifications will be rewritten to require higher standards, thereby displacing an equal number of less qualified people. They show, however, that the pressure to redefine job standards will be stronger than was expected.

Throughout this analysis, a conservative estimate of supply has been combined with a generally optimistic projection of demand. The main conclusion is that a supply-demand imbalance is imminent across the educational spectrum, and not simply at the PhD level.

## The Key Area Approach

In this section we focus our attention only on a few significant areas. Supply and demand can be regarded as intersecting in the form of a matrix, as shown in Figure 3. We will deal with three elements in this matrix.

1. Research and development in all Canadian industries: its current demand for graduates at all levels;

2. Demand for graduates, for all functions in a specific industrial group—the chemical industry;

3. Demand for PhDs from all employment sectors.

### Industrial R & D

This is a far smaller market place than most people realize. Altogether, it employs less than one year's university output. Furthermore, its employees and expenditures are concentrated in a fairly small group of companies.

As indicated in a previous section, while the number of industrial research labora-

**Table 5—Supply and Demand: Science and Engineering University Graduates, 1971**

<b>Supply of graduates</b>	<b>14 000</b>
<b>Demand for graduates</b>	
Graduate school	2 200
University faculty	450
Other post-secondary faculty	200
Secondary teachers	700
Post-doctoral fellowships	500
Industry	3 200
<b>Sub-total</b>	<b>7 250</b>
Replacements for attrition	2 900
<b>Total Demand</b>	<b>10 150</b>

tories established each year in Canada grew quite smoothly until 1966, this rate of growth has fallen sharply in the last four years; we now have, essentially, a fixed number of laboratories—about 640.

Appendix C contains an analysis of recent manpower trends in industrial R & D. In summary: since 1968 there has been a serious weakening in demand for graduates. In the last two years most medium-sized companies have actually reduced the size of their research laboratories. The large research organizations have managed modest increases, but seem to be nearing their maximum size. Small companies continue to increase R & D in general, but employ a distinct minority of industrial scientists.

The overall trend since 1965 has been declining rates of increase in industrial research. In 1970 no growth occurred. This can be seen by ranking laboratories by size: the increases (in small and very large companies) exactly balance the decreases in medium-sized companies. Figures 4 and 5 illustrate this point.

This does not mean zero demand for scientists and engineers in R & D. Attrition should, in 1971, produce a demand for 30 PhDs, 50 MScs and 250 BScs. In other words: for the next year, and possibly longer, industrial R & D seems to require only enough graduates to cope with attrition—perhaps 350 graduates, or about 2 percent of this year's output.

### **The Chemical Industry**

We now look at the demand for science and engineering graduates in other industrial capacities—marketing, production, technical service, quality control, general management. The Canadian chemical industry's trade association, the CCPA, has just completed a survey of its graduate needs through 1974; this is the only survey of its kind conducted by any industrial group in Canada in recent years. Appendix D provides an abstract of their conclusions.

The chemistry industry has concluded, not only that its R & D effort is unlikely to grow for several years, but also that it has greatly reduced graduate requirements

until 1974—in all areas of employment. Its demand for chemical engineers, for example, has dropped from 18 percent to 7 percent of bachelor degree output from universities; the proportion of each year's supply of PhDs in chemical engineering likely to find employment with CCPA members has fallen from 33 percent to 7 percent.

The profitability of the Canadian chemical industry has been adversely affected by increases in the cost of raw materials and by economies-of-scale competition from the U.S. Under these circumstances, most companies resist increases in operating costs. Coincidentally, however, projected graduate requirements of chemical companies in the U.S. almost parallel the Canadian projections.

The chemical industry, is not an isolated instance. Certain other industries (the aircraft/aerospace industries, and certain parts of the electronics industry, are examples) have recently revised their graduate requirements, and now appear to need far fewer graduates than they had anticipated.

### **PhD Supply and Demand**

In 1969 the National Research Council published a projection of science and engineering research in Canadian universities from 1968 to 1972—the "Bonneau Report".<sup>1</sup> Part of this report dealt with the supply and utilization of PhDs. A study prepared for the Science Council in 1970 has now revised and extended the Bonneau projections; a summary of the conclusions is provided in Appendix A.

The study concludes that 1 200 to 1 500 science and engineering PhDs may be expected to graduate during 1971.<sup>2</sup> Estimates of new employment opportunities indicate that university faculties will increase 7 percent, at most, in 1971: this provides 400 positions. It is assumed that

<sup>1</sup> Projections of manpower resources and research funds 1968-1972. National Research Council, 1969.

<sup>2</sup> It is possible, however, that a proportion of these prospective graduates will deliberately defer submission of their theses: the A.B.D. (all but dissertation) has recently become almost a degree in its own right. Whether this practice will continue as the numbers of A.B.D.s mount is not clear, however.

Figure 3-Selected “Key Areas”

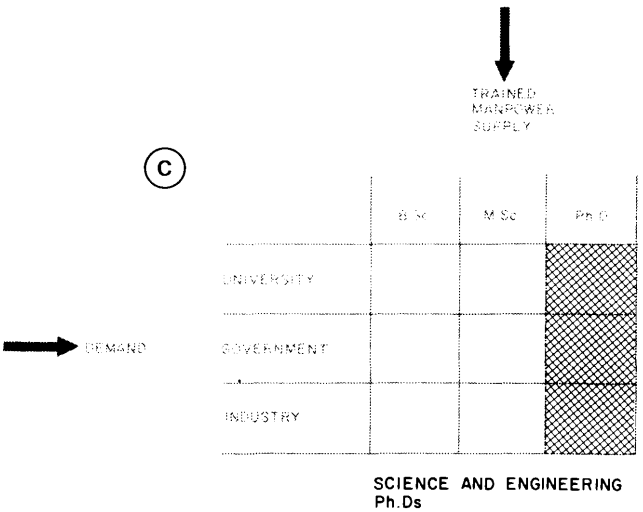
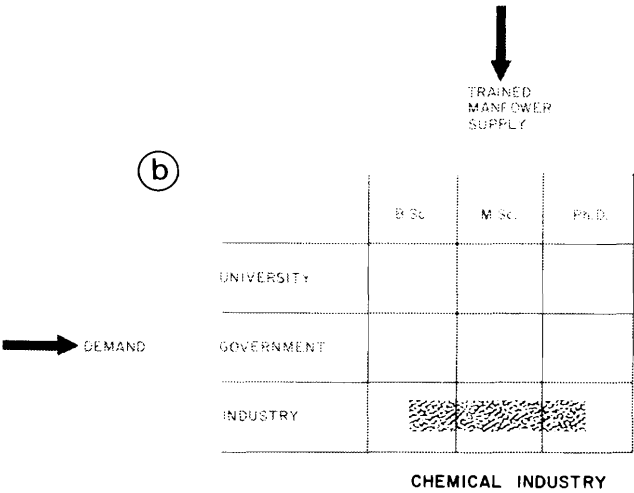
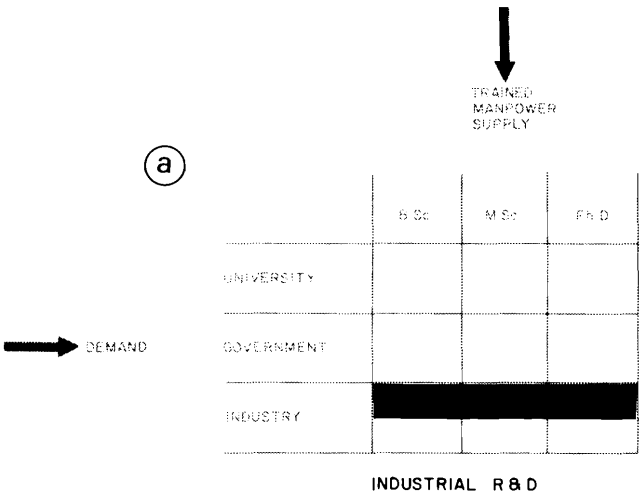
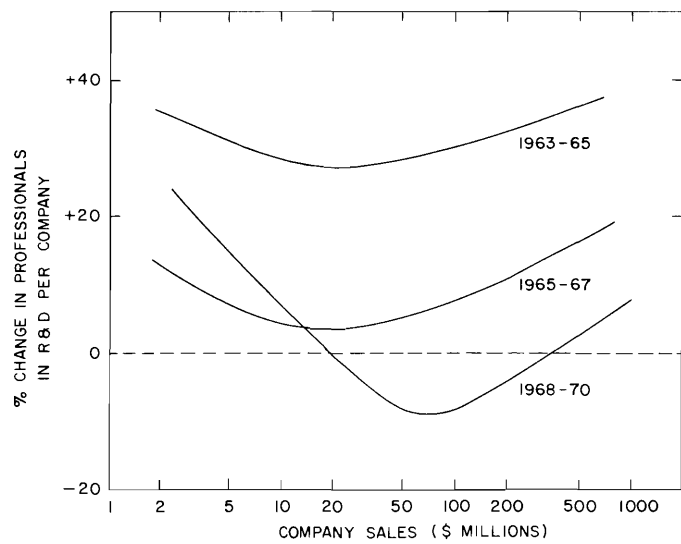


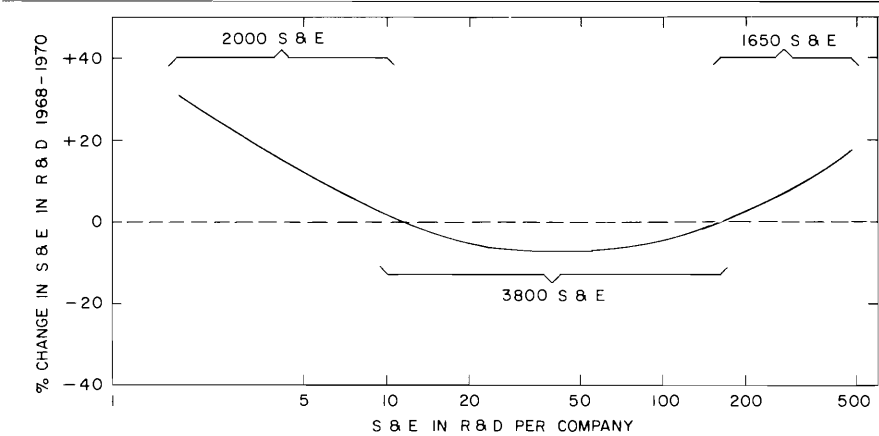
Figure 4—Change in Size of Industrial R & D Establishments, 1963-70



S & E: scientists and engineers

Sources: DBS 13-527 and 13-532; and Science Council survey—See Appendix C.

Figure 5-Relative Change in Industrial R & D Establishments, 1968-70



S & E: scientists and engineers

Source: Science Council survey-See Appendix C.

the freeze on government employment will be eased, and that the government work force will increase 3 percent: this provides 60 positions. It is also assumed that industrial employment will increase by an amount corresponding to 6 percent of the PhDs in industrial R & D, thereby providing 60 new positions; these PhDs will not necessarily be employed in R & D.

In all, about 520 new positions are forecast. About 80 percent of these are in universities; this is the same proportion as in the years when PhDs were in short supply. Attrition (assuming a 4 percent rate) will possibly provide 350 additional employment opportunities, bringing the total to 870.

Between 350 and 650 PhDs remain. If the creation of post-doctoral fellowships is allowed—or encouraged—to continue its 20 percent rate of increase, 400 new positions will be made available in 1971. If, on the other hand, a gradual decline to a 7 percent rate of increase (the same as for university faculty) by 1972 is considered desirable, only 250 new PDF positions will be available in 1971.

Figure 6 summarizes these conclusions on supply and demand. Figure 7 indicates the likely imbalance between supply and demand; two models for PDF increases are used.

Depending on these decisions, the overall surplus in 1971 may range from zero to 400 PhDs. We can, however, avoid a surplus only by renewing all existing post-doctoral fellowships, and by granting PDFs to 400 of this year's graduates.

If the post-doctoral fellowship is regarded as only a temporary form of employment, it must be concluded that permanent employment is available for only one half of this year's PhD output.

This analysis disregards any potential net immigration of PhDs, and also simplifies the issue by assuming that discipline imbalances do not occur. In practice, both these effects are likely to worsen the situation.

For 1972, the most optimistic analysis indicates a supply of 1 800 science and engineering PhDs, and a total demand

(in both "temporary" and "permanent" positions) for 1 300.

This concludes our examination of the "key areas". The prognosis they offer is undeniably gloomy, and it is likely that the true picture lies somewhere between the optimistic holistic approach and the pessimism of the "key areas". Even this average, however, indicates effective utilization of only half this year's output of science and engineering graduates.

## Sources of Information

There is no lack of information on employment prospects for university graduates in 1980. However, reports on this topic invariably combine extrapolation of recent trends with normative projections of trends considered socially or economically desirable. A recent publication from the National Science Foundation illustrates this mixture of statistics and prophecy<sup>1</sup>:

"(For the U.S. in 1980)...the projected range of expected science doctorates (320 000 to 350 000) lies about half-way between the 'basic' and the 'improved' utilization projections (275 000 to 390 000). It would therefore appear that present and projected trends are not likely to produce an oversupply of doctorates... Significant numbers of PhDs are likely to be engaged in activities which are markedly different from those practiced by most present doctorate holders."

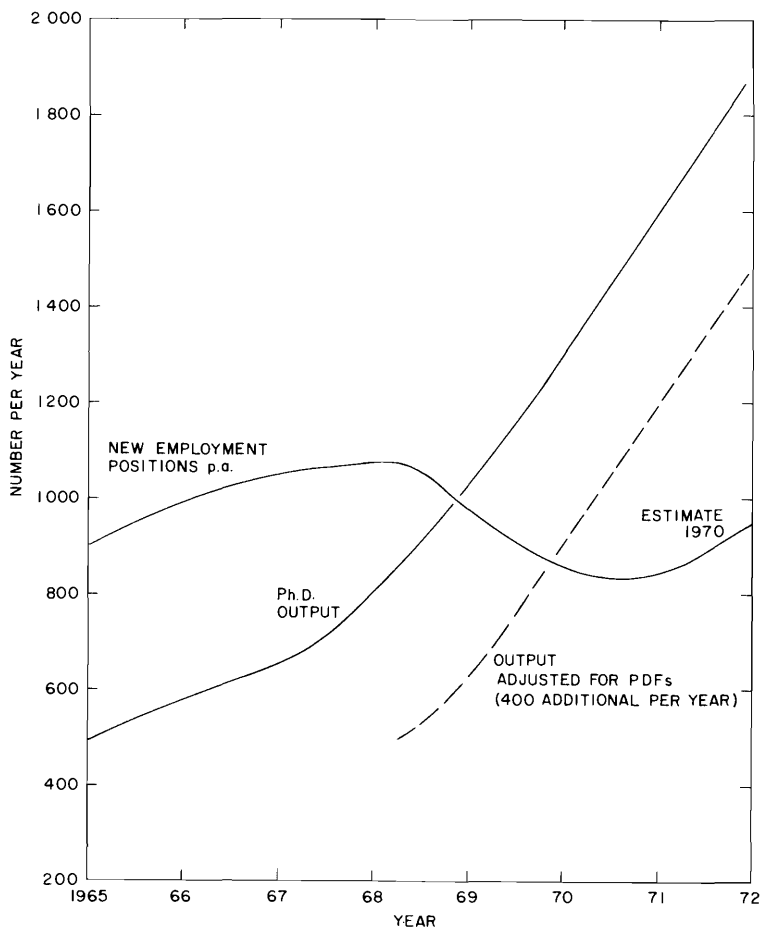
Projections must, of course, take account of trends; there is, however, often little distinction made between extrapolation of perceived trends and the superposition of "desirable" changes. In general, it is essential to examine the range of assumptions made in these reports before accepting their conclusions.

Information on employment prospects in the 1971-75 period is far harder to obtain; in fact, short-range employment projections seem almost an unpopular field of study. For one thing, the effects of

<sup>1</sup> Charles E. Falk. *Mosaic*, p. 14. March 1970.

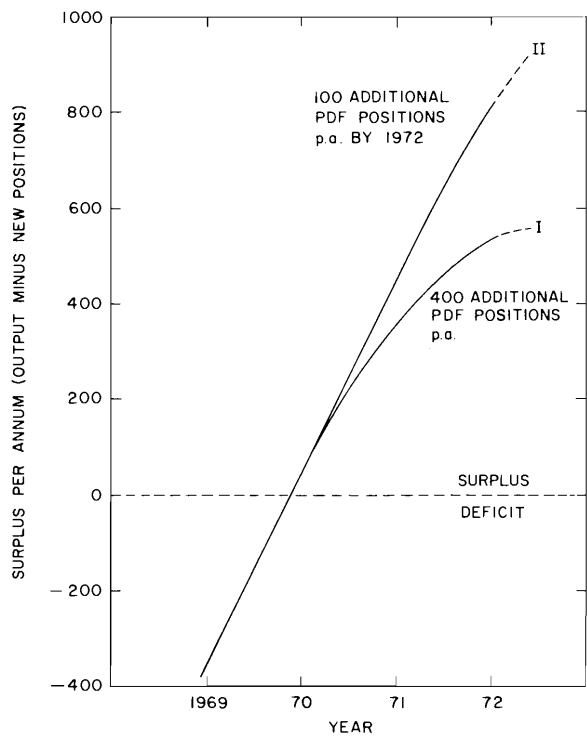


Figure 6—Supply and Demand for Science and Engineering PhDs



Sources: Projections of manpower resources and research funds 1968-1972. National Research Council, 1969. and Science Council survey—See Appendix A.

Figure 7-Projected Surplus of Science and Engineering PhDs



Sources: Projections of manpower resources and research funds 1968-1972. National Research Council, 1969. and Science Council survey-See Appendix A.

economic perturbations cannot be averaged out as satisfactorily as in long-range projections. It is also necessary to forego assumptions about changes in the content of educational programs, or about gradual changes in the aspirations of graduates. The main difficulty, however, is that data about short-term demand by various employment sectors are almost non-existent. There is also, of course, the consideration that long-range projections are safer: errors are less likely to be remembered than are miscalculations affecting the immediate future.

We survey below those agencies or employment sectors to which an undergraduate (or his counsellor) might reasonably turn for information about his employment prospects upon graduation. As will be seen, this advice is either unavailable or inadequately founded.

### Universities

There is almost unanimous agreement in universities on future demand for university teachers. The universities of Ontario, for example, foresee 1 100 new employment opportunities for faculty each year until 1980<sup>1</sup>; other provinces have similarly estimated new faculty requirements.

Mostly, these estimates are based on a recent projection of enrolment in Canadian educational institutions to 1980.<sup>2</sup> This study uses a sophisticated methodology to take account of complicated interrelationships; the model is flexible, however, and can be adapted to a variety of educational policy decisions. In order to produce reasonably operational projections, various assumptions were considered necessary; some of them are:

1. No changes will occur in the current policies governing admittance to post-secondary institutions.
2. The portion of post-secondary operating costs covered directly by students' fees will not be increased.
3. Net immigration rates will continue

at 1966-69 levels (i.e. about 120 000 persons per year).

4. University undergraduate enrolment will continue to increase at 5 percent per year.<sup>3</sup>

5. Graduate student enrolment, as a proportion of total university enrolment (5% in 1951; 8.5% in 1967) will increase to 15 percent in 1980.

These assumptions were made for want of any accurate information on the demand for graduates in Canada, and it is unlikely that better assumptions can be substituted at present. However, the enrolment projections (and thence the teacher projections) which follow from them have since acquired an air of inevitability.

There is some evidence that our substantial recent investments in university education have produced benefits smaller than those we have been accustomed to expect: the ratio of national cost to national benefit has begun to increase. As a result, some of these assumptions are now being re-examined. The issue, as many critics see it, is not so much public expense as public credibility.

While this re-examination proceeds, it may be wise to regard university faculty projections as maximum estimates.

### Government

As far as can be determined, none of the levels of government in Canada publish estimates of their future demand for scientists and engineers. Most departments, both federal and provincial, maintain five-year *program* estimates, revised annually; these presumably incorporate manpower requirement estimates.

These projections can be revised at short notice; the restriction on new hiring in 1968 is a good example. In these circumstances, the value of published demand data becomes questionable. It is nevertheless anomalous that these data seem totally inaccessible.

<sup>1</sup> Study for the Committee of Presidents of Universities of Ontario, Section 3.2. November 1970.

<sup>2</sup> Z.E. Zsigmond and C.J. Wenaas. Staff Study No. 25. Economic Council of Canada, 1970.

<sup>3</sup> This implies that the proportion of the 18-to-21 age group attending university, which was 13 percent in 1960 and 20 percent in 1967, will rise to 30 percent in 1975.

## Industry

It might have been expected that the long period of graduate shortage had forced Canadian industry to become quite expert in its projection of future demand for scientists and engineers. This, regrettably, is not the case.

The manpower requirements of Canadian industry have for many years been surveyed by the Department of Manpower and Immigration.<sup>1</sup> Many company officers interviewed during a recent Science Council study indicated that they replied to these surveys by routinely forecasting a 5 to 10 percent annual increase in graduate staff. In most cases these replies were based on sanguine expectations rather than on rigorous technological forecasting.

There are several extenuating circumstances. Economic forecasting is fairly prevalent in industry, but takes relatively little account of the impact of new technology. Technological forecasting is still in its infancy in Canadian industry, and those companies that have attempted it are only now beginning to realize its volatile interrelation with international trade and fiscal policies. Technological manpower forecasting is, if anything, even less precise.

A second justification is that industry's expectations were, until recently, amply confirmed. From 1960 to 1967, for instance, employment of scientists and engineers in industrial R & D increased 5 to 9 percent each year—as anticipated. Industry projections for 1968 to 1970 extrapolated this trend. These expectations were not fulfilled, and current projections now suggest zero rate of growth. The chemical industry, in the report referred to earlier, abruptly changed its manpower projections in a similar manner. In all, there are grounds for suspecting that industrial forecasts *follow* trends rather than anticipate them.

Canadian companies are mostly unaware that their manpower projections play an integral part in the nation's educational and immigration policies. As the demand for teachers proportionately lessens in this

decade, progressively more weight will be attached to industrial forecasts. Even so, few companies believe that their forecasts should commit them to a specific course of action. Governmental policies, international trade arrangements, and in many cases parent company decisions, inevitably overrule last year's projections.

The fact is that most Canadian companies have little inducement to spend money on medium-term manpower projections. Furthermore, they lack the management skills to make meaningful projections. In a period of plentiful graduate supply they will have even less incentive to acquire these skills. There is, in short, a good case to be made for allocating funds to assist industry to designate realistic requirements.

## Manpower and Immigration

The Department of Manpower and Immigration regularly issues series of publications designed to be used by manpower counsellors and educators.<sup>2</sup> For the most part, these reports respond slowly to changing patterns of graduate demand, and are inclined to superimpose long-term speculation on their analysis of the previous year's data.

In a recent publication<sup>3</sup> the following passages occur:

"Canadian universities are experiencing a period of extremely rapid growth and, despite the number of PhDs being earned in Canada, they have been forced to recruit outside the country to fulfil their requirements for faculty...This situation is expected to continue at least until the mid-1970's...Academic employment provides only a small proportion of the market for holders of higher degrees. Government has always needed and absorbed a large number of higher degree holders, and this tendency seems to be on the increase. On the other hand, business and industry seem

<sup>2</sup> Some typical publications: "New university graduates: supply and demand", "Requirements and average starting salaries for university graduates", "Directory of employers of new university graduates".

<sup>3</sup> New university graduates: supply and demand, 1969-1970.

<sup>1</sup> Surveys of current manpower utilization are also made by the Dominion Bureau of Statistics and the Department of Industry, Trade & Commerce.

to have been relatively backward, and only recently have they become aggressive recruiters. In the past, employers in the private sector tended to limit their recruiting of higher degree holders (other than the M.B.A.) to potential research and development staff...Now the graduate degree is becoming a more common requirement for other types of employment as well. General administration, labour and industrial relations, and engineering are only a few of the areas for which the higher degree is being specified."

These remarks may have been intended as self-fulfilling prophecies rather than as projections; in any event, they have not yet been fulfilled.

Official publications walk a narrow line between factual and normative statements; Manpower and Immigration publications are no exception. There is the danger, however, that undergraduate advisors and university educators may confuse what *should* happen with what *is likely to* happen in the next few years.

As sources of historical information, these publications are as accurate as the DBS statistics on which they are based. Their projections of demand, however, are essentially linear extrapolations with an optimistic bias.

### **Professional Societies**

At least one half of the scientists and engineers in Canada belong to one or more of the country's professional societies and associations. This proportion now seems to be falling: society membership is now increasing less rapidly than is the total scientific work force. In particular, the low membership rate for new graduates is cause for concern to most of the societies.

For the most part, these societies have done a workmanlike job of informing their members on recent advances in both basic and applied aspects of the discipline they represent. Their regular meetings provide a forum for presentation of papers, as well as opportunities for personal discussion. Their journals regularly review activities in academic, governmental and industrial

sectors in which their members are involved.

Their involvement in the issue of supply and utilization of scientific manpower has been largely passive, however. Mostly it is confined to providing advertising space in their journals, an employment exchange at their annual meetings, and yearly salary and university graduation surveys.

Few societies have gone further, to analyse the meaning of these figures or to point out imbalances between sub-disciplines. Part of this attitude stems from a desire to appear impartial (not to seem to promote physical chemistry at the expense of organic chemistry, for example), part from financial limitations: few societies have the funds to analyse their existing membership files, let alone attempt the projection of supply and demand.

There can be no doubt that this deficiency has made membership in professional societies less attractive to new graduates. It is also disturbing to members seeking re-employment. Unfortunately, most of the societies have already committed their essentially fixed budgets, and even substantial reallocation of funds would not produce results for some time.

Professional societies in other countries are similarly under attack. In the U.S. some societies are additionally accused of representing the interests of employers rather than members. Unemployment of scientists and engineers, especially in the aerospace industry in the western U.S., has led to the establishment of professional-oriented unions. Some societies are replying in kind, by offering deferment of fees for unemployed members, and by attempting to arrange portable pension plans for their members.

The next few years will undoubtedly test each society's ability to serve its members' interests besides promoting the science it represents. It is to be hoped that SCITEC will help co-ordinate each society's efforts. In the meantime, however, professional societies are little better informed on a graduate's employment prospects than is the graduate himself.

# The Changing Scene

So far, our analysis has led to the conclusion that an over-supply of science and engineering graduates is likely to persist for at least two years. The twin questions, "What action should be taken?" and "What adjustments should be allowed to occur of their own accord?", now enter the debate.

Although this report cannot answer these questions, it can provide some background information on the various lines of reasoning likely to be invoked in the debate. In this concluding section we also draw attention to trends now influencing the education/employment systems, and developments likely to occur before the end of this decade.

In a sense, the questions posed above are part of the general question, "What constitutes a successful country?" Employment opportunities for all? Steadily increasing gross national product? Elimination of poverty? General availability of university education? Given inevitably limited resources, the simple answer "All of these" will not do—especially if all are accorded equal priority.

The discrepancy between the potential and the current performance of the Canadian economy ("economic slack") further complicates our response to these questions. So, too, does the fact that a plentiful supply of university graduates is merely one facet of a general abundance of young people seeking jobs—itself a consequence of the postwar "baby boom".

In a sense, many of the social objectives of the policy-makers have been achieved. As salary differences between PhD and BSc (and between BSc and high-school graduate) begin to lessen, income transfers from the poor to the rich begin, in effect, to decline. It is now possible to begin to use highly educated people in secondary school teaching, in all aspects of industry (and not simply in R & D), and in the service sector. The recent emphasis on education, especially in science and engineering faculties, as training for well-paid professional jobs, may be expected to decline; education for its own sake, and for its problem-solving potential, should become more prevalent. Post-secondary

education (at all levels) may become a matter of individual choice, rather than a response to market opportunities or the educational imperative.

Most of us were unprepared for so large—or so sudden—a transition. It is, nevertheless, under way. The smoothness of the transition will depend on many factors, about some of which we know very little at present. What follows is a selected list of topics bearing on this issue. The topics are arranged in an approximate order of timeliness, beginning with short-range and immediate developments.

### **Communication between Employers and Educators**

Employers have always had a simple means of signalling saturation levels in certain types of activity: they stop hiring. This technique is also used to communicate dissatisfaction with a particular kind of graduate or course of study. Unfortunately, it is often difficult to find out which message is being conveyed. The message is also, as far as universities are concerned, four years (or, in the case of advanced degrees, perhaps eight years) too late.

Resolving this expensive communications gap places an onus on both employers and educators. The problem is partially solved through "co-operative" university programs; this is a solution available to only a few universities in Canada, however. Visits by delegations of university teachers to industrial establishments have increased considerably over the last year or two; in many cases they have so far obtained little positive guidance. The process has started, however, and should intensify.

### **Counselling and Placement Activities**

It was pointed out earlier that the career advice offered to high-school and university graduates is often an uncertain mixture of fact and prophecy. Often, too, it seems to bear little relationship to the overall strategies now being developed for the seventies by industry and at all levels of government. No sector can escape censure on this issue: unstated policies contribute substantially to supply-demand mismatching.

The placement services offered by universities, by Manpower, and by private or semi-private agencies such as the Technical Service Council operate almost autonomously. Little information exists on their relative efficiency, their degree of overlap, or whether they fail to reach certain areas. It is also uncertain to what extent they reinforce unrealistic or narrow expectations in graduates or employers. Clearly there is still room for individual initiative: a recent staff study for the Science Council indicates that about 15 percent of science graduate hiring by industry resulted from "off the street" interviews.

It has been remarked of late that science graduates have unrealistic or misguided aspirations. What we do not know is whether this condition will cure itself. To what extent is it a result of the content of a degree course? How are aspirations fostered by teachers, or by professional societies? "Underutilization" will continue as long as these questions remain unanswered.

### **Immigration and Emigration**

The future impact of immigration is less clear than at any time in the past. In its projections to 1984 the Dominion Bureau of Statistics has considered a variety of immigration possibilities, ranging from 140 000 per year to 200 000 per year. While the present period of economic slack lasts, it seems likely that immigration will follow, or fall below, the lower estimate.

Canadians have mostly emigrated to the U.S., the U.K., and France in the past.<sup>1</sup> For a variety of reasons, including employment difficulties in most developed countries and—in the U.S.—the imposition of stricter regulations on immigration from Canada, the flow of emigrants is now rapidly diminishing.

The U.S. uses a tabulation of preferred professional categories, revised from time to time, to screen professional immigrants. The paucity of demand data has made

this system unworkable in Canada. There can be little doubt, however, that some version of this screening process will be necessary as Canada approaches self-sufficiency in graduates—even if only for the benefit of prospective immigrants.

### **The Desirable Graduate**

As far as manpower is concerned, much of Canadian industry is in a frozen condition. However resourceful or skilled a new graduate may appear, current restrictions on hiring prevent his employment. This situation has several potentially serious consequences. First, companies are deprived of an infusion of new ideas and techniques. Since graduates are not considered for employment as technicians or in non-scientific work, the general educational upgrading of Canadian industry is hampered.

Although statistical data are unavailable, there are indications that the mobility of scientists and engineers, whether within a company or between industries, has declined sharply in the last year or two. Generally, this mobility has been regarded as a prime source of technological transfer leading to industrial innovation.

In a sense, this is a self-perpetuating dilemma. Most industrial employers prefer to hire a graduate with some industrial experience. Despite increasing graduating classes, the number of these "desirable" graduates may be on the decrease. Similarly, the number of graduates with broad experience (in two or more industries) may be reaching a plateau.

### **Undergraduate Preferences**

The distribution of first degrees between arts, science and engineering disciplines has changed in favour of science over the last ten years. Preliminary undergraduate enrolment statistics indicate, however, an imminent change. The proportion of undergraduates choosing physical and life sciences seems to be reaching a plateau; engineering shows a pronounced downward trend.

The social sciences have gained considerably in undergraduate enrolment. In a sense, our experience with the physical

<sup>1</sup> A proportion of immigrants have also used Canada as a stopping-off point before moving to the U.S. within a year or two; this practice seems to have declined substantially in recent years.



sciences over the last ten years seems likely to be repeated here: most of the demand for social science teachers must now be filled by immigrants. Within five years, however, we may produce an abundance of graduates who consider teaching social sciences their prime field of employment.

**Graduates and Post-graduates**

During the sixties, government and industry each hired about 15 percent of our science and engineering PhD output; universities hired the rest. Universities can now offer positions to only 35 percent of their PhD output, and government and industry have declined to double their share of an output that has, in itself, doubled since 1967.

The 20 percent annual increase in university post-doctoral fellowships in recent years underscores this issue. So, too, does the fact that almost half the science and engineering graduate students in Canadian universities are twenty-nine or older.<sup>1</sup> (An undetermined fraction of these students, however, have interrupted their university life since their first degree.)

Two responses are now occurring. Some university departments have recently announced higher admission standards for graduate students; more are expected to follow suit. At the same time, several provincial departments concerned with university affairs have increased graduate student fees, or reduced the number of graduate scholarships, or both.

Whether these responses are appropriate, or excessively restrictive, will not be known for at least two years. Even then, the answer will not be unequivocal. Graduate students have traditionally served as "slave labour" in producing university research; this research has never been assigned a book value, and the loss of a certain proportion of it cannot be assigned an unequivocal cost.

It is almost impossible to arrive at any kind of estimate of the relative costs of

producing first and higher degrees. Depending on one's starting assumptions, these estimates can range from \$20 000 to \$140 000 for a PhD. Whatever the cost, Canada is now producing proportionately more PhDs than the U.S. or the U.K. for an employment system that currently finds it difficult to make use of their skills.

A trend to part-time graduate studies is now discernible. In Ontario, for example, the number of full-time graduate students rose 14 percent from 1969 to 1970; during this same period the number of part-time graduate students increased 25 percent.<sup>2</sup>

**Regional Differences**

Unquestionably, Ontario is the most postgraduate-conscious of the provinces: although it contains only 36 percent of Canada's population (and 34% of the 18-to-24 age group), it has 40 percent of the graduate student population.

Even so, the graduate student proportion has declined rapidly in recent years (from 50% of Canada's total in 1965), while during the same period its share of the undergraduate population increased from 25 to 32 percent.

These trends are shown more clearly in the 1965-1970 annual growth rates:

	Annual Growth Rates	
	Ontario	Rest of Canada
Undergraduate Students	18.1 %	10.7 %
Graduate Students	16.7 %	26.6 %

Overall, it seems clear that a process of equalization is in progress: universities across Canada are beginning to offer more equal opportunities, in both undergraduate and graduate education, to the population in their respective provinces.

Some provinces have already drawn ahead in this respect: Manitoba and Saskatchewan, for example, now have almost 13 percent of their 18-to-24 population enrolled in post-secondary institutions; the overall Canadian average is 9.8 percent. Since employment opportunities in these provinces have not kept pace with this growth in education, we may expect

<sup>1</sup> Oscar H. Levine and Gordon J. Coogan, Age of graduate students enrolled for the doctorate in science and engineering at Canadian universities, 1968-69. National Research Council. December 1970.

<sup>2</sup> CPUO Monthly Review. April, 1970.

an intensification of the province-to-province movement of graduates documented in the Macdonald report.<sup>3</sup>

### **Participation by Women**

After a lengthy period during which the proportion of women graduates in science remained a constant 20 percent of total science graduations, there are now signs of steadily increasing participation by women. Participation in engineering disciplines has grown even more rapidly—though from a minuscule base—especially in non-mechanical fields such as computer and design disciplines.

In former years a relatively small proportion of these graduates remained in the labour force for more than two years. This pattern, too, seems to be changing. On the other hand, it seems regrettably likely that discrimination against women graduates, documented in several recent surveys, will be reinforced during a time of plentiful graduate supply. This is likely to apply particularly to first degree graduates, and seems more severe for industrial positions than for government and university appointments.

### **Technological Forecasting**

Most governments in 1971 are attacking environmental and sociological problems with skills that barely existed ten years ago. Well over half the products industry now makes available are innovations of the last ten years. In the same period, oceanography moved from the universities to become a commercial proposition, and new sciences—limnology, for example—were virtually invented.

It seems certain that this decade will produce equally rapid changes. Technological forecasting, however, while it uses more sophisticated techniques than in the sixties, now produces clouded scenarios. It has not yet been able to incorporate the assessment of technology, a screening process made necessary by concern for

the environment, the rise of consumerism, population limitation sentiments, and other recent—and volatile—developments.

In these circumstances, predicting the new sciences of the seventies becomes extremely uncertain. Indeed, many people believe that the traditional scientific classifications will be largely discarded, and that professionals will be trained in problem-solving areas rather than in specific scientific disciplines.

It is not clear to what extent Canadian universities are involved in the technological forecasting activities of industry and government. It is, after all, an activity that concerns their livelihood: they are ultimately responsible for meeting society's manpower demands.

### **Demand and Need.**

Much of the present lack of agreement on educational policies can be traced to a confusion between "demand" and "need". "Demand" is the number of openings for which money can be found, or for which future funds can be earmarked, and is clearly connected with the economic climate. "Need", on the other hand, is the number of experienced people required to achieve a specified goal or way of life; in practice these goals, even though universally sought by a country, may be severely tempered by the rate of growth of the country's economy.

Until fairly recently, "demand" and "need" were almost synonymous: a nation's goals were, generally speaking, adjusted to take account of fiscal limitations and manpower shortages. The escalation of national goals over the last decade now makes it necessary to distinguish between the two, for "demand" and "need" are widely diverging quantities. It is, for example, doubtful whether we are producing even half enough educated people to achieve the national goals proposed in the Science Council's Report No. 4.

Few people would argue that the educational system should produce only enough graduates to meet our projected demand. Equally few would have the temerity to suggest that we should be guided solely by

<sup>3</sup> Science Council of Canada and Canada Council. Special Study No. 7, The role of the federal government in support of research in Canadian universities, by J.B. Macdonald *et al.* Information Canada. Ottawa, 1969.

national needs. No one, however, can yet offer guidelines for the precise demand-need compromise Canada should adopt.

### **Demand Projections**

Estimating the demand for graduates in specific scientific and engineering disciplines has never been easy, even when all kinds of graduates were in relatively short supply. To an extent, the imprecision of our demand projections has been compensated for by various adjustment mechanisms, chiefly immigration and occupational mobility. To take one example: in 1967 only one of every five chemical engineering graduates in Canada was working as a chemical engineer; conversely, only half of those employed as chemical engineers had received a degree in that discipline.<sup>1</sup>

Occupational flexibility has a limit, however, and may be expected to decline when graduates in most disciplines are in equally plentiful supply: an employers' market can successfully demand a graduate chemical engineer.

Demand projections in the past have also concentrated too closely in some areas, and too broadly in others. A recent projection of manpower requirements to 1975 (by the Department of Manpower and Immigration), for example, lists four categories of professional engineers, but takes no account of physical or life scientists (except, possibly, "biologists and agricultural professionals").

Enough has been said earlier of the pressing need for demand projections in this decade. It is obviously more difficult a task than ever before, since it must now take account of new technology, the social assessment of technology, governmental trade and fiscal policies—and above all, the aspirations of Canadians.

An Institute of Manpower Studies was set up in the U.K. in 1969 in an attempt to describe future patterns of employment. It is supported by government, universities, employers' associations and trade unions. It seems likely that only this kind of coali-

tion can produce meaningful demand statistics in Canada.

### **The Accessibility of Education**

Education is Canada's biggest industry; its cost represents 8.5 percent of the gross national product. In 1969 a total of 5.9 million students were enrolled in educational institutions: this corresponds to 74 percent of the 5-to-24 age group. Of this total about 430 000 were enrolled in universities, colleges and other post-secondary institutions.

Of late it has been observed increasingly that university education is unequally distributed among the population; that this education is accessible mainly to the relatively well-to-do; and that the establishment of community colleges has gone only a certain distance towards narrowing this accessibility gap.

Pressures to extend university education to a larger proportion of the college-age population may be expected to mount in this decade. This issue has already been raised in a preliminary report of the Commission on Post-Secondary Education in Ontario. So, too, has the principle of offering university education to all age-groups, and not simply to the young.

In the U.S. these issues have arisen in the form of concrete proposals by the Carnegie Commission on Higher Education. Among other changes, the commission has recommended a guarantee of two years of college for everyone, available at any age; the restriction of the PhD to "career" researchers; and essentially a continuous spectrum of degrees, starting at the two-year level.

Roughly similar sentiments can be detected in Canada. The countervailing pressure is, of course, the willingness of the taxpayer to pay. We may expect, however, a growth in support for what one critic has called the "less college for more people" movement, and another, "the high-schoolization of universities".

### **Educational Productivity**

The Economic Council has frequently pointed out the need to improve Canada's

<sup>1</sup> Survey of professional, scientific and technical manpower, 1967. Canada Department of Manpower and Immigration.

educational productivity, and has indicated some of the directions that should lead to higher productivity. As more of the "population bulge" moves into the university age-group, this need becomes increasingly pressing. Otherwise, we face a doubling of post-secondary expenditures before 1980.

It is clear that simple tactics will not work. Immediate year-round operation of all of Canada's universities, for example, may decrease capital requirements, but only at the price of increased operating expenses. Yet it is on simple statistics that universities are likely to be censured. Universities have already had their attention drawn to their student-teacher ratios, or the percentage of their undergraduate courses with five or fewer students.

The issue is complicated by the present unsatisfactory state of cost-benefit analysis as applied to educational spending. Conventionally, this kind of analysis disregards personal non-monetary benefits, and other external benefits. Given this bias, it tentatively concludes that returns on post-secondary educational investments are greater for the individual concerned than for society as a whole. These tentative results thus provide a rationale for the suggestion that students should bear a larger proportion of the cost of their education.

### **Education /Employment Modelling**

We now know enough about many of the interrelationships in this complex system to begin simulating its behaviour in certain hypothetical situations. If this did nothing else, it would help to damp the violent swings that have occurred in recent years.

There are other advantages, however. Systems analysis can help clarify the options available; in particular, it can indicate which short-term policies are likely to be unproductive—or even counter-productive—in the long run. Many intuitively "obvious" policies, when examined in this way, turn out to be an attack on precisely the wrong problem—or, rather, to be an attack on a symptom rather than a cause.

Systems analysis has been used for several years in industrial dynamics. A start has been made in using it to plan the future of urban communities. Its application to the education/employment system seems overdue.

# Appendices

Appendix A

Science and Engineering PhDs:  
Supply and Demand to 1972\*

This study uses the general methodology of the Bonneau Report.† It further assumes that since the number of Canadian post-graduate students abroad approximately equals the number of non-Canadians studying in Canada, we may take the output of Canadian universities as a reasonable minimum estimate of the supply of PhDs in Canada.

For several years the PhD output from Canadian universities has grown about 23 percent each year; this corresponds to a doubling of output in 3.5 years. Table A.1, reproduced from the Bonneau Report, illustrates recent and immediate trends.

Table A.1—PhD Output from Science and Engineering  
Faculties of Canadian Universities

Year	Output
1968	800
1969	1 020
1970	1 280
1971	1 460
1972	1 850

A considerably more accurate estimate of the demand for PhDs can be made now than was possible two years ago. In all employment sectors the Bonneau estimates turn out to have been optimistic.

Universities

The Bonneau Report estimates that the annual growth rate of employment in science and engineering faculties will drop from 13 percent in 1968 to 8 percent in 1973. There are now indications that the rate of increase in university faculty will decline to 6 percent in 1972. This estimate implies that about 40 percent of each year's output will find employment in Canadian universities.

\* The Science Council study summarized in this Appendix was carried out by F.J. Kelly and P.L. Bourgault.

† Projections of manpower resources and research funds 1968-1972. National Research Council, 1969.

Government

Only a modest increase (4 % per year, with essentially no growth in 1969-70) was forecast in the Bonneau Report. The actual increase in employment of PhDs has been exceedingly modest. The discrepancy is unimportant in absolute numbers.

Industry

In April 1970, sixty companies (including the thirty research-intensive companies collectively employing 75 % of all PhDs in industry) were surveyed as part of a Science Council study of industrial innovation. Trends in scientific manpower, by degree level, were collected in this survey. Over the 1968-1970 period the net increase in employment of PhDs was 40, instead of the 210 originally estimated in 1968. Given prevailing economic conditions, we cannot expect any significant change in this trend in 1971. For the 1972-73 period a 3 percent annual increase in employment of PhDs seems reasonable.\*

In the absence of information on the industrial employment of PhDs in non-R & D functions, we assume that their numbers are about the same as in R & D (i.e. about 1 000) and are increasing by about 3 percent each year.

We now combine these sectoral trends to produce a forecast of employment positions available each year. In deriving these figures we have anticipated a 4 percent annual attrition rate; attrition is currently responsible for over one third of the total demand. Figure A.1 illustrates these forecasts.† For a variety of reasons the annual number of employment positions is declining, and in 1971 may be expected to reach its lowest value since 1964.

The consequence of declining employment opportunities during a period of increasing PhD output is shown in Figure 6

\* It is worth noting, however, that the companies that are PhD-intensive are currently showing least increase in total research staffing.

† The upper curves are reproduced from the Bonneau report projections.

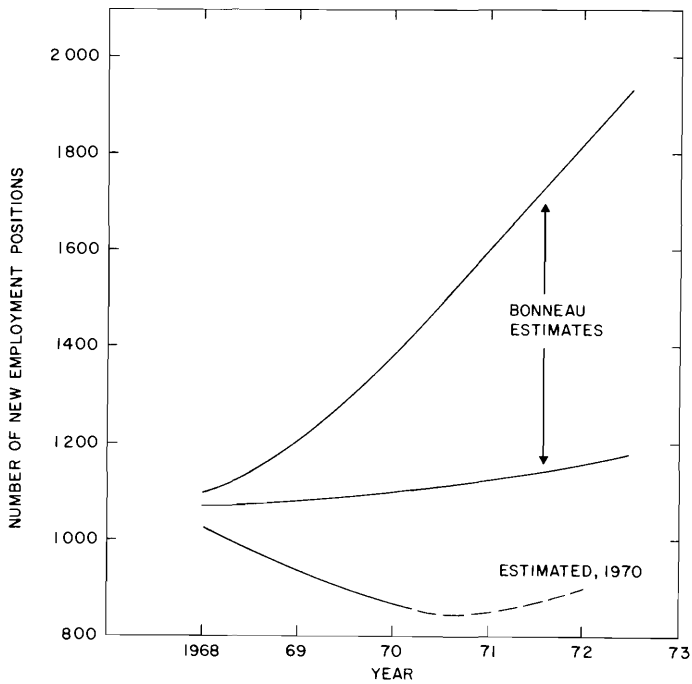
‡ Figure 6 is based on the supposition that existing trends in Canadian support of non-Canadian science and engineering graduate students will continue. At present, 50 percent of graduate students are non-Canadians; they receive 30 percent of PhDs granted.

(page 35). Figure A.2 is another version, presenting the range of consequences which the return (or continued absence) of Canadians studying abroad, and the departure (or continued residence) of non-Canadian students, might be expected to produce.†

Figure 7 (page 36) indicates our forecast of the PhD surplus to 1972. Two models were used for the growth of the PDF force; these models are illustrated in Figure A.3.

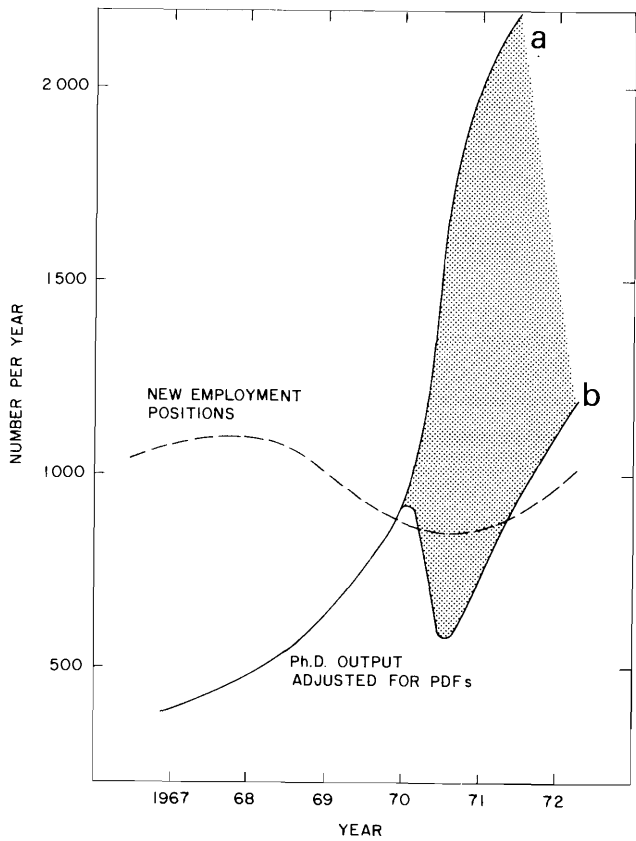
This analysis does not take into account the prospect of net immigration of PhDs; it is difficult to estimate the magnitude of this effect, but it may increase the supply of PhDs by 300 per year. Nor do we consider the discipline mismatching now apparent in the economy; the net effect of mismatching is to reduce further the number of employment opportunities effectively available.

**Figure A.1—New Employment Positions for Science and Engineering PhDs**



Sources: Projections of manpower resources and research funds 1968-1972. National Research Council, 1969. and Science Council survey—See Appendix A.

Figure A.2—Projected Range of Supply of Science and Engineering PhDs

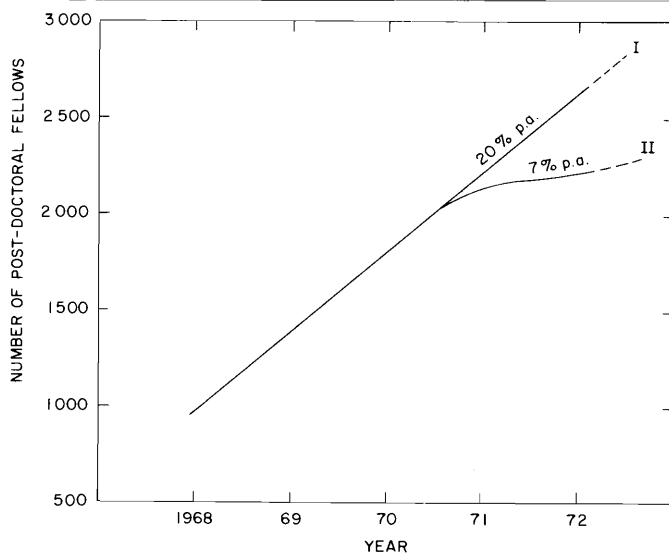


(a) All non-Canadian graduates remain in Canada—All overseas graduates return to Canada.  
(b) All non-Canadian graduates leave Canada—All overseas graduates remain overseas.

Source: Science Council survey—See Appendix A.



**Figure A.3—Postdoctoral Workforce in Science and Engineering Faculties**



*Source:* Science Council survey—See Appendix A.

# Appendix B

## Science and Engineering PhDs: Post-Graduation Employment in mid-1970\*

The main conclusion to be drawn from Appendix A is that during 1970 Canada overcame its PhD deficit; an increasing surplus now seems likely to occur.

Our analysis also indicates that the transition will be rapid. To check the reliability of these projections, a study was made of the post-graduation employment of science and engineering PhDs who obtained their degrees in the convocation ceremonies held between autumn 1969 and spring 1970. This survey was conducted in mid-1970. A similar study will be made in mid-1971 to determine whether changes are occurring in unemployment levels, post-doctoral fellowships, and other utilization patterns.

Although this comparison is not yet available, much of the information obtained in the 1970 survey bears directly on the issues discussed in this report. The information was obtained via the deans and department heads of the 17 universities producing 88 percent of Canada's science and engineering PhDs.

Only 3 percent of these PhDs were reported as unemployed. On the other hand, one third of the output accepted post-doctoral fellowships; this is a higher proportion than in recent years. Table B.1 illustrates distribution of the PhD output in various employment sectors.

**Table B.1—Post-Graduation Employment of PhDs, 1969-70**

Employment Sector	Engineering	Physical Sciences	Life Sciences
Industry	34	63	17
Government	18	33	42
University teaching	59	94	89
Research fellowship	23	177	65
Unemployed	2	12	7
Other	4	10	17
Total	140	389	237

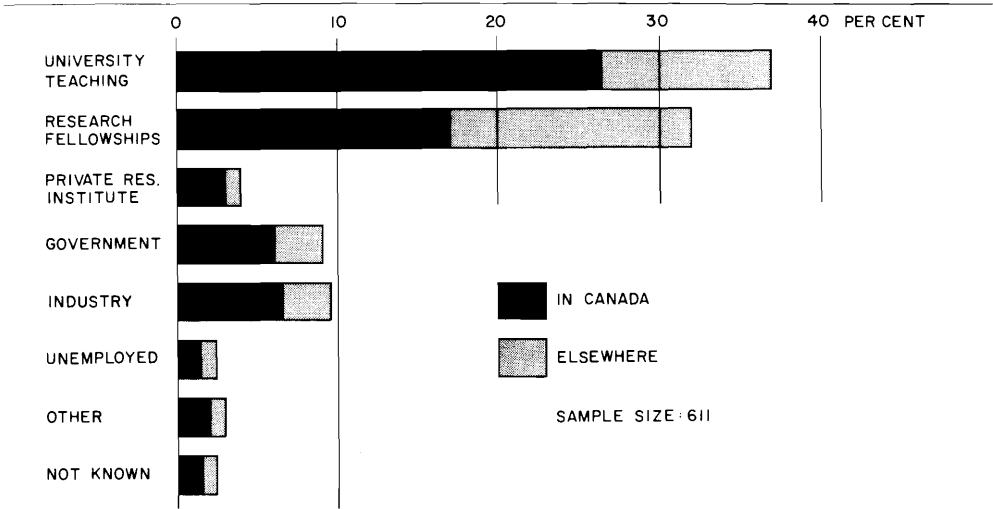
\* The study from which the information in this Appendix is derived was performed for the Science Council by A.D. Boyd.

One half of the 766 PhD graduates surveyed are not Canadian citizens; of these, one half remained in Canada following graduation. Sixty percent of the non-Canadians who remained found employment; most of the rest accepted post-doctoral fellowships. Unemployment is greater for non-Canadians (6.1 %) than for Canadians (2.3 %).

Of the 263 Canadians who remained in Canada, only 17 percent accepted employment in industry. Other employment choices were: universities, 32 percent; non-university teaching, 1 percent; government, 19 percent; post-doctoral fellowships, 27 percent. The distribution is very similar for the 180 non-Canadians who remained in Canada, with two exceptions: more post-doctoral fellowships (34 %), and less government employment (5.5 %).

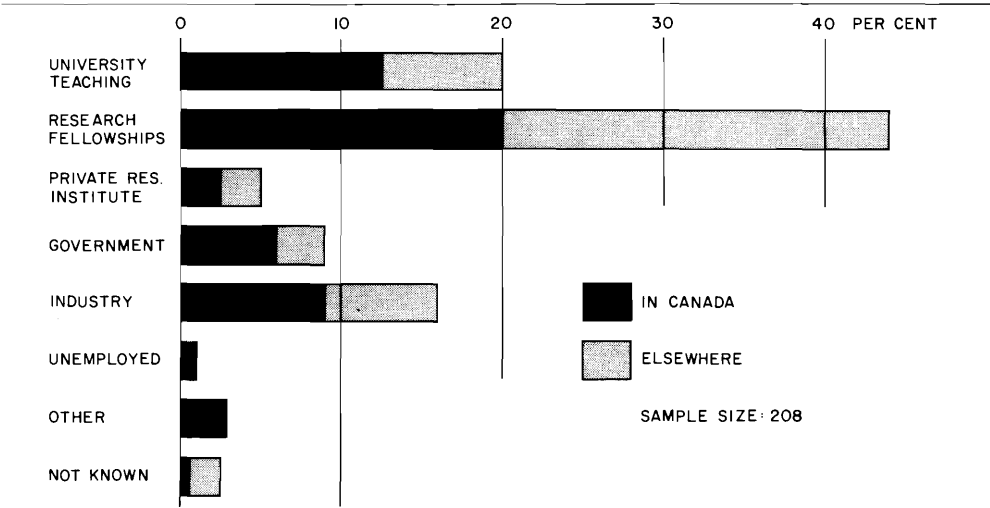
Overall, these results confirm that unemployment had not become a problem in mid-1970. They have since been confirmed by a study performed for the Canadian Association of Graduate Schools; the results of this study are summarized in Figures B.1 to B.3. Although the sample is smaller, the CAGS study provides information on PhDs in all disciplines, scientific and non-scientific; it also indicates the employment areas of the PhDs who left Canada.

Figure B.1-Post-Graduation Employment of 1969-70 PhDs: All Disciplines



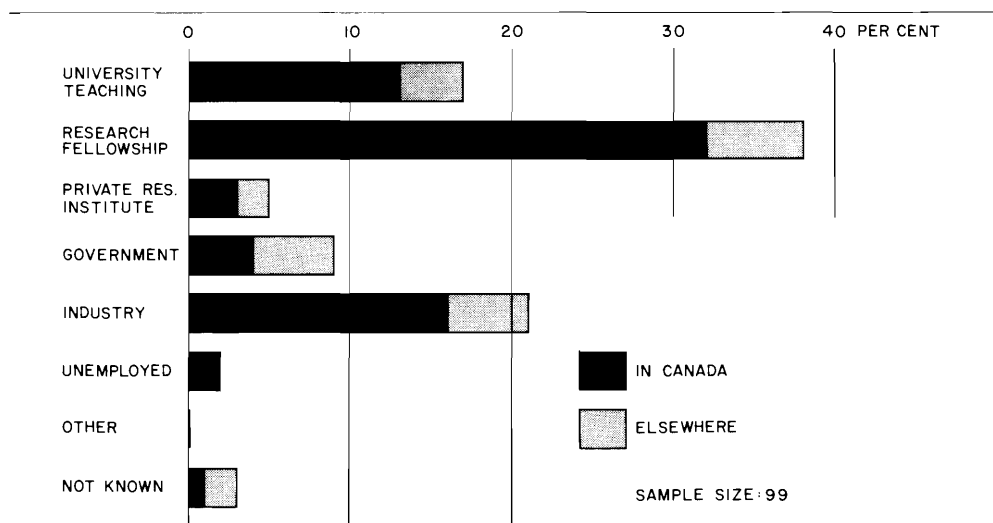
Source: Survey by Canadian Association of Graduate Schools, January 1971.

Figure B.2-Post-Graduation Employment of 1969-70 PhDs: Physical Sciences



Source: Survey by Canadian Association of Graduate Schools, January 1971.

**Figure B.3—Post-Graduation Employment of 1969-70 PhDs: Engineering**



*Source:* Survey by Canadian Association of Graduate Schools, January 1971.

# Appendix C

## Industrial R & D (1970)\*

Official data on industrial R & D are compiled every other year; this information does not appear for at least two years, however.† To obtain information on recent trends, a small-scale study was made for the Science Council in mid-1970; the survey included the 60 companies responsible for a substantial majority of industrial R & D in Canada, and provided information on expenditures as well as on staffing trends by degree level.

The hitherto exponential growth in the establishment of new research laboratories has now shown an abrupt discontinuity. In 1955, a new industrial laboratory was established in Canada every three weeks; in 1965, every six days. This was the high-water mark: by 1967 the growth rate had fallen back to 1960 levels, and no net increase in the number of laboratories occurred during the whole of 1969. Figure C.1 illustrates these data.

Canada now has about 640 industrial R & D establishments. The number of research establishments became essentially fixed around 1965, but each laboratory continued to grow in size. For the next two years most laboratories grew almost 5 percent each year (about 12% in expenditures), although medium-sized companies (for example, those with annual sales around \$15 million) were noticeably more cautious. Very large companies (sales over \$200 million) expanded their laboratories 15 to 20 percent over these two years.

This attitude has not persisted. Since 1968 no net growth can be detected in industrial R & D. Medium-sized companies have, in the aggregate, cut back on R & D. Large companies are currently increasing their research staff, but by only 1 to 2

percent per year. Small companies continue to show substantial percentage increases, but small absolute increases.

The balancing of staff increases and decreases can be seen most clearly by ranking companies on the basis of laboratory size. This comparison is made in Figure 5 (page 33).

In all but the largest companies, two changes now seem to be taking place in the composition of R & D laboratories. Positions for which a bachelor degree was once considered essential are now being offered to technical college graduates. In addition, the proportion of PhDs in the total professional staff has declined slightly in recent years. A possible cause is the size of the difference in salary between PhDs and other graduates—though this, too, has begun to decrease.

Industrial R & D expenditures have continued to increase, although rather more slowly than in the past. A substantial proportion of the current increase is now spent on “inflation” and “sophistication”, now estimated at 8 to 10 percent per year. Recent industrial R & D budgets are:

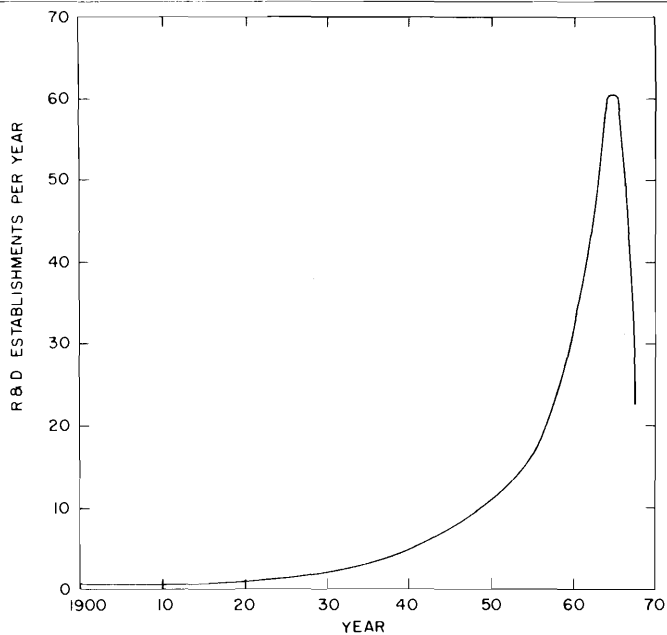
Year	Total R & D expenditures (\$ millions)
1963	210
1965	317
1967	375
1969	410

Overall, it appears that a period of stocktaking is now in progress; that while it lasts, no demand for industrial research personnel can be counted upon.

\* The Science Council study from which the information in this Appendix is derived was carried out by F.J. Kelly.

† Industrial research and development expenditures in Canada, 1967 (Dominion Bureau of Statistics, 1969) and earlier publications in this series; these reports were used as the foundation of the study described in this Appendix.

**Figure C.1—Rate of Establishment of Industrial R & D Laboratories**



*Source:* Three-year moving averages, derived from DBS 13-532 (and earlier DBS series) and Science Council survey.

# Publications of the Science Council of Canada

## **Annual Reports**

First Annual Report, 1966-1967

(SS1-1967)

Second Annual Report, 1967-1968

(SS1-1968)

Third Annual Report, 1968-1969

(SS1-1969)

Fourth Annual Report, 1969-1970

(SS1-1970)

## **Reports**

Report No. 1, A Space Program for Canada

(SS22-1967/1, \$0.75)

Report No. 2, The Proposal for an Intense

Neutron Generator: Initial Assessment and

Recommendations (SS22-1967/2, \$0.25)

Report No. 3, A Major Program of Water

Resources Research in Canada

(SS22-1968/3, \$0.75)

Report No. 4, Towards a National Science

Policy for Canada (SS22-1968/4, \$0.75)

Report No. 5, University Research and the

Federal Government (SS22-1969/5, \$0.75)

Report No. 6, A Policy for Scientific and

Technical Information Dissemination

(SS22-1969/6, \$0.75)

Report No. 7, Earth Sciences Serving the

Nation—Recommendations (SS22-1970/7,

\$0.75)

Report No. 8, Seeing the Forest and the

Trees (SS22-1970/8, \$0.75)

Report No. 9, This Land is Their Land...

(SS22-1970/9, \$0.75)

Report No. 10, Canada, Science and the

Oceans (SS22-1970/10, \$0.75)

Report No. 11, A Canadian STOL Air

Transport System—A Major Program

(SS22-1971/11, \$0.75)

Report No. 12, Two Blades of Grass: The

Challenge Facing Agriculture

(SS22-1971/12, \$0.75)



## Special Studies

The first five of the series were published under the auspices of the Science Secretariat.

Special Study No. 1, Upper Atmosphere and Space Programs in Canada, by J.H. Chapman, P.A. Forsyth, P.A. Lapp, G.N. Patterson (SS21-1 /1, \$2.50)

Special Study No. 2, Physics in Canada: Survey and Outlook, by a Study Group of the Association of Physicists headed by D.C. Rose (SS21-1 /2, \$2.50)

Special Study No. 3, Psychology in Canada, by M.H. Appley and Jean Rickwood (SS21-1 /3, \$2.50)

Special Study No. 4, The Proposal for an Intense Neutron Generator: Scientific and Economic Evaluation, by a Committee of the Science Council of Canada (SS21-1 /4, \$2.00)

Special Study No. 5, Water Resources Research in Canada, by J.P. Bruce and D.E.L. Maasland (SS21-1 /5, \$2.50)

Special Study No. 6, Background Studies in Science Policy: Projections of R & D Manpower and Expenditures, by R.W. Jackson, D.W. Henderson, and B. Leung (SS21-1 /6, \$1.25)

Special Study No. 7, The Role of the Federal Government in Support of Research in Canadian Universities, by John B. Macdonald, L.P. Dugal, J.S. Dupré, J.B. Marshall, J.G. Parr, E. Sirluck, E. Vogt (SS21-1 /7, \$3.00)

Special Study No. 8, Scientific and Technical Information in Canada, Part I, by J.P.I. Tyas (SS21-1 /8, \$1.00)

Part II, Chapter 1, Government Departments and Agencies (SS21-1 /8-2-1, \$1.75)

Part II, Chapter 2, Industry (SS21-1 /8-2-2, \$1.25)

Part II, Chapter 3, Universities (SS21-1 /8-2-3, \$1.75)

Part II, Chapter 4, International Organizations and Foreign Countries (SS21-1 /8-2-4, \$1.00)

Part II, Chapter 5, Techniques and Sources (SS21-1 /8-2-5, \$1.25)

Part II, Chapter 6, Libraries (SS21-1 /8-2-6, \$1.00)

Part II, Chapter 7, Economics (SS21-1 /8-2-7, \$1.00)

Special Study No. 9, Chemistry and Chemical Engineering: A Survey of Research and Development in Canada, by a Study Group of the Chemical Institute of Canada (SS21-1 /9, \$2.50)

Special Study No. 10, Agricultural Science in Canada, by B.N. Smallman, D.A. Chant, D.M. Connor, J.C. Gilson, A.E. Hannah, D.N. Huntley, E. Mercier, M. Shaw (SS21-1 /10, \$2.00)

Special Study No. 11, Background to Invention, by Andrew H. Wilson (SS21-1 /11, \$1.50)

Special Study No. 12, Aeronautics-Highway to the Future, by J.J. Green (SS21-1 /12, \$2.50)

Special Study No. 13, Earth Sciences Serving the Nation, by Roger A. Blais, Charles H. Smith, J.E. Blanchard, J.T. Cawley, D.R. Derry, Y.O. Fortier, G.G.L. Henderson, J.R. Mackay, J.S. Scott, H.O. Seigel, R.B. Toombs, H.D.B. Wilson (SS21-1 /13, In Press)

Special Study No. 14, Forest Resources Research in Canada: Current Status, Adequacy, and Desirable Future Development, by J.H.G. Smith and G. Lessard (SS21-1 /14, In Press)

Special Study No. 15, Scientific Activities in Fisheries and Wildlife Resources, by D.H. Pimlott, C.J. Kerswill, and J.R. Bider (SS21-1 /15, In Press)

Special Study No. 16, Ad Mare: Canada Looks to the Sea, by R.W. Stewart and L.M. Dickie (SS21-1 /16, In Press)

Special Study No. 17, A Survey of Canadian Activity in Transportation R & D, by C.B. Lewis (SS21-1 /17, In Press)

Special Study No. 18, From Formalin to Fortran: Some Basic Facts and Futures About Basic Biology in Canada, by P.A. Larkin and W.J.D. Stephen (SS21-1 /18, In Press)

Special Study No. 19, Research Councils in the Provinces: A Canadian Resource, by Andrew H. Wilson (SS21-1 /19, In Press)