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REVIEW OF NATIONAL R&D DATA BASES

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REVIEW OF NATIONAL R&D DATA BASES

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MOSST
Forecasting Division
June, 1978
R. Patterson ✓
D. Richardson



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Review of National R&D Data Bases at Statistics Canada

Preface

This report is the result of a data review and analysis exercise by the University Branch in connection with the preparation of the national R&D scenarios and the Council budget simulations in January 1978. Upon completion of the analysis, it was apparent that the results should be made available, for information, to other possible users within the Ministry.

In drafting this report and making recommendations for improving the national R&D statistics, Mr. H. Stead, Chief, Science Statistics Centre, provided welcome assistance and was consulted on the broad content and recommendations contained herein. This report is necessarily limited in scope, but provides some input to the advisory role which exists between the Ministry and the Science Statistics Centre with respect to the adequacy and relevance of the national science statistics. Obviously, considerably more work needs to be done in this area and periodic analytic reviews should be a continuing responsibility of each of the user-Branched of the Ministry.

SUMMARY OF MAJOR FINDINGS

1. The GERD matrix has been forecasted at an assumed 8 percent rate for 1976 and 1977 for all components. This methodology does not make full use of federal survey data available through the program forecast exercise.

2. There is a substantial slippage between federal funds to industry as reported in the federal survey and the reported receipt of federal funds in the industrial survey. In 1973 this slippage amounted to some \$92 million. There are a number of reasons for this discrepancy:
 - a) The federal survey includes payments of IT&C for the IRDIA program which are grants and credits for past R&D performed. These amounts, totalling some \$250 million over the years 1966 to 1975, are not included in the sources of industry funds. This program has been terminated. However the 1977 industrial survey will capture estimated investment tax credits as a source of current funding, but these credits will not show up in the federal survey results.

 - b) Payments by AECL to cover the net operating costs (about \$20 to 30 million per year). The Douglas Point and Gentilly I prototype reactors have been included in the federal survey, but will be reclassified as RSA in the future. SSC will revise the historical series to exclude these costs from federal R&D expenditures.

- c) Federal R&D contracts with industry for the provision of non-R&D inputs to the federal programs are included in the federal survey as payments to industry R&D, but are not captured in the industry survey. These amounts should be classified as federal intramural R&D contracts, as provided for on the federal survey questionnaire.
3. The provincial surveys are conducted by the provinces using questionnaires provided by Statistics Canada. No provincial data are collected in Quebec. Currently only Ontario, British Columbia and Saskatchewan are surveyed. The quality of the survey results varies considerably between provinces and is a function of the interest of the provinces and their experience with the survey.
4. The industrial survey is well established. It has been conducted since 1955 and appears to produce acceptable estimates of intramural R&D performed by industry.
5. The private non-profit organizations, as currently defined, are largely active in the medical and health research field. In the GERD matrix these organizations are considered to be suppliers of funds to the universities, and not performers of R&D. In the 1973 survey, the private non-profit organizations indicated intramural R&D of about \$7 million, but it is considered that this R&D was implicitly included in the university sector R&D aggregate as the research largely takes

place at teaching hospitals and universities. Without a survey of hospitals and medical faculties it is difficult to distinguish between non-university and university non-profit institutes.

6. There is no direct survey of university R&D. The total value of R&D performed by universities is estimated by the SSC based on the operating and capital costs of universities, the proportion of faculty in human and natural sciences, and a set of assumed research coefficients, which represent the assumed time devoted to research by members of these faculties. The sources of funding of university R&D are based mainly on the CAUBO sponsored research series. The university intramural contribution to R&D is derived residually by deducting the CAUBO amount from the estimate of the total value of university R&D.

7. There are a number of observations that can be made about the university estimating procedure now used for GERD:
 - a) The operating costs include expenditures for scholarships, bursaries and the cost of ancillary operations. These items are not related to R&D and totalled some \$219.2 million in 1975-76. If these are excluded, university R&D in the natural sciences would be reduced by 14 to 17 percent.

 - b) The capital costs cover the entire university complex - plant, grounds, and facilities. The expenditures are on

a current annual basis, as they are incurred. However, it would be preferable if they were on a depreciation expense basis which reflects the useful life of the assets acquired.

- c) The research coefficients relating to the proportion of time university teachers spend at R&D are not based on Canadian data.

Recommendations

1. General

Detailed reviews of the science statistics should be prepared annually by MOSST. Statistics Canada questionnaires, samples and methodology should be vetted with an advisory group at MOSST to ensure comparability between definitions and data series on an historical basis. Production of the GERD estimates should be placed on a regular publication schedule which provides for preliminary and revised estimates.

2. Federal Survey

The federal R&D contracts with industry, which do not require R&D on the part of industry, should be recorded as federal intramural R&D contracts. A cell is available for this purpose on the federal survey questionnaire and respondents should be reminded of the problem. The purpose of this recommendation is to minimize the differences between the federal and the industrial survey with respect to federally sponsored industry R&D.

A comparability problem will occur between the federal survey and the industry survey with respect to the R&D investment tax credit in the 1977 industrial survey. Industry respondents will be asked to indicate their estimated investment tax credit when listing the sources of funds for their current intramural R&D program. These credits will not be recorded in the federal survey as expenditures. The credits may, however, appear in

the GERD matrix as funds provided to industry from the federal government. This question should be discussed further within MOSST.

3. Provincial Survey

Efforts should be made to improve provincial response and continuity from survey to survey through closer working relationships between SSC and the provinces. It is important to have a Quebec R&D survey as the available data on this Province's R&D funding is rapidly becoming out of date.

4. Private Non-Profit Organizations Survey

The results of the 1976 survey should be reviewed by MOSST with the purpose of securing a better understanding of the funding activities of this sector and the extent of intramural R&D performed.

5. University R&D Estimates

A joint project should be initiated between the SSC and the University Branch to examine the present estimation methodology and to explore possible improvements that could be made. It would be desirable as well, to consider the feasibility of structuring a direct survey of university R&D in view of recent initiatives in the area of university/industry technology transfer and the possible monitoring requirements arising from the re-orientation of the Granting Council programs.

DIAGRAM 1
Organization of National Science Statistics

	Natural Sciences	Human Sciences	All Sciences
Research & Development (R&D)	GERD		
Related Scientific Activities (RSA)			
Total Scientific Activities			

Review of National R&D Data Bases at Statistics Canada

1. Introduction

This report presents a review of the existing science data sources, as reported by the Science Statistics Centre (SSC) of Statistics Canada, with particular emphasis on the gross expenditure on research and development (GERD) series. An outline of the conceptual structure of the data bases is provided. In addition, the report includes a critical review of the methods and estimating procedures, a reconciliation of major data discrepancies, and a set of recommendations for improvement of the series.

2. Structure of the R&D Data Bases

The national science statistics are organized on a matrix concept as shown in Diagram 1. A distinction is made between the type of scientific activity - research and development (R&D) or related scientific activities (RSA) and the type of science involved, natural sciences or human sciences. R&D may be defined as "creative work undertaken on a systematic basis to increase the stock of scientific and technical knowledge and to use this knowledge in new applications". RSA are categorized somewhat differently in the human and natural sciences, but include scientific data collection, scientific information, testing and standardization, feasibility studies and education support. Natural sciences include life

GERD
DIAGRAM 2
PERFORMERS

	Federal Government	Provincial Government	Provincial Ind. Res. Orgn.	Industry	Univ. & Others	TOTAL
Federal Government						
Provincial Government						
Prov. Ind. Research Organization						
Industry						
Universities						
Private Non-Profit Organization						
Foreign						
TOTAL						

SOURCE OF FUNDS

sciences, physical sciences, environmental sciences and engineering and mathematical sciences. Human sciences include the social sciences and humanities. GERD is defined as R&D in the natural sciences and represents the most widely quoted statistic in the national science data base. Its location in the data matrix is indicated in Diagram 1.

The source data for estimating R&D and RSA are surveys of performers of R&D. In the case of natural sciences, the performers include the federal government, provincial governments, provincial non-profit industrial research institutes, industry, and universities. All of these performers are surveyed directly by SSC with the exception of the universities where estimates are based on financial data reported to Statistics Canada by the Canadian Association of University Business Officers (CAUBO). Each of these performers, including the universities through CAUBO, provide a breakdown of sources of funds for research. A matrix emerges then, using the R&D series as an example, in which the rows represent the sources of funds and the columns, the performers. (see Diagram 2).

It is an international convention to use the performer's sources of funds in estimating GERD rather than the funder's distribution of expenditures by performer. This convention is based on the premise that the performer is in the best position to identify work that is performed by him as R&D. It will be argued in this report, however, that if the work is R&D in the funder's but not in the performer's perspective, then it should not be counted as R&D by the performer, but rather as an input to intramural R&D by the funder. As will be seen later in this report, there are substantial differences between the funds reported by the federal government as paid to industry and the amount industry reports receiving from the federal government. The reason for this discrepancy is related to such differences in perspective, and will be discussed in detail.

3. Focus of the Study

One main purpose of this paper is to identify and explain differences in figures reported by various sources of information. In particular, comparisons are provided of the GERD matrix estimates and the original survey data

where they are available (e.g. federal, provincial, industrial, private non-profit surveys and the CAUBO assisted research series). These comparisons serve to highlight some of the gaps in present statistical sources and the extent of estimation procedures as included in GERD. Where it is appropriate, historical tabulations are provided covering the period 1963 to 1977; however, selected comparisons for the year 1973 are shown as this is the most recent year for which complete data from all surveys are available.

DIAGRAM 3
FEDERAL GOVERNMENT AS A SOURCE OF FUNDS

PERFORMERS

	Federal Government	Provincial Government	Provincial Ind. Res. Orgn.	Industry	Univ. & Others	TOTAL
Federal Government						
Provincial Government						
Prov. Ind. Research Organization						
Industry						
Universities						
Private Non-Profit Organization						
Foreign						
TOTAL						

SOURCE OF FUNDS

I. The Federal Survey

The particular detail in the GERD matrix discussed in this section is the vector of federal R&D funding, both intramural and other (see Diagram 3).

Data have been collected since 1959 on resources devoted to scientific activities in the natural sciences by the federal government. As the need for better policy and planning data has increased, the range in detail of information gathered has also increased. During the past year, the federal survey has been integrated with the budget forecasting exercise through the science addenda schedule to the main estimates. The 1976-77 survey marked the first time that forecast data on the scientific activities of the federal government for the year became available at Main Estimates review. Unfortunately, however, this prospective information is not incorporated in the recent GERD estimates which have been projected at an assumed annual rate of 8 percent in 1976 and 1977.

Federal Intramural R&D

Only the federal intramural R&D component of the federal survey finds its way into the GERD matrix, with an adjustment added to reflect the non-program costs associated with the overall administration of the program, services provided by other government departments, and accommodation

TABLE 1

FEDERAL GOVERNMENT FUNDING OF NATURAL SCIENCE R&D IN CANADA
BY PERFORMER, 1973

SOURCE OF DATA	PERFORMERS							TOTAL
	FEDERAL GOVERNMENT AND MUNICIPAL GOVERNMENTS	PROVINCIAL GOVERNMENTS	PROVINCIAL INDUSTRIAL RESEARCH INSTITUTES	INDUSTRY	UNIVERSITIES	PRIVATE NON-PROFIT ORGANIZATIONS	OTHER PERFORMERS	
FEDERAL SURVEY	401.2	0.9	(a)	172.9	127.8	3.1	(a)	710.2
GERD	397.2	1.8	1.7	80.6	117.3	-	-	598.6
OTHER SURVEYS(b)	-	1.1(c)	1.7(c)	80.6(d)	133.3(e)	5.1(f)	-	-

SOURCES: STATISTICS CANADA, ANNUAL REVIEW OF SCIENCE STATISTICS - 1977, CAT. NO. 13-212.

STATISTICS CANADA, FEDERAL GOVERNMENT ACTIVITIES IN THE NATURAL SCIENCES - FISCAL YEARS 1970-71 TO 1976-77 (HISTORICAL SERIES).

NOTES: (a) \$4.3 MILLION INCLUDES PROVINCIAL COUNCILS AND FOUNDATIONS, AND INDIVIDUALS NOT WORKING IN ANY OTHER SECTOR (INCLUDED IN TOTAL).

(b) OTHER SURVEYS (PROVINCIAL, PROVINCIAL INDUSTRIAL NON-PROFIT, INDUSTRIAL, CAUBO AND PRIVATE NON-PROFIT SURVEYS AS DETAILED BELOW).

(c) PROPORTION OF R&D EXPENDITURES FOR PROVINCIAL GOVERNMENTS AND PROVINCIAL INDUSTRIAL RESEARCH INSTITUTES AS A PORTION OF TOTAL SCIENTIFIC EXPENDITURES OF PROVINCIAL GOVERNMENTS AND PROVIN

(d) STATISTICS CANADA, INDUSTRIAL R&D EXPENDITURES IN CANADA 1973-75, CAT. NO. 13-203, TABLE IV; AND THE 1975 SURVEY RESULTS (\$504*0.16=\$80.6 MILLION).

(e) STATISTICS CANADA, UNIVERSITY FINANCIAL STATISTICS 1971-72 TO 1974-75, CAT. NO. 81-212, TABLE 3. INCLUDES SOCIAL SCIENCES R&D AND ALL RSA.

(f) STATISTICS CANADA, EXPENDITURES ON SCIENTIFIC ACTIVITIES BY PRIVATE NON-PROFIT ORGANIZATIONS - 1973, CAT. NO. 13-404, TABLE 1. INCLUDES FINANCING FOR SOCIAL SCIENCES R&D AND ALL RSA AS WELL AS NATURAL SCIENCE R&D.

costs. The federal contribution to other performers (ie. the provinces, industry, and universities) are not used in preparing the GERD estimates, rather these are derived from the surveys of the performers. This sets the stage for differences between the federal survey and the national R&D estimates with respect to federal contributions to industry and to the universities, that need to be reconciled.

The extent of the differences is illustrated in Table 1 which compares, for 1973, the federal R&D contribution to extramural performers, as reported in federal survey, and the GERD estimates of federal contributions, as reported by the surveys of the performers. The federal intramural R&D from the survey and as shown in GERD differ by a small amount. Table 2 shows the two series on an historical basis, 1963 to 1977, and differences occur in this series over the entire period. It is appreciated that recent years, 1975 to 1977, have significant differences arising from the projection technique used in the GERD estimates which assume growth at 8 percent per year, and the federal survey data as reported by MOSST which exclude non-program costs. The Science Statistics Centre updates the federal intramural GERD estimate as final data become available (with a time lag). The advance information from the federal survey is not used for this purpose, rather the preliminary estimates are derived by assuming a growth rate (such as 8% in recent

TABLE 2
FEDERAL INTRAMURAL R&D (NATURAL SCIENCE)
(MILLIONS OF CURRENT DOLLARS)

YEAR	FEDERAL SURVEY(a)	GERD(b)	PER CENT DIFFERENCE (COL.2 TO COL.1)
1963	174.4	175.2	0.5
1964	194.8	195.5	0.4
1965	221.0	221.8	0.4
1966	240.3	241.2	0.4
1967	281.2	282.1	0.3
1968	305.8	304.7	-0.4
1969	307.2	305.7	-0.5
1970	319.7	318.2	-0.5
1971	343.7	342.2	-0.4
1972	366.1	364.8	-0.4
1973	401.2	397.2	-1.0
1974	444.8	440.0	-1.1
1975	433.9(c)*	452.3	4.2
1976	460.8(d)*	488.5	6.0
1977	511.1(d)*	532.1	4.1

SOURCES: STATISTICS CANADA, FEDERAL GOVERNMENT

(a) ACTIVITIES IN THE NATURAL SCIENCES - FISCAL YEARS 1963-64 TO 1976-77 (HISTORICAL SERIES).

(b) STATISTICS CANADA, ANNUAL REVIEW OF SCIENCE STATISTICS - 1977, CAT. NO. 13-212, TABLE 2.2.

(c) MOSST, FEDERAL SCIENCE EXPENDITURES 1975-76 TO 1977-78, MARCH 1977, REPORT NO. 100-3.

(d) MOSST, FEDERAL SCIENCE EXPENDITURES, 1976-77 TO 1978-79, MARCH 1978, REPORT NO. 100-4.

* EXCLUDES NON-PROGRAM COSTS E.G. ACCOMMODATION COSTS, SERVICES PROVIDED BY OTHER DEPARTMENTS AND THE SHARE OF OVERHEAD ATTRIBUTABLE TO SCIENTIFIC ACTIVITIES.

years). The use of advance information from the federal survey should be considered in place of assumptions. As to earlier years, they are fairly comparable, although not identical.

Federal Contributions to Industry R&D

Table 1 shows federal payments to industry for R&D in the amount of \$172.9 million for 1973. In comparison, the industrial R&D survey, which is the source of data for the GERD estimates of federal funding for industry, shows a federal contribution of \$80.6 million. The difference amounts to \$92.3 million in 1973. Table 3 shows the differences between the federal and industrial surveys with respect to federal funding to industry for the period 1963 to 1977 and these amounts are substantial.

There are a number of reasons for these differences:¹

1. There are different interpretations of R&D by the two groups of respondents (government departments and industrial companies).
2. The industrial survey excludes funds paid under the Industrial Research and Development Incentives Act (IRDIA) on the ground that these incentives relate to past R&D and take the form of tax credits or grants.

¹Statistics Canada, Science Statistics Bulletin, Vol. I, Cat. No. 13-003.

TABLE 3
FEDERAL FUNDING OF INDUSTRIAL R&D (NATURAL SCIENCE)
(MILLIONS OF CURRENT DOLLARS)

YEAR	FEDERAL SURVEY(a)	GERD(b)		DIFFERENCE (COL.1 - COL.2)
1963	47.1	28.9	61	18.2
1964	55.8	38.6	69	17.2
1965	75.5	51.7	69	23.8
1966	83.7	50.7	61	33.0
1967	84.4	47.0	36	37.4
1968	108.9	47.9	43	61.0
1969	109.7	55.3	50	54.4
1970	143.9	62.4	44	81.5
1971	141.5	74.8	53	66.7
1972	146.3	73.5	50	72.8
1973	172.9	80.6	47	92.3
1974	164.0	84.2	51	79.8
1975	178.2(c)	77.6	44	100.6
1976	222.3(d)	115.0	52	107.3
1977	214.8(d)	125.0	58	89.8

SOURCES: STATISTICS CANADA, FEDERAL GOVERNMENT

(a)ACTIVITIES IN THE NATURAL SCIENCES - FISCAL YEARS 1963-64 TO 1976-77 (HISTORICAL SERIES)

(b)STATISTICS CANADA, SPECIAL TABULATIONS OF THE SCIENCE STATISTICS CENTER.

(c)MOSST, FEDERAL SCIENCE EXPENDITURES 1975-76 TO 1977-78, MARCH 1977, REPORT NO. 100-3.

(d)MOSST, FEDERAL SCIENCE EXPENDITURES 1976-77 TO 1978-79, MARCH 1978, REPORT NO. 100-4.

IRDIA expenditures increased rapidly from inception in 1966 to \$30 million by 1970-71 and held relatively stable at this level until the program terminated in 1975-76. In total, IRDIA expenditure amounted to \$230 million by 1975-76 and are included in the federal survey totals between 1966 and 1975. Estimated payments were \$40 million and \$15 million in 1976 and 1977 respectively.

3. Payments by AECL to provincial power commissions to cover the net costs of operating the Gentilly I and Douglas Point prototype nuclear generating plants are not reported by the operators in the industrial survey. These amounts are estimated at \$20 to \$30 million and are included in the federal surveys. AECL has agreed to classify these as demonstrated projects in the future and not R&D. SSC plans to revise the historical federal survey data to reflect this change.
4. Most industrial companies use a calendar fiscal year whereas the federal government's year runs from April 1 to March 31. There is, therefore, a timing problem in cash flows reported.
5. Some contracts identified as R&D by government departments are for services or equipment required for in-house R&D projects or for prototypes. Usually, these services or equipment do not require R&D by the contractor. It is argued that these amounts should be included in government intramural R&D contracts because they serve a federal R&D purpose.

*adding
misses amount
at our time.*

6. The IT&C Program for the Advancement of Industrial Technology (PAIT), initiated in 1965 and terminated in 1975-76, included a number of post-R&D activities as qualifying for support. However, the entire program was included in the federal survey, but the industry survey captured only the R&D portion of the payments.

PAIT involved annual expenditures of about \$30 million during the mid-1970s. (PAIT recently has been incorporated in the Enterprise Development Program (EDP) of IT&C).

Recent industrial survey questionnaires did not provide for the recording of R&D investment tax credits received by companies. However, the 1977 survey does provide for this source of funds. In retrospect, it appears that the IRDIA payments should have been credited to the federal government through the industrial survey. And, as well, the R&D portion of the new EDP of IT&C will be included in the industry funding sources or the 1977 survey.

There remains, however, a significant problem in the federal survey with respect to federal payments to industry for non-R&D inputs to federal R&D programs (point 5 above). These inputs are really part of the federal intramural program and should be counted as such in the GERD statistics. At present, such payments are excluded from GERD because they are not captured in the

*why not
of R&D*

industrial survey. In view of the importance placed by the federal government on the contracting-out policy, this problem may grow larger, as departments report increased contract volumes for work which does not require R&D on the part of industry. Such contracts should be reported as intramural R&D contracts and closer scrutiny paid to the survey returns of departments with large extramural contracting activity.

Federal Funding of University R&D

Table 1 shows the federal contribution to university R&D in 1973 with comparable estimates from the GERD statistics. It should be noted that the GERD series for university R&D are prepared using a methodology independent of the federal survey. (This methodology is described in detail in Appendix I.) It is sufficient to observe, at this point, that the GERD funding estimates for university R&D are based on the financial records of the Canadian Association of University Business Officers (CAUBO) as reported by Statistics Canada (University Finance Statistics Section) which detail three sources of funds for "sponsored research". The first of the three sources is the federal government. The CAUBO estimate of federal funding relates to the combined natural and human sciences. For GERD purposes it is split into human and natural sciences R&D based on the federal survey distribution in 1974-75 which indicated that 88 percent of federal university R&D funding was allocated to natural sciences R&D. This same proportion has been used

TABLE 4

COMPARISON OF THE FEDERAL SURVEY AND CAUBO
FEDERAL CONTRIBUTIONS TO UNIVERSITY R&D

YEAR	ALL SCIENCES -- SPONSORED RESEARCH			NATURAL SCIENCES - SPONSORED RESEARCH		
	FEDERAL SURVEY (a) (b)	CAUBO (FEDERAL CONTR.) (c) (d)	PER CENT DIFFERENCE	FEDERAL SURVEY (b)	GERD (e)	PER CENT DIFFERENCE
1963	20.3	22.7	11.8	20.3	20.0	-1.5
1964	27.2	27.3	0.4	27.2	24.0	-11.8
1965	37.9	36.6	-3.4	37.9	32.2	-15.0
1966	52.2	52.1	-0.2	52.2	45.8	-12.3
1967	76.6	71.2	-7.0	76.6	62.7	-18.1
1968	96.9	86.2	-11.0	96.9	75.8	-21.8
1969	110.9	98.4	-11.3	110.9	86.6	-21.9
1970	123.5	105.0	-15.0	113.7	92.4	-18.7
1971	131.5	122.5	-6.8	120.0	107.8	-10.2
1972	134.9	125.8	-6.7	122.2	110.7	-9.4
1973	142.8	133.3	-6.7	127.8	117.3	-8.2
1974	150.8	147.4	-2.3	132.8	129.7	-2.3
1975	165.0	158.4	-4.0	143.8	139.4	-3.1
1976	169.9 *	164.1	-3.4	148.5*	150.6	1.4
1977	193.7 *	n.a.	n.a.	168.7*	162.6	-3.6

SOURCES: STATISTICS CANADA, FEDERAL GOVERNMENT ACTIVITIES IN THE HUMAN SCIENCES - (a) FISCAL YEARS 1970-71 TO 1976-77 (HISTORICAL SERIES), PAGE 17.

(b) STATISTICS CANADA, FEDERAL GOVERNMENT ACTIVITIES IN THE NATURAL SCIENCES - FISCAL YEARS 1963-64 TO 1976-77 (HISTORICAL SERIES), PAGES 33-34.

(c) STATISTICS CANADA, FINANCIAL STATISTICS OF UNIVERSITIES AND COLLEGES, 1976-77. PART 11.

(d) STATISTICS CANADA, UNIVERSITY FINANCIAL STATISTICS - 1975-76. CAT. NO. 81-212.

(e) STATISTICS CANADA, ANNUAL REPORT OF SCIENCE STATISTICS - 1977, CAT. NO. 13-212.

* MOSST, FEDERAL SCIENCE EXPENDITURES AND MANPOWER 1976-77 TO 1978-79, MARCH 1978, REPORT NO. 100-4.

for all years, 1963 through to 1975. The GERD estimates for 1976 and 1977 are based on an assumed 8 percent increase each year. Table 4 shows these data for the period 1963 to 1977.

Table 4 also shows that CAUBO and the federal survey do not agree as to the total amount of federal funding for university R&D (human and natural sciences). These differences are significant, in percentage terms, during the late 1960s but have moderated in recent years. There are a number of reasons for these differences:

1. There are fiscal year differences between the federal government and the universities.
2. Federal funds are first recorded in trust accounts at the universities when received and are paid out to recipients as required. The timing of the expenditure of "sponsored-research" funds may differ significantly from receipt of the funds. It is the latter that is reported in the federal survey.
3. Only funds administered by the university are recorded by CAUBO. Funds paid directly to individuals, groups and organizations are excluded from CAUBO. In the case of the Canada Council, for example, a significant portion of the funding was allocated to individuals and was not recorded in the university accounts. This is an important source of difference, especially in the case of the human sciences, but relatively less important in the natural sciences.

DIAGRAM 4
 PROVINCIAL GOVERNMENT AS A SOURCE OF FUNDS

PERFORMERS

	Federal Government	Provincial Government	Provincial Ind. Res. Orgn.	Industry	Univ. & Others	TOTAL
Federal Government						
Provincial Government						
Prov. Ind. Research Organization						
Industry						
Universities						
Private Non-Profit Organization						
Foreign						
TOTAL						

SOURCE OF FUNDS

II. The Provincial Surveys

This section of the report is concerned with provincial funding of R&D (see Diagram 4).

The first provincial surveys were initiated in 1973-74. Only three provinces were surveyed that year - Nova Scotia, Ontario and Alberta. Saskatchewan was surveyed the following year, and British Columbia in 1976-77. It is significant that Quebec is not surveyed. This represents a substantial gap in the source data. The GERD statistics include estimates for Quebec based on the reports in the series Inventaire de la R-D au gouvernement du Québec 1972-73.

Surveys are also conducted of provincial industrial research institutes. Each province, except Newfoundland and Prince Edward Island, has its own research institute.

The statistics which are available from 1973 show that most of the funds of the provincial research institutes are allocated to intramural R&D. For GERD purposes, the SSC differentiates R&D expenditures by provincial governments and the industrial research institutes.

TABLE 5

PROVINCIAL GOVERNMENT FUNDING OF NATURAL SCIENCE R&D IN CANADA
BY PERFORMER, 1973

SOURCE OF DATA	PERFORMERS						TOTAL
	PROVINCIAL GOVERNMENT	PROVINCIAL INDUSTRIAL RESEARCH INSTITUTES	INDUSTRY	UNIVERSITIES	PRIVATE NON-PROFIT ORGANIZATIONS	OTHER PERFORMERS (a)	
PROVINCIAL SURVEY	26.0	-	5.7	3.4	0.6	8.6	44.3
PROVINCIAL NON-PROFIT RESEARCH ORGANIZATIONS SURVEY	-	9.4 (b)	-	-	-	-	-
GERD	30.9	9.5	1.1	25.8	-	-	-
OTHER SURVEYS	-	-	10.0 (c)	-	26.4 (d)	-	-

SOURCE S: STATISTICS CANADA, ANNUAL REVIEW OF SCIENCE STATISTICS - 1977, CAT. NO. 13-212.

STATISTICS CANADA, PROVINCIAL SURVEY RESULTS (NOVA SCOTIA AND ALBERTA, 1973-74, ONTARIO, 1974-75)

- (a) ALL OTHER PERFORMERS, INCLUDING PROVINCIAL INDUSTRIAL RESEARCH INSTITUTES AND FOUNDATIONS, FEDERAL AND MUNICIPAL GOVERNMENTS, AND FOREIGN PERFORMERS.
- (b) PROPORTION OF R&D FUNDS RECEIVED FROM THE PROVINCIAL GOVERNMENT (\$14.4 MILLION+2.4 MILLION)*13.1/25. PLUS THE INTERNALLY GENERATED FUNDS OF \$0.6 MILLION. STATISTICS CANADA, EXPENDITURES OF PROVINCIAL NON-PROFIT INDUSTRIAL RESEARCH INSTITUTES
- (c) MAXIMUM ESTIMATE BASED ON THE 1973 INDUSTRIAL SURVEY UPDATED FOR REVISED EXPENDITURES.
- (d) FUNDS RECEIVED BY PRIVATE NON-PROFIT ORGANIZATIONS FROM PROVINCIAL GOVERNMENTS FOR ALL SCIENTIFIC ACTIVITIES. STATISTICS CANADA, EXPENDITURES ON SCIENTIFIC ACTIVITIES BY PRIVATE NON-PROFIT ORGANIZATIONS - 1973, CAT. NO. 13-404, TABLE 1.

The provincial surveys are conducted by the provinces, with assistance and questionnaires provided by Statistics Canada. The quality of the results, therefore, is a direct function of the effort, experience, and attention devoted to the task by the provinces. In the 1976-77 survey, Ontario and British Columbia are considered to have had good results, largely due to prior years experience with the survey and because a Statistics Canada representative visited the provinces and helped administer the survey. Nova Scotia dropped their provincial survey in 1977-78, leaving coverage to Ontario, B.C., Saskatchewan, and Alberta. After editing by Statistics Canada, the survey questionnaires are returned to the provinces who then distribute the results as they wish. In view of substantial problems in "breaking in" the provincial surveys, it is not surprising that the survey results are ambiguous with respect to funding levels and allocations to performers.

Some of the data problems involved are illustrated in Table 5, which shows provincial R&D funding by performer in 1973 and the GERD estimates which are based on the provincial and non-profit industrial research institute surveys. The provincial survey for Nova Scotia and Alberta 1973-74 and Ontario for 1974-75 (the 1973-74 survey is considered to be less complete), indicated intramural research of \$26 million. However, about \$15 million of this amount, in SSC view, more properly belongs



in the university sector. The GERD estimate of \$30.9 million, therefore, represents the above adjustment and a further adjustment to cover provinces that did not conduct provincial surveys.

The provincial institute survey conducted by Statistics Canada has been used, with minor adjustments, in the GERD estimates.

Due to lack of data, provincial intramural R&D performed by the provinces and the research institutes has been estimated to grow at 8 percent per year from 1963 to 1973 and for 1977. This is the average annual rate of change for the period 1973 to 1976 for which survey data are available.

Provincial funding to industry, as shown in GERD, is based on the industry survey source of funds. As to the difference in the provincially-financed industry R&D, these could be due to the same kind of factors as were discussed in connection with the federally-financed industrial R&D.

Provincial funding of university R&D in GERD is based on CAUBO sources. The provincial survey indicates a much lower level of support than the CAUBO source for provincially sponsored R&D in the universities, mainly because much of the intramural provincial R&D shown in the provincial survey should be classified as university R&D.

DIAGRAM 5
INDUSTRY AS A SOURCE OF FUNDS

PERFORMERS

	Federal Government	Provincial Government	Provincial Ind. Res. Orgn.	Industry	Univ. & Others	TOTAL
Federal Government						
Provincial Government						
Prov. Ind. Research Organization						
Industry						
Universities						
Private Non-Profit Organization						
Foreign						
TOTAL						

SOURCE OF FUNDS

III. The Industrial Survey

The GERD data reviewed in this section relates to the vector shown in Diagram 5, i.e. industry as a source of funds.

Data on industrial R&D have been collected since 1955 by means of an industrial R&D survey. In this survey, R&D data are collected only for the natural sciences. To include the human sciences would require expansion of the sample to cover the services, trade and financial industries. The NSF in the U.S. has twice conducted pilot surveys of human sciences R&D by industry but has decided not to proceed further due to problems in defining human sciences R&D clearly enough to secure reliable data.

Industry Intramural R&D

The industrial survey is the source of the GERD estimates for industry-funded intramural R&D. As shown in Table 6, the 1973 industrial survey, updated to incorporate revised estimates available in the 1975 survey, totalled \$388.1 million. The GERD estimate is \$386.2 million (the difference is attributed to the use of rounded data as reported in the relevant publications).



TABLE 6

INDUSTRY FUNDING OF NATURAL SCIENCE R&D IN CANADA BY PERFORMER
(MILLIONS OF CURRENT DOLLARS)

SOURCE OF DATA	PERFORMERS					TOTAL	
	FEDERAL AND PROVINCIAL GOVERNMENTS	PROVINCIAL INDUSTRIAL RESEARCH INSTITUTES	INDUSTRY UNIVERSITIES	PRIVATE NON-PROFIT ORGANIZATIONS	OTHER CANADIAN PERFORMERS		
INDUSTRY SURVEY	0.6(a)	-	388.1	1.7 (b)	0.7	0.3	391.4
GERD	-	2.9	386.2	1.0	-	-	390.0
OTHER SURVEYS	-	2.6(c)	-	-	4.3 (d)	-	-

SOURCES: STATISTICS CANADA, ANNUAL REVIEW OF SCIENCE STATISTICS - 1977, CAT. NO. 13-212.

STATISTICS CANADA, EXPENDITURES OF PROVINCIAL NON-PROFIT INDUSTRIAL RESEARCH INSTITUTES - 1974, CAT. NO. 13-209.

STATISTICS CANADA, INDUSTRIAL RESEARCH AND DEVELOPMENT EXPENDITURES IN CANADA - 1973, CAT. NO. 13-203.

(a) INCLUDES FEDERAL AND PROVINCIAL GOVERNMENTS AND PROVINCIAL INDUSTRIAL RESEARCH INSTITUTES.

(b) INCLUDES SCHOLARSHIPS AND FELLOWSHIPS TO INDIVIDUALS.

(c) PROPORTION OF 1973 R&D FUNDS. \$5.007*13.1/25=2.6 MILLION. STATISTICS CANADA, EXPENDITURES ON PROVINCIAL NON-PROFIT INDUSTRIAL RESEARCH INSTITUTES - 1974, CAT. NO. 13-209, PAGES 23 AND 24.

(d) FUNDS RECEIVED BY PRIVATE NON-PROFIT ORGANIZATIONS FROM INDUSTRY FOR ALL SCIENTIFIC ACTIVITIES. STATISTICS CANADA, EXPENDITURES ON SCIENTIFIC ACTIVITIES BY PRIVATE NON-PROFIT ORGANIZATIONS - 1973, CAT. NO. 13-404.

DIAGRAM 6
PRIVATE NON-PROFIT ORGANIZATION AS A SOURCE OF FUNDS

PERFORMERS

SOURCE OF FUNDS	Federal Government	Provincial Government	Provincial Ind. Res. Orgn.	Industry	Univ. & Others	TOTAL
Federal Government						
Provincial Government						
Prov. Ind. Research Organization						
Industry						
Universities						
Private Non-Profit Organization						
Foreign						
TOTAL						

IV. Private Non-profit Organizations Survey

This section reviews the distribution of funding by performer of private non-profit organizations as shown in Diagram 6.

The 1973 survey of private non-profit organizations was the second survey conducted; the first survey was taken in 1965. The most recent survey relates to the year 1976. There are five types of private non-profit organizations: private philanthropic organizations; voluntary health organizations; associations and societies; semi-provincial government organizations; and research institutes and operating foundations.

Table 7 compares the published results from the 1973 survey with the GERD estimates of private non-profit organizations funding to universities. As would be expected, the survey results, when adjusted to reflect R&D in the natural sciences only, are used directly in calculating GERD. Of interest, though, is that the 1973 survey indicated private non-profit organizations conduct intramural R&D (about \$6.9 million) and fund some R&D outside of the universities (about \$3.3 million). These figures, however, are somewhat misleading in that the private non-profit organizations largely fund medical research in the hospitals and at universities. Without a survey of hospitals and medical faculties it is nearly impossible to establish a distinction between

TABLE 7
PRIVATE NON-PROFIT ORGANIZATION FUNDING OF NATURAL SCIENCE R&D
BY PERFORMER - 1973

SOURCE OF DATA	PERFORMERS			TOTAL
	PRIVATE NON-PROFIT ORGANIZATIONS	UNIVERSITIES(a)	OTHER PERFORMERS	
PRIVATE NON-PROFIT ORGANIZATION SURVEY	6.9	19.1	3.3(b)	29.3
GERD	-	19.2	-	19.2

SOURCES: STATISTICS CANADA, ANNUAL REVIEW OF SCIENCE STATISTICS - 1977, CAT. NO. 13-212

STATISTICS CANADA, EXPENDITURES ON SCIENTIFIC ACTIVITIES BY PRIVATE NON-PROFIT ORGANIZATIONS - 1973, CAT. NO. 13-404

(a) INCLUDES PAYMENTS TO OTHER EDUCATIONAL INSTITUTIONS AND OTHER HOSPITALS AND CLINICS.

(b) INCLUDES NATIONAL ASSOCIATIONS, MUNICIPAL AGENCIES, RELIGIOUS AGENCIES, OTHER INSTITUTIONS AND INDIVIDUALS. STATISTICS CANADA, EXPENDITURES ON SCIENTIFIC ACTIVITIES BY PRIVATE NON-PROFIT ORGANIZATIONS - 1973, CAT. NO. 13-404, TABLE 4.

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non-university non-profit institutes and university non-profit institutes. In effect, then, the intramural R&D indicated in the private non-profit organizations survey is implied in the aggregate R&D performed by universities and is shown in GERD as university-funded R&D.

It is of interest to note that the historical series of private non-profit funding of university research is based on the 1973 survey figure, through the methodology employed in calculating the funding for university R&D. A description of the university R&D calculation algorithm is contained in Appendix I.

DIAGRAM 7
UNIVERSITIES AS A SOURCE OF FUNDS

PERFORMERS

SOURCE OF FUNDS	Federal Government	Provincial Government	Provincial Ind. Res. Orgn.	Industry	Univ. & Others	TOTAL
	Federal Government					
Provincial Government						
Prov. Ind. Research Organization						
Industry						
Universities						
Private Non-Profit Organization						
Foreign						
TOTAL						

V. University Research and Development

This section of the report examines the vector of university-funded R&D as shown in Diagram 7.

No direct survey of university R&D is conducted in the university sector as is done in the case of government and industry. The funding attributed to the universities is a residual amount which is derived by first estimating the total R&D performed by the universities and then deducting known sources of funds from this total. These known sources are those contained in the CAUBO "sponsored research" series previously noted in the federal government section of this report. University-funded R&D includes "free-time" research of universities and the implied overhead costs associated with that sponsored research which covers direct costs only, such as R&D funded by the federal granting councils.

Table 8 shows the estimates of university R&D performed in the human and the natural sciences, the CAUBO sponsored research series, and the size of the implied university-funded research for each year, 1963 to 1975. These "overhead" amounts are substantial and exceed 50 percent of the total R&D performed by the universities. Since CAUBO does not distinguish between the natural and human sciences, such division of the total funding must be estimated by the SSC in order to prepare the GERD estimates.

TABLE 8

UNIVERSITY R&D: IMPLIED OVERHEAD COST FACTOR
(HUMAN AND NATURAL SCIENCES - MILLIONS OF CURRENT DOLLARS)

UNIVERSITY R&D (HS+NS)	CAUBO SPONSORED RESEARCH FUNDS	IMPLIED OVERHEAD FACTOR (\$)	IMPLIED OVERHEAD FACTOR (%)
1963	91.5	36.8	54.7
1964	115.2	47.6	58.7
1965	135.2	61.5	54.5
1966	170.0	80.7	52.5
1967	206.7	104.2	49.6
1968	222.1	127.4	42.6
1969	251.0	143.1	43.0
1970	272.0	151.9	44.2
1971	393.1	174.2	55.7
1972	401.1	184.4	54.0
1973	420.9	201.1	52.2
1974	482.8	234.0	51.5
1975	559.0	254.9	54.4

SOURCE: MOSST: FORECASTING DIVISION AND STATISTICS CANADA

University R&D Calculations

The methodology used by the SSC in calculating total R&D performed by the universities and the funding of this amount, is described in Appendix I. This description is based on the outline provided by the SSC in the recent publication, Annual Review of Science Statistics-1977.

The calculation procedure may be briefly summarized as follows. The total value of university R&D performed is based on the operating and capital expenditures of the universities which are allocated to the health sciences, other natural sciences and human sciences in the same proportion as the full-time teaching faculties in these fields of science each year. It is assumed that 15 percent of faculty time in the human sciences is devoted to R&D and 30 percent and 40 percent of faculty time in the health and the other natural sciences, respectively, are so allocated. In 1974-75, these proportions resulted in approximately 22 percent of the total operating and capital costs of the universities being allocated to R&D in the human and natural sciences combined. The funding of this total is based on CAUBO and other information and assumptions as described in Appendix I.

Some Comments on the University R&D Estimates

1. Total university operating expenditures include certain items which are substantial in value, but which are not directly related to R&D. For example, expenditures for scholarships, bursaries and prizes amounted to \$25.6 million

in 1975-76 and "expenses of ancillary operations", which include books and goods purchased for resale, cafeteria and residence expenditures, the operation of the bookstores and other items, which in 1975-76 amounted to \$193.6 million

2. Total university capital costs on a current dollar basis include the entire university complex: plant, grounds, offices, recreational facilities, equipment, teaching facilities and residences. It is clear that a large investment in university infrastructure was made during the 1960's and that this investment is implicitly reflected in GERD. This means that if there is a decline in university capital expenditure, as might be expected in the future, the implied university R&D would also decline. It would be an improvement to the current methodology to use estimated depreciation expense which is a more stable item than current capital expenditure and reflects the useful life of the assets acquired. It would also be an improvement to segregate R&D-relevant capital items from the aggregate.
3. The total operating and capital costs of universities as estimated by CAUBO and Statistics Canada include estimates to cover all universities in Canada, but it seems likely that only a sub-set of this total is concerned with R&D--- those with graduate faculties, for example.
4. While the research coefficients bear a relationship to similar coefficients used in other countries for the same purpose, it would be desirable to have Canadian data to confirm the proportions assumed.

5. The CAUBO sponsored research series appears to be a suitable source of information on the funding of university R&D. Unfortunately this series does not provide a breakdown of the type of science being funded nor does it provide sufficient details on the sources of funds as set out in the GERD matrix. It would be desirable to explore the possibility of securing such breakdowns in lieu of a full performer survey of university R&D.
6. The overhead costs associated with sponsored research include the costs of the facilities and university resources used by the investigator and the salary of the principal investigator. A joint CCFUR-CAUBO pilot study is underway to develop a basis for estimating these costs and the appropriate ratios. When this report is available, these findings could be reviewed and may provide a basis for possible revisions to the current estimating methodology.

Impact of Excluding Costs of Ancillary Operations and Scholarships
from the Calculation Base

An analysis was made of the impact of excluding the above costs from the operating costs of universities using the SSC algorithm for estimating university R&D. The results of this study are shown in Tables 9 and 10 for the natural sciences and the human sciences respectively. (It should be noted that the recalculated university R&D series do not agree with the SSC estimates in every year, but are quite close.) In the case of natural sciences R&D, the exclusion of the above costs had the effect

TABLE 9

UNIVERSITY R&D EXCLUDING SCHOLARSHIPS AND ANCILLARY OPERATIONS
NATURAL SCIENCES

	SSC ESTIMATES	RECALCULATED	EXCLUDING SCHOLARSHIPS ANCILLARY OPERATIONS	DIFFERENCE	PER CENT DIFFERENCE
1963	91.5	91.6	78.0	13.6	14.9
1964	115.2	115.2	97.3	18.0	15.6
1965	135.2	135.1	112.0	23.1	17.1
1966	170.0	172.0	143.2	28.8	16.7
1967	206.7	206.7	175.3	31.4	15.2
1968	222.1	225.0	193.8	31.2	13.9
1969	251.0	250.9	216.5	34.4	13.7
1970	272.0	276.0	238.1	37.9	13.7
1971	283.0	282.8	242.0	40.8	14.4
1972	287.2	287.1	244.5	42.7	14.9
1973	301.1	299.9	249.9	49.9	16.7
1974	347.1	347.1	286.2	60.9	17.5
1975	401.1	394.1	327.9	66.2	16.8

SOURCE: MOSST: FORECASTING DIVISION AND STATISTICS CANADA

of reducing university R&D by some 14 to 17 percent. In the human sciences, the exclusions resulted in a reduction of R&D by some 15 to 20 percent. This analysis demonstrates the sensitivity of the R&D estimates to changes in assumptions and underlines the need for a more detailed review of the problem of estimating university R&D.

TABLE 10

UNIVERSITY R&D EXCLUDING SCHOLARSHIPS AND ANCILLARY OPERATIONS
HUMAN SCIENCES

	SSC ESTIMATES	RECALCULATED	EXCLUDING SCHOLARSHIPS ANCILLARY OPERATIONS	DIFFERENCE	PER CENT DIFFERENCE
1963	-	29.5	24.5	5.0	17.0
1964	-	38.8	31.7	7.1	18.2
1965	-	48.0	38.4	9.5	19.9
1966	-	63.3	51.1	12.2	19.3
1967	-	79.8	65.9	13.9	17.5
1968	-	89.4	75.4	14.0	15.6
1969	-	107.3	90.9	16.4	15.3
1970	-	110.7	93.8	16.8	15.2
1971	110.1	110.1	92.6	17.5	15.9
1972	113.9	113.8	95.7	18.1	15.9
1973	119.8	119.8	99.0	20.8	17.3
1974	135.7	135.7	110.9	24.7	18.2
1975	157.9	157.9	130.3	27.6	17.5

SOURCE: MOSST: FORECASTING DIVISION AND STATISTICS CANADA

Appendix I

Estimation of University R&D

This methodology is summarized based on a full description provided by the Science Statistics Centre (SSC) in the Annual Review of Science Statistics-1977.

The calculation steps are as follows:

1. The annual operating and capital expenditures of the universities, as reported by CAUBO and Statistics Canada in University Financial Statistics, are allocated to the natural and human sciences based on the proportion of full-time teaching faculty in these fields. In order to make full use of available data, the natural sciences are divided into health sciences and other natural sciences and combined in the last step of the routine. A further refinement is made to the faculty proportions in allocating capital expenditures in view of the assumed higher capital requirements of health sciences and other natural sciences.
2. The result of the above step is the estimated operating and capital expenditures attributed to the natural and human sciences. Costs attributed to the faculties of education and fine and applied arts have been excluded at this point.
3. The value of R&D performed by the universities is calculated by applying research coefficients to the above cost totals. It is assumed that the human science faculties devote 15 percent of their time to R&D; the health sciences, 30 percent; and

the other natural sciences, 40 percent. These coefficients are held constant through time.

4. The result of the above step is used in GERD; that is, the sum of health sciences and the other natural sciences R&D represents the total value of the R&D performed by the universities in the natural sciences.
5. The funding of this research is developed in several steps. The primary source of funding information is the CAUBO "sponsored research" series. These data provide sub-totals of funds provided by the federal government, the provincial government and other sources. The difference between the total CAUBO sponsored research and the estimated R&D performed is assumed to be financed by the universities.
6. The CAUBO "other sources" sponsored funding is allocated to the GERD matrix funders--industry, private non-profit, universities and foreign sources. Industry funding can be estimated from the industrial R&D survey. Foreign funding can be estimated from U.S. data provided by the N.S.F. and other information. The residual is allocated two-thirds to private non-profit organizations and one-third to universities.
7. Step 6 provides estimates of the funding sources for all sciences. The funding for health sciences, other natural sciences and human sciences are estimated in successive steps.
8. The funding of health research is based on the brief of the Association of Canadian Medical Colleges to the Senate Committee on Science Policy relating to the year 1974-75.

These data were adjusted to reflect coverage of all universities and to conform to the GERD matrix funder categories.

9. The federal survey in 1974-75 indicated that 12% of the total university R&D funding was for human sciences research. Therefore, the federal funding in CAUBO was allocated 12 percent to human sciences, 88 percent to natural science in all years. The other funders are assumed to allocate their non-health funds on the basis of one-quarter to human sciences and three-quarters to other natural sciences in all years.
10. This completes the funding matrix for university R&D. The health and other natural sciences are combined and the funding totals inserted in the GERD matrix.

Appendix II
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