New Zealand research and experimental development statistics : all sectors, 1990/91 / Ministry of Research, Science and Technology.

New Zealand Research and Experimental Development Statistics

All Sectors, 1990/91.

Ministry of Research, Science and Technology

Te Manatu Putaiao

Publication No.7

Cover: Significant areas of R&D (Clockwise)

1. Government sector: Research to enhance the productivity of mussel farms; the FRV "Kaharoa" working in Mills Bay, Kenepuru Sound, Marlborough Sounds.

2. Business enterprise sector: High speed motor winding in the production of the Smart Motor for automatic washing machines at Fisher and Paykel.

3. University research: "Examining the sample"; an often essential part of health research even in this age of technological innovation.

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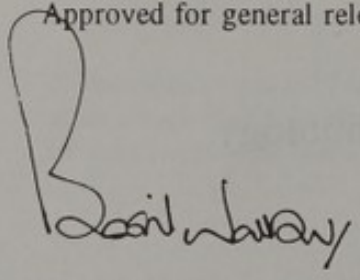
This document is the report of the survey of government and private sector R&D carried out jointly with the Department of Statisitics by the Ministry of Research, Science and Technology, with additional data on university R&D derived from the Ministry's benchmark survey and the survey of the tertiary sector study group. The report was compiled by Pamela Walker.

Approved for general release



Basil Walker
Chief Executive

FOREWORD

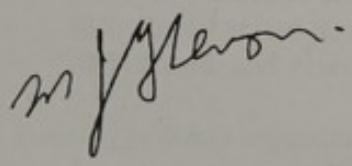
This survey of research and development in the government, business enterprise and university sectors is the third in a series of R&D surveys to be undertaken by the Ministry of Research, Science and Technology. This is the first publication in which information on all three sectors is provided. The survey was carried out jointly with the Department of Statistics and should provide valuable information to policy makers in government, business and the education sector.

The process for carrying out this survey was developed with the valuable assistance of an advisory group whose members were drawn from business and the government science departments. I would like to thank the advisory group for their informed comment and attention to detail which have helped to ensure the acceptance of and good response to the survey.

The respondents were generally very willing to provide the information and to participate in the survey. Any survey of R&D is likely to encounter definitional problems in its early stages, and some departments had difficulty in providing data according to the OECD definitions. These problems will become easier to resolve as the participants start to record the information in the desired format.

The tabulations presented here are designed to make information available as quickly as possible. Further analysis of the information, especially in relation to economic indicators, will follow when data for the next year become available.

R&D statistics become more valuable for policy development and other purposes when the surveys have been repeated for a number of years, and trends in expenditure and human resources become evident. The Ministry is at present undertaking a survey of government and business enterprise sector R&D for the 1991/92 financial year, and a survey of higher education sector research undertaken during 1992 is planned.



Margriet Theron
Group Manager, Research Services
Ministry of Research, Science and Technology

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NZ R&D Statistics 1990/91

One of the functions of the Ministry or Research, Science and Technology is to collect statistics on research in New Zealand. Two previous surveys, referred to throughout this report as "Business Enterprise Survey" and "Government Survey" provided the first year of comprehensive statistical data on private and government sector research and development (R&D) in New Zealand. This report extends the survey into its second year and includes both private and government sectors, with some additional data on research in the higher education sector.

The survey aims to establish a methodology for the survey process, which will then be repeated at regular intervals to obtain statistics for release to government, business and other users in the community. The statistics are used in the development of science policy.

The surveys are being carried out according to international definitions and conform to standards of the Organisation for Economic Cooperation and Development (OECD) for the collection of R&D statistics. The results are used to fulfil New Zealand's international obligations to provide R&D statistics and only research and development activities, as defined by the OECD, are included in the survey. Consulting and scientific and technological (S&T) services are excluded.

The survey of government and business enterprise R&D was conducted jointly with the New Zealand Department of Statistics.

Questionnaires were sent to a total of 1,945 enterprises, of which 1,889 were business enterprises and 56 government agencies. The response rate for the survey was 96 percent. A 100 percent response rate was achieved for all enterprises with more than 100 full time equivalent (FTE) persons engaged.

The survey used the OECD definition of R&D:

"Research and experimental development comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

The definition of R&D, in accordance with a change in OECD standards, now includes research into, and development of, computer software such as applications software, new programming languages and new operating systems.

Australia, Denmark, Finland, Ireland, Sweden and Norway are used in this report as a basis for comparison of some of the main results, and are referred to in this report as the "OECD reference countries".

There are limitations to the level of accuracy that can be expected from an R&D survey. Many respondents do not keep separate account of their R&D expenditure, and considerable estimation may be required. Since 1989/90 businesses may have reviewed their assessment of the output class into which their R&D should be classified, particularly in the information technology (IT) area.

Capital expenditure is given rather than depreciation.

By combining data from all three surveys it is estimated that the business enterprise sector spent $224 million on R&D, the government sector spent $334 million and the universities spent $90 million.

$13 million of New Zealand-funded R&D was carried out overseas. The business enterprise expenditure included $45 million spent on R&D by the producer boards.

The results show that New Zealand's ratio of gross domestic R&D expenditure to GDP was 0.9 percent, compared with an average of 1.7 percent for OECD reference countries. Private sector expenditure on R&D was 0.3 percent of GDP, or 36 percent of the total, compared with 53 percent for OECD countries.

There was an increase in reported government operational research. Government departments reported $5.6 million more operational research than in 1989/90. There was an adjustment (to ensure tax neutrality) to the public good science fund of $4.5 million.

Total full time equivalent personnel engaged in R&D in the government sector totalled 3,880 which was 200 fewer FTE than in the previous year. The national total of R&D personnel represents 5.5 per thousand of the labour force, compared with 9.1 per thousand for the OECD reference countries. Persons engaged in R&D in the business enterprise sector represented 30 percent of the national total of R&D personnel, compared with an average of 48 percent for the six OECD reference countries. The total number of personnel employed in R&D came to 8,809 FTE. There are 0.57 technical staff for each researcher.

Of the total expenditure of $204 million on intramural R&D, over one third ($69 million) is aimed at better ways to process, and improve products from, meat, dairy products, fruit and other crops, fibres and skins, and wood and paper.

Over a quarter of the R&D ($53 million) is aimed at the development of new and improved materials and industrial processes, engineering products and processes, and computing, electronic, telecommunications and instrumentation processes, systems and products.

The substantial expenditure in the primary products and processing group of output classes (a total of $69 million) reflects the economic importance of these primary products in the New Zealand economy, and the presence of research associations and producer marketing boards in the meat, dairy, wool, fruit sectors. These organisations carried out R&D on the processing of primary products to the value of $39 million.

Business enterprises overall spent $29 million on research aimed at the development of new and improved dairy processes, storage techniques and products. This is the largest of all the output classes in the business enterprise sector in 1990/92.

Information systems comprise a large area of business enterprise sector R&D in New Zealand. Electronics, communication systems and software R&D totalled $43 million, or just more than a fifth of all the business enterprise R&D.

In addition to the R&D carried out within the business enterprise sector, business enterprises reported that they funded R&D to a total value of $31.0 million which was carried out by government organisations, universities and organisations overseas.

Wages and salaries consumed 54 percent of the $204 million allocated to R&D. Other current expenditure accounted for 36 percent. Capital expenditure was 10 percent.

1 Background

Previous publications[1,2], which will be referred to throughout this report as the "Business Enterprise Survey" and the "Government Survey", provided the first year of comprehensive statistical data on private and government sector research and development (R&D) in New Zealand. This publication extends the survey to its second year, and includes both private and government sectors, with some additional data on research in the higher education sector which have been obtained from a benchmark survey[3] of all Crown-funded research, and from further data based on a recalibration of this survey by a joint university and government review of university public good science outputs. This review was carried out during March to June 1992 under the chairmanship of Dr A.E.Bollard[4].

The R&D surveys aim to collect comprehensive R&D statistics from the three sectors for the first time in New Zealand, so that they can be combined to generate a full picture of R&D for the period 1990/91. They also aim to establish a methodology for the survey process, which will then be repeated at regular intervals to obtain statistics for release to government, business and other users in the community. The statistics are used in the development of science policy in areas such as the setting of research priorities, government funding levels, research strategies, science education, and innovation encouragement schemes.

The surveys are being carried out according to international definitions and conform to standards of the Organisation for Economic Cooperation and Development (OECD) for the collection of R&D statistics. The results are used to fulfil New Zealand's international obligations to provide R&D statistics.

Only research and development activities, as defined by the OECD, are included in the survey. Consulting and scientific and technological (S&T) services are excluded.

In line with OECD methodology, statistical information is gathered from the providers rather than the funders of research. This is in order to prevent the same research being reported twice, by both the provider and the funder. Providers are also usually in the best position to determine whether work is R&D or S&T services, and to report on the resources actually expended on research. Information on the sources of the funds used by providers is used to estimate the expenditure on R&D by each sector.

2 Changes in government-funded research

The past six or seven years has been a time of considerable change in the nature of government-funded research in New Zealand. The processes which had occurred up to, and including, the time of this survey (September 1991) included:

- definition of the concept of "public-good" scientific research and of desirable science outcomes resulting from such research;
- definition of a set of forty science "output classes", used in developing science priorities and funding levels;
- formulation of all research within each output class in terms of research programmes with stated goals; each programme comprising defined, usually one year, research tasks or objectives;

- recommendation by a Science Task Force[5] that the Department of Scientific and Industrial Research, and the research branches of the Ministry of Agriculture and Fisheries, the Ministry of Forestry and the Meteorological Service, be re-organised into ten Crown Research Institutes as from 1 July 1992; and

- continued encouragement for government research organisations to undertake commercial work funded from non-government sources.

New arrangements for the management of public good science were established on 1 October 1989. Science policy advice was separated from the allocation of funding and from science provision with the formation of the Ministry of Research, Science and Technology to advise the Minister of Research, Science and Technology; and the Foundation for Research, Science and Technology to allocate funding on a contestable basis. This replaced the direct allocation of funds by Parliament to science departments.

The period of the first R&D survey, 1989/90, was the last year in which the government science departments received their Crown funding through direct appropriation. The contestable bidding system commenced early in 1990 and came partially into effect during the financial year 1990/91 and fully into effect in 1991/92.

3 Role of the Ministry of Research, Science and Technology

When it was established the Ministry of Research, Science and Technology had the following principal functions:

- to advise the Minister of Research, Science and Technology on national science and technology policy;

- to identify national priorities for government funding of research and technology;

- to facilitate and publish science reviews, to collect data on all forms of national R&D activity, and to fulfil international obligations to provide data on R&D; and

- to maintain international government to government science agreements and to encourage scientific co-operation.

In January 1993, the science review function was moved to the Foundation for Research, Science and Technology.

In relation to this survey, the function of the Ministry of Research, Science and Technology is to arrange for the collection of data on national inputs into, and outputs from, R&D, including fulfilling international obligations to provide data on national science and technology activity to the OECD and other bodies.

4 Survey methodology

The survey of government and business enterprise R&D was conducted jointly with the New Zealand Department of Statistics.

An advisory group with representatives from the business enterprise sector was set up to review the questionnaire and to advise on the survey methodology. The membership is detailed in Annex 1 to this report. The questionnaire used was the result of the discussion and recommendations made at the advisory group meeting on 11 July 1991.

Changes from the previous year included an expanded definition of R&D, a definition of "studies", a clarification of the categories for personnel, and an increase in the number of categories for qualifications of R&D personnel. In addition, a separate letter giving a full definition of what constitutes R&D in the software industry was included with the questionnaire sent to each enterprise surveyed in that industry.

Questionnaires were sent to a total of 1,945 enterprises, of which 1,889 were business enterprises and 56 government agencies. The population surveyed consisted of:

- all those who answered "Yes" to an R&D question in the Department of Statistics' 1991 Annual Business Directory Update survey;
- those that answered "Yes" to any of the questions in the 1989/90 R&D survey;
- all large enterprises involved in manufacturing. "Large" was defined as those enterprises with more than 100 full time equivalent persons engaged; and
- those government departments and Crown agencies undertaking public good research, or operational research to support their own outputs, including positive respondents to the 1989 government sector R&D survey[2].

The response rate for the survey was 96 percent. A 100 percent response rate was achieved for all enterprises with more than 100 full time equivalent (FTE) persons engaged. Data for the non-respondents were imputed, and comprised 0.08 percent of the total R&D expenditure recorded, or 0.2 percent of the business enterprise sector R&D. All government agencies responded. The government organisations are listed in Annex 2.

5 Definitions used in the survey

In OECD publications, standard abbreviations are used for the measures of R&D given in this report. Most of the tables represent expenditure on R&D *carried out* in each of the three sectors; business enterprise R&D or "BERD", government R&D or "GOVERD", and higher education R&D or "HERD". That part of University funds for research which comes from Vote: Education and is part of the employment contract of academic staff is called "general university funds" or "GUF", as distinct from research monies allocated by independent funding bodies such as the Foundation for Research, Science and Technology or the Health Research Council.

Total *funding* of R&D by each sector is estimated by subtracting from its intramural R&D that part which is funded from outside the sector and adding any R&D which it funded in any other sector. Data from R&D providers are preferred because estimates given by funders may include double-counting as the same funds may be provided by one body, allocated by another, and reported by both.

The survey used the OECD definition of R&D:

"Research and experimental development comprises creative work undertaken on a systematic basis in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this stock of knowledge to devise new applications."

Any activity classified as R&D is characterised by *originality;* it should have *investigation* as a primary objective, the outcome of which is *new knowledge*, with or without a specific practical application, or *new or improved* materials, products, devices, processes or services. R&D ends when work is no longer primarily investigative.

The definition of R&D, in accordance with a change in OECD standards, now includes research into, and development (or substantial modification) of, computer software such as applications software, new programming languages and new operating systems.

A more comprehensive interpretation of the definition of R&D activity is given in the OECD publication *The Measurement of Scientific and Technical Activities* (the Frascati Manual)[6].

Intramural R&D statistics presented in this publication refer to R&D activity *carried out* by an organisation on its *own* behalf or on behalf of other organisations or individuals. *Extramural* R&D statistics refer to R&D activity *funded* by an organisation but *carried out* by others.

R&D *expenditure* includes *capital* expenditure on the acquisition of fixed, tangible assets such as land, buildings, vehicles, plant, machinery and equipment attributable to R&D activity; *current* expenditure on wages, salaries and other labour costs, materials, repair, travel, etc; and the proportion of expenditure on general services and overheads which is attributable to R&D activity.

Human resources devoted to R&D measures the effort of researchers, technicians and other staff *directly* involved with R&D activity. Overhead staff (e.g. administrative and general services employees such as personnel officers and cleaners) whose work *indirectly* supports R&D activity, are excluded from counts of personnel but their costs are included in overheads.

Researchers are those involved with the conception and/or development of new products or processes. They include project managers, directors, scientists and engineers concerned with project content but exclude those concerned with administrative matters.

Technicians are those performing technical tasks in support of R&D activity, normally under the direction and supervision of a researcher. These tasks include performing experiments, maintaining and operating advanced equipment, and computer programming.

Other supporting staff are those skilled and unskilled craftspersons, and secretarial, administrative and clerical staff directly associated with R&D activity.

Technological balance of payments is the collation of those invisible international transactions relating to trade in technical knowledge or know-how. *Technical know-how* is defined as: existing specialised technical knowledge that is required to produce a successful product or implement a process e.g. patents; licenses; technical data and information; and scientific, technical or engineering assistance that increases technical knowledge and understanding in the organisation.

Payments for technical know-how exclude other costs such as overseas travel and subscriptions to periodicals as well as the cost of computer software and scientific, technical or engineering services that are not aimed at increasing the technical knowledge of the organisation.

Receipts for technical know-how exclude contract or commission work carried out on behalf of others.

The *business enterprise* sector includes all enterprises whose primary activity is the production of goods or services for sale to the general public at a price intended to cover at least the cost of production, and the private non-profit institutions mainly serving them.

The organisational unit for the collection of R&D statistics is the enterprise. An *enterprise* is defined broadly as the unit comprising all the operations in New Zealand of a single operating legal entity (e.g. company, partnership or sole proprietor).

The vast majority of enterprises included are private businesses. The remainder are public business enterprises mainly engaged in trading or financial activities, research associations funded by levy or grant, producer boards, private non-profit organisations and local authorities.

Farming enterprises (i.e. industries in major group 111 of the *New Zealand Standard Industrial Classification (NZSIC)*, 1987 edition) were not included in the Department of Statistics Business Directory update, so were not canvassed for inclusion in the survey. Farming companies known to be doing R&D were included. Agricultural R&D activity is generally carried out by specialised research associations. The Agriculture Survey carried out by the Department of Statistics in June 1993 will include a question on R&D, in order to identify farmers who engage in research.

For the purposes of R&D statistics, the OECD recommends that research institutes be classified to the industry they predominantly serve, and this recommendation has been followed in this report. The predominant output area specified by each research association was used as a guide, and supplementary NZSIC codes assigned and used in all tables for the data provided by the research association.

Each enterprise is classified to the industry in which it mainly operates even though one or more of its component activity units (factories, shops, etc.) may be classified to other industries. For further comment see the *New Zealand Standard Industrial Classification*, 1987 Edition[8].

6 International comparisons

Six countries from within the OECD have been identified by the NZ Institute of Economic Research as having a number of similar characteristics to New Zealand as regards population, size of the economy and stage of economic development. These countries: Australia, Denmark, Finland, Ireland, Sweden and Norway, will be used in this report as a basis for comparison of some of the main results, and will be referred to as the "OECD reference countries".

7 Limitations of the survey data

There are limitations to the level of accuracy that can be expected from an R&D survey. Many respondents do not keep separate account of their R&D expenditure, nor do they include R&D with other scientific and technological services, such as consulting. Records may not be kept in the form required for the survey, and considerable estimation may be required. Detailed descriptions of what should and should not be included as R&D were provided on the questionnaire form, and phone-in help was available and utilised. However, best estimates were required in many cases. As the survey

is repeated the results can be expected to become more reliable, as respondents become more experienced.

The OECD requirement for international comparability meant that capital expenditure was requested rather than depreciation. Large capital expenditures can cause fluctuations in total expenditure from year to year which can mask a trend or introduce a false trend.

The 1989/90 business enterprise survey was based on a stratified sample, while the current survey has full coverage. Sampling error will no doubt contribute to the fluctuations noted between the two years, and must be taken into account when making comparisons. In some cases it appears that businesses may have reviewed their assessment of the output class into which their R&D should be classified. This seems to have occurred particularly in the information technology (IT) area, with firms stating in the second survey the purposes (health, commerce, economics) towards which their IT research was addressed, rather than simply that it was IT research.

8 All sectors in summary

Expenditure on R&D *carried out* in the business enterprise sector for the year ended June 1991 totalled $204.4 million. As a percentage of Gross Domestic Product (GDP) this amounted to 0.3 percent (using GDP at March 1991 of $73,747 million).

The results show that New Zealand's ratio of gross domestic R&D expenditure to GDP was 0.9 percent, compared with an average of 1.7 percent for OECD reference countries.

Private sector expenditure on R&D was 36 percent of the total, compared with 53 percent for OECD reference countries. This includes work contracted to government departments, universities and overseas and includes $11 million from overseas sources. The figure for 1989/90 was similar when reporting uncertainties are taken into account.

The results indicate that half of the R&D in the business enterprise sector was carried out by three percent of the enterprises that do research. These included the Research Associations who did 23 percent, the Producer Boards who did 3 percent and State-Owned Enterprises (5 percent).

The survey shows a drop in personnel doing R&D (see Table 9). Private sector figures reported fewer R&D personnel in the chemical, electronics and appliances industries. The majority of the decrease was in the number of technicians (down by 19 percent), rather than the more highly qualified researchers and scientists (down by 1 percent). Support staff were down by 7 percent.

Total personnel working in R&D in the business enterprise sector was 2,603 full time equivalents (FTE), 223 fewer FTE than were reported in 1989/90, including 182 fewer FTE technicians.

In spite of some difficulties with the definition of R&D, the data from the business enterprise survey on R&D expenditure in the second year were remarkably consistent with the first year, which were based on a stratified sample of firms in each industry sector.

There was an increase in reported government operational research. Government departments reported $5.6 million more operational research than in 1989/90, with small increases spread between thirteen departments. There was an inflation adjustment to the public good science fund of $4.5 million.

Total full time equivalent personnel engaged in R&D in the government sector totalled 3,880, which is 200 fewer FTE than in the previous year. The contestable public good science fund was the main source of revenue for 3,354 FTE, while about 524 FTE were engaged in operational research as part of the policy function of government agencies. The estimate of researcher full time equivalents (FTE) engaged in R&D was 5 percent down on the 1989/90 estimate. There was little change in technician FTEs, but support staff FTE was down by 12 percent. The overall reduction in R&D personnel was five percent.

When staff engaged in consulting and other non-R&D scientific services were included in the total, the changes were less marked, with a 2 percent increase in researchers, a 3 percent reduction in support staff, and an overall decrease in personnel of 3 percent.

Government expenditure included a payment of $13.3 million in 1990/91 for the marine research vessel, the "Tangaroa".

When university researchers are included, New Zealand has 3 FTE research scientists and engineers per 1000 in the labour force, compared with an average of 5.9 per 1000 labour force in OECD reference countries. The national total of R&D personnel represents 5.5 per thousand of the labour force, compared with 9.1 per thousand for the OECD reference countries, or 8.8 per thousand average for all available OECD data.

Conclusions from the comparison between the first two years for which the survey has been operating have to be made with some caution because of the lack of experience in many respondents of what should be included in R&D as defined by the OECD. As experience of R&D surveys develops, the data will become more reliable.

Universities are estimated to have spent $90 million on R&D, based on time estimate surveys and other data (section 17). The university data were not collected on the same basis as was used for the first two sectors. The definition of R&D used may have caused an over-estimation of up to 15 percent, but this was more than balanced because the data did not include the cost of expenditure funded from external sources, which is estimated at between $30 million and $70 million.

9 The business enterprise sector

9.1 Introduction

In the first year of the survey, a stratified random sample of 2,508 firms was surveyed, representing a population of 7,904 firms in areas of the manufacturing and service sectors which could be expected to engage in R&D. In the second year, a brief question on R&D activity was sent to the population of 147,173 firms (all non-government firms in the Department of Statistics Business Directory). There were 1,889 positive responses (1.3 percent), all of which received the full R&D questionnaire.

It was subsequently found that 886 of these (0.6 percent of the population) provided or funded R&D or traded in technology.

R&D was being done by 736 (including imputes), and 265 were funders, compared with estimates from the first year's sample of 1,027 providers and 315 funders.

The workforce of the firms doing R&D represented 11 percent of the total labour force.

Persons engaged in R&D in the business enterprise sector represented 30 percent of the national total of R&D personnel, compared with an average of 48 percent for the six OECD reference countries, or 46 percent for all OECD countries for which data are available.

9.2 Concentration of R&D in firms

R&D expenditure was heavily concentrated in a small number of firms, as follows:

The top 5 firms spent $ 53.8 million, or 26 percent of the total.
The top 10 firms spent $ 72.4 million, or 35 percent of the total.
The top 23 firms spent $102.8 million, or 50 percent of the total.
The top 100 firms spent $154.6 million, or 76 percent of the total.

Thirty-three enterprises carried out R&D to the value of $1 million or more.

This means that half of the R&D being carried out was concentrated in the top three percent of providers.

9.3 Size of firms carrying out R&D

The introduction of Goods and Services Tax has led to an increased number of small firms entering into the formal economy in New Zealand. The New Zealand R&D survey is based on the GST register, so that more very small firms are likely to be surveyed here than in other OECD countries. In Australia, for instance, only employers are registered, while in the larger countries, firms with more than 400 to 500 people are selected for the R&D survey.

Twenty-five percent of firms carrying out R&D had only 2.5 or fewer personnel (FTE) and carried out only 4 percent of the total R&D. Fifty percent had 14.5 or fewer full time equivalent personnel and carried out 16 percent of the R&D. At the other end of the scale, 25 percent had 100 or more FTE personnel and carried out 55 percent of the R&D.

Firms were grouped according to the number of researchers (in full time equivalents or FTE).

More than fifty percent of firms had only half or less than half of a full time researcher working on R&D at any time. Their mean expenditure on R&D was $43,000 with half spending less than $23,000.

A further 31 percent of firms engaged between a half and two full time researchers at any time. These firms spent an average of $167,000 on R&D.

Nine percent of firms employed between 2 and 5 researchers full time. These firms spent on average $423,000 on research, with half of them spending less than $338,000.

The top seven percent of R&D providers engaged more than five researchers full time and their mean R&D expenditure was $2,411,000. Half of these spent less than $1,108,000.

In all groups the mean expenditure on R&D was greater than the median expenditure, which indicates that a few high spenders clustered at the upper boundaries of each group.

Table 1. Distribution of R&D expenditure in firms by number of researchers employed

Researchers (FTE)	Firms		Mean Expenditure ($000)	Total Expenditure		Median Expenditure ($000)
	Number	%		$M	%	
0-0.5	389	53	43	16.7	8	23
0.5-1	154	21	125	19.3	9	80
1-2	75	10	252	18.9	9	170
2-5	68	9	423	28.8	14	338
>5	50	7	2,411	120.6	59	1108
TOTAL	736	100		204.2	100	

Thus firms carrying out R&D correspond to the 80/20 rule; if all items are arranged in order of value, 80 percent of the value will lie in only 20 percent of the items. Taking the top three categories in order of the number of researchers employed, 82 percent of the R&D was carried out by 26 percent of the firms.

10 Intramural business enterprise R&D, by science output class

10.1 Overview of R&D by output

In addition to the classification of firms by NZSIC, R&D in New Zealand is grouped by science output class. Output classes are New Zealand government science funding categories, used in setting priorities and making funding allocations for public good research.

Each firm was asked to state the output class which best described the purpose of its R&D.

Table 2 shows expenditure on all R&D carried out in 1990/91 by business enterprises, according to the purpose of the research. Industry research associations and producer boards are listed separately as well as being included in the total. The shaded columns give the figures for the previous year for comparison.

Research expenditure is then sub-totalled by groups of outputs. In Table 3 the same information is grouped by science area, a grouping used by the Foundation for Research, Science and Technology for the development of research strategies.

Details of New Zealand's science output classification system and the thirty-eight science output classes are given in Annex 3.

The total expenditure on R&D carried out by the business enterprise sector increased by $4.4 million to $204.4 million from 1989/90 to 1990/91. This increase in R&D provided is about the same as the proportional increase in GDP, thus the ratio of business R&D expenditure to GDP was 0.3 percent, as in 1989/90. The average for the six OECD reference countries (Australia, Denmark, Finland, Ireland, Norway and Sweden) was 1.0 percent.

Of the total expenditure of $204 million on intramural R&D, over one third ($69 million) is aimed at better ways to process, and improved products from, meat, dairy products, fruit and other crops,

Table 2. Intramural business enterprise R&D, by science output class

Science Output Class	1990/91 ($000)	1989/90 ($000)	Grouped, 1990/91			Grouped, 1989/90	
			Producer Boards and Research Assns	All enterprises			
				($000)	%	($000)	%
01 Sheep Production (meat)	731	251	2,655	16,670	8	13,894	7
01 Sheep Production (wool)	875	638					
01 Sheep Production (general)	1,521	1,358					
02 Beef Production	1,668	550					
03 Dairy Production	2,521	2,493					
04 Alternative Animal Species	1,025	1,082					
05 Generic Animal Research	n.p.	334					
06 Forage Plants	1,785	1,426					
07 Horticulture	1,786	2,017					
08 Arable Crops & Other Plants	1,620	723					
09 Plantation Forestry	1,827	1,927					
10 Fisheries	1,071	1,094					
11 Meat Processing	10,437	8,897	39,218	69,252	34	65,082	33
12 Dairy Processing	29,287	28,561					
13 Other Food Processing	7,319	7,410					
14 Fibre, Textiles & Skin Processing	14,591	12,361					
15 Wood & Paper Processing	7,618	7,853					
16 Materials & Industrial Processing	15,490	17,523	2,880	53,235	26	65,186	33
17 Engineering	18,114	16,889					
18 Electronic & Instruments	19,631	30,774					
19 Construction	5,392	4,785	6,213	46,036	23	41,590	21
20 Commercial & Trade Services	8,099	4,735					
21 Energy	5,665	5,549					
22 Transport Services	3,246	4,341					
23 Information & Communication	23,271	21,662					
24 Urban & Rural Planning	364	518					
25 History, Society & Culture	418	161	0	4,237	2	2,285	1
26 Relationships & Well-being	442	217					
27 Political & Economic Relationships	2,947	1,831					
28 Education, Knowledge & Training	430	76					
29 Environmental Protection	2,157	2,899	n.p.	2,157	1	2,899	1
30 Geological Structures & Processes	1,098	2,061	n.p.	1,881	1	3,802	2
31 Land use, Flora & Fauna	n.p.	35					
32 Marine & Fresh Waters	414	649					
33 Climate & Atmosphere	n.p.	16					
34 Space	0	503					
35 Antarctica	0	0					
36 Fundamental Knowledge	245	n.p.					
37 Health	10,342	4,466	n.p.	10,342	5	4,466	2
38 Defence	589	n.p.		589		n.p.	
TOTAL	204,400	200,048	52,867	204,400	100	200,048	100

n.p. = Not for publication to protect confidentiality of responses.

fibres and skins, and wood and paper. R&D reported in this area was $4 million more than the 1989/90 figure.

Over a quarter of the R&D ($53 million) is aimed at the development of new and improved materials and industrial processes, engineering products and processes, and computing, electronic, telecommunication and instrumentation processes, systems and products. R&D reported in this area decreased by $12 million since 1989/90. This is discussed in more detail in section 10.4.

Twenty-three percent of the research ($46 million) is aimed at the development of improved infrastructure and services. These include: construction, commercial and trade services, energy, transport, information and communication services and urban and rural planning. R&D in this area increased by $4.4 million.

The business enterprises targeted $17 million (8 percent of the total, an increase of $3 million) at agricultural, horticultural, forestry and fisheries research; and $10.3 million (5 percent, an increase of $6 million) at health research. Research aimed at the protection of the environment (which includes pollution and waste management) took $2.2 million (down by $0.7 million), and research into natural resources and the environment took $2 million (down by $2 million). Reported research on social development, including economic research, increased by $2 million to $4 million.

10.2 Primary production

In Table 2, expenditure on primary production R&D carried out by the business enterprise sector is shown as the first group of science output classes. Private sector R&D in primary production received a proportionately low level of funding compared to other industry sectors. Total funding was $16.7 million, an increase of $2.8 million above 1989/90. Internationally, primary production R&D is not normally well funded by the private sector.

Primary production involves ten output classes. Eight of these are agricultural with one each devoted to forestry and fishing.

Almost one-half of the primary production research ($8.6 million) was aimed at improving farm animals and animal production systems. This was an increase of nearly $2 million over animal R&D carried out in 1989/90. Just under $2 million each was carried out in horticulture and forestry, slightly less than in 1989/90. Research on other plants, including forage plants, arable crops, cut flowers, and conservation and shelter plants increased from $2.1 million to $3.4 million.

The private sector continued to undertake research to the value of $1 million aimed at marine and freshwater fisheries.

10.3 Primary products and processing

The substantial expenditure on this group of output classes (a total of $69 million) reflects the economic importance of these primary products in the New Zealand economy, and the presence of research associations and producer and marketing boards in the meat, dairy, wool, and fruit sectors. These organisations carried out R&D on the processing of primary products to the value of $39 million.

Business enterprises overall spent $29 million on research aimed at the development of new and improved dairy processes, storage techniques and products. This is the largest of all the output classes in the business enterprise sector in 1990/91.

Research into new and improved meat and meat by-product processing and quality management methods, packaging, storage, and transport techniques and products increased by $1.5 million to $10.4 million.

R&D into processing and products from natural and artificial fibres, textiles, clothes and skin products, including leather, increased by $2.2 million to $14.6 million, while fruit, crops and other food and beverage processing and quality management R&D dropped slightly to $7.3 million. Wood and paper processing R&D also fell, by $0.2 million to $7.6 million.

10.4 Materials, engineering, computing and communications

Expenditure on materials, engineering, computing and communications R&D carried out by the business enterprise sector is the third group in Table 2.

Of the $53 million in this group, $20 million is spent on research aimed at new and improved computing and electronic, communication and instrumentation processes, systems and products. This is $11 million less than was reported in 1989/90, when this was the highest expenditure on intramural R&D of all the output classes. The wording of output classes 18 (Computing and electronic, communication and instrumentation processes, systems, and products) and 23 (Information processing and communications services) was clarified in the 1990/91 questionnaire, which could account for some repositioning of R&D between these classes. Some firms engaged in software R&D were sold or became distributors. There were increases in other research output classes for firms in the financial and software services industry group, which indicates that some of this research was simply classified to different output classes.

New and improved materials, industrial processes and products, from chemicals, petroleum and coal, base metals and glass, including plastics, rubber and pharmaceutical, accounted for R&D of $15 million, a fall of $2 million. Engineering processes, systems and products (manufacturing, automation and production technologies for fabricated metal products, transport equipment, agricultural machinery and mechanisation, appliance and electrical equipment, and industrial and construction machinery and equipment) accounted for another $18 million, an increase of $1.2 million.

10.5 Infrastructure and services

The fourth group in Table 2 shows the expenditure on infrastructure and services R&D carried out by the business enterprise sector, by science output class.

This grouping includes R&D in construction and building ($5 million), commercial and trade services including tourism (increased by $3 million to $8 million), energy ($6 million), transport (decreased by $1 million to $3 million), and urban and rural planning ($0.4 million).

Most significantly, more than half of the $46 million of R&D in this grouping ($23.3 million) was spent on new and improved information and communication services, including computer software, information processing, library and related information services, broadcasting, telecommunications, postal and other communications services. Much of the research in this output involves computer software research. When this output is combined with output 18 which represents electronics including communications hardware, it is clear that information systems comprise a large area of business enterprise sector R&D in New Zealand. The two outputs total $43 million, or just more than a fifth of all the business enterprise R&D.

Table 3. Intramural business enterprise R&D by strategic science area

Strategic Science Areas	1990/91			1989/90
Output Aggregation	Number of firms	R&D Expenditure		R&D Expenditure
		($000)	%	($000)
02 Beef Production 11 Meat Processing 14 Fibre, Textiles & Skin Processing	79	29,822	15	24,055
03 Dairy Production 12 Dairy Processing	65	31,808	16	31,054
04 Alternative Animal Species	11	1025	1	1082
05 Generic Animal Research	n.p.	n.p.	n.p.	n.p.
06 Forage Plants	9	1,785	1	1,426
07 Horticulture 08 Arable Crops & other Plants 13 Other Food Processing	76	10,725	5	10,150
09 Plantation Forestry 15 Wood & Paper Processing	59	9,445	5	9,780
10 Fisheries	19	1,071	1	1,094
16 Materials & Industrial Processing 17 Engineering 18 Electronic & Instruments	303	53,235	26	65,186
19-24 Infrastructure	222	46,036	23	41,590
19 Construction	41	5,392		4,785
20 Commercial & Trade	64	8,099		4,735
21 Energy	34	5,665		5,549
22 Transport Services	25	3,246		4,341
23 Information & Communication	82	23,271		21,662
24 Urban & Rural Planning	10	364		518
25 History, Society & Culture 26 Relationships & Wellbeing 27 Political & Economic Relationships 28 Education, Knowledge & Training	30	4,237	2	2,285
29 Environment Protection 30 Geological Structures & Processes 31 Land use, Flora & Fauna 32 Marine & Fresh Waters 33 Climate & Atmosphere	38	3,794	2	5,660
34 Space 36 Fundamental Knowledge	16	245	0	1,076
37 Health	57	10,342	5	4,466
38 Defence	7	589	0	n.p.
TOTAL	736	204,400	100	200,048

10.6 Social sciences, environment, natural resources and fundamental knowledge

These three groups of research do not receive many resources in the business enterprise sector. The social sciences engaged more attention in 1990/91, with an increase of $2.0 million, mainly in the area of politics and the economy, where research carried out increased to $2.9 million. There was a decrease in money spent on environmental research (down by $700,000), while R&D into natural resources (minerals, land, flora and fauna, marine and fresh water ecosystems and the atmosphere) and fundamental research with no particular application in view, dropped by $1.9 million to $1.9 million.

10.7 Health and defence

The question in the Department of Statistics Business Directory update identified several significant new enterprises engaged in health research which were not in the survey in 1989/90. Health research identified rose by $5.9 million to $10.3 million.

Expenditure on R&D for the purposes of defence was similar to the previous year.

11 Funding of R&D expenditure in the business sector

11.1 Source of funds for intramural R&D

In the survey, enterprises were asked to provide information on the sources of funds for their R&D. The results are summarised in Table 4.

The business enterprise sector used its own funds, the funds of other firms and government, and overseas sources in order to carry out intramural R&D to the value of $204.4 million.

A similar proportion (89 percent, while the 1989/90 figure was 88 percent) of R&D funding in the New Zealand private sector came from the organisations within the sector.

Sixty-eight percent of the R&D was funded by the organisation doing the work. A further fourteen percent came from related New Zealand private sector enterprises, and seven percent from unrelated enterprises.

Eleven percent of the research performed in the business enterprise sector was funded from outside the sector. In percentage terms the contribution from the New Zealand central government was 6.2 percent, that from related private enterprises abroad was 3.8 percent, while unrelated private enterprises abroad contributed 1.0 percent.

Of the funds coming from outside the business enterprise sector, $12.6 million came from the government sector, mainly to research associations. A further $9.8 million came from overseas. This compares with $13.0 million from government, and $10.4 million from overseas in 1989/90. Overall there was a decrease of $1.0 million in outside funds, but this was more than compensated for by an increase in firms' own R&D spending.

The proportion of industry funds used for R&D carried out by the New Zealand business enterprise sector (89 percent) is in line with the experience in the six OECD reference countries, where this figure averages 88 percent for the most recent available years. The portion of business enterprise R&D financed by government is 6.2 percent, lower than the reference country average of 9 percent.

Table 4. Source of funds for intramural business enterprise R&D, 1990/91

Source of funds	1990/91		1989/90	
	($000)	%	($000)	%
Own Funds	138,005	67.5	141,285	70.6
Related Private NZ Firm	28,557	14.0	28,737	14.4
Unrelated Private NZ Firms	14,777	7.2	5,643	2.8
NZ Central Government	12,593	6.2	12,951	6.5
NZ Local Government	347	0.2	572	0.3
Overseas Funds From Related Firms	7,689	3.8	5,472	2.7
Overseas Funds From Un-related Firms	2,096	1.0	4,911	2.5
Other Sources of Funds	317	0.2	477	0.2
TOTAL	204,400	100.0	200,048	100.0

Note: NZ Tertiary Education Sector included in NZ Central Government. Columns will not always agree with totals shown due to rounding of individual estimates.

11.2 Additional research funded but not performed in the sector

In addition to the R&D carried out within the business enterprise sector, business enterprises reported that they funded research to the value of $9.9 million carried out by government organisations, $0.5 million by local authorities, $7.7 million by the universities, and $13.0 million carried out overseas. This represented a total of $31.0 million funded outside the business enterprise sector, compared with $32.7 million in 1989/90.

The survey asked firms to report any amounts paid in levies to another organisation, where the levy contained an unknown component for R&D. The total reported here included levies paid to New Zealand firms already included in the survey, and $7.3 million paid in levies to overseas firms. The R&D content of these levies is not known.

11.3 Extramural R&D, by industry group

Table 5 provides information by industry group about all R&D funded by a business enterprise but carried out by other enterprises, institutions or individuals. This includes R&D funded at other business enterprises which has already been reported as intramural R&D by the provider. A total of $83 million was spent on extramural R&D, if funds circulating within the sector are included.

Funders of R&D stated that other business enterprises were funded a total of $52 million, of which $39 million went to an enterprise related to the funder. Some of these funds may have been reported twice as it is not uncommon for funds for research to be sub-contracted or passed to a funding organisation to be allocated, in which case both funders would report the same R&D. Also, as noted above, this research has already been counted among the responses from R&D providers.

Of the total of $13 million spent on R&D carried out overseas, $12 million went to an overseas enterprise related to the funder.

The amount stated as spent with government is lower than reported by government departments in the government survey. One reason for this is that firms may not know how much true R&D was included in a contract with a scientific or technological content. Much of the work that government science departments carry out for business enterprises includes the use of scientific knowledge, but may or may not involve original investigation or further research. The research provider is more likely to have accurate knowledge of the extent of the R&D done.

Most of the funds spent on R&D undertaken by another organisation came from the wholesale trade sector, which includes most of the producer boards. The figures for the producer boards are shown in brackets in Table 5. Of the total of $52 million from this sector, $38 million was spent with local private sector enterprises, $6.1 million was spent in the government sector, and $6.4 million was spent overseas. Producer boards spent $45 million of the total, $34 million of which went to other business enterprises, including the research associations.

Engineering and scientific services was the next largest source of funds for extramural R&D. This group spent a fifth of the amount spent by the wholesalers. The universities and other enterprises were the main providers to this industry group.

Of the remaining industry groups, the electrical industry was notable for the fact that 90 percent of its extramural R&D funds were spent overseas, and the food, textiles and plastics industries for the fact that 47 percent was spent overseas. The other manufacturing (wood, paper and concrete) group used government as well as private sector providers, while the chemical industry spent most of its extramural funds at universities.

11.4 Total R&D funded by the business enterprise sector

In spite of the decrease in external research funded, total research expenditure by the business enterprise sector increased from $209.4 million in 1989/90 to $212.6 million. This is obtained from total R&D performed ($204.4 million) by subtracting R&D funded from outside ($22.4 million) and adding R&D funded by but not performed in the sector ($31.0 million).

11.5 Intramural estimate of total R&D expenditure by the business enterprise sector, by output class

Total expenditure on R&D by the business enterprise sector includes R&D financed and carried out by the sector, and R&D paid for by the sector and carried out by government or other enterprises outside the business enterprise sector, or carried out overseas.

The estimate obtained from this survey was that a total of $212.6 million was spent on R&D by the business enterprise sector in 1990/91. This does not include any part of the $7.3 million paid to overseas firms as levies which may be used for R&D. Flows of funds for R&D usually include only funds both intended and used for R&D.

Table 5. Extramural R&D funded by business enterprises, 1990/91 by industry group

Industry of Enterprise		Number of Enterprises	Sector of Recipient of R&D Funding, ($000)				Total ($000)	Increase since 1989/90
NZSIC Codes	**Description**		**Government***	**Universities**	**Other Business Enterprises**	**Overseas Organisations**		**($000)**
1000	Agriculture, forestry and fishing	12	525	348	230	388	1,002	+0.2
2000,371,372,381	Mining, basic metals and metal fabrication	14	60		76		626	-0.3
351,352,353,354	Chemicals (fertilizers, pesticides, paint, drugs)	24	797	1,252	696	684	3,429	-1.7
310,320,355,356	Food, textiles, plastics production	52	647	575	1,276	2,188	4,686	+1.1
3830,3832	Electrical machinery (electronic, appliances)	14	n.p.	n.p.	n.p.	3,207	3,564	-0.5
3820,3825,3850	Machinery (industrial, office, instruments)	11	n.p.	n.p.	770	n.p.	877	+0.6
330,340,360,390	Other manufacturing (wood, paper, concrete)	24	1,528	136	1,633	n.p.	3,498	
384	Transport equipment		0	n.p.	n.p.	n.p.		
4000 - 7000	Infrastructure services (includes producer boards)**	48 (6)	6,110 (5,108)	1,966 (568)	37,955 (34,354)	6,377 (4,975)	52,408 (45,004)	-1.3
8000 except 8324	Financial, Software development services	15	n.p.	n.p.	432	21	487	
8324,9000	Engineering, scientific services	53	630	3,091	8,239		11,981	+7.5
1000-9000	Total 1990/91	265	10,366	7,661	51,519	13,012	82,559	79,995
1000-9000	Total 1989/90	315	12,160	6,092	44,357	14,387	76,995	

* Local authorities are included in the Government column.

** Producer board sub-totals are shown in brackets ( )

Adjacent cells have been amalgamated where necessary to protect confidentiality.

Table 4 shows that business enterprises carried out R&D in-house to the value of $182 million with their own funds or with funds from other business enterprises. Table 5 shows that business enterprises also funded R&D to the value of $31 million extramurally in other sectors (in the universities, government or overseas).

There was a difference between the total value of R&D that enterprises said they had carried out with funds from other enterprises ($43 million), and the total that funders said they paid to other business enterprises to provide R&D ($52 million). Providers responding to the survey are judging the R&D that they perform against the definitions provided, so their response is more likely to be correct. There may also be double-counting among funders.

To obtain the estimates in Table 6, funding from government and overseas was deducted from the value of each enterprise's intramural R&D, in the same proportion per output class as the proportions for research carried out. This provides the intramural R&D funded solely by business enterprises, shown in column two of Table 6.

Business financed extramural R&D carried out by universities, government or overseas had to be allocated to output classes, because the survey asked only for the total. If the enterprise carried out R&D it was assumed that it would fund in the same output areas. If it simply funded R&D then the industrial classification was used to allocate the funds to the most likely outputs. The resulting estimates are shown in the third column, total extramural expenditure on R&D in each output by the business enterprise sector.

Dairy processing is the largest single target of private sector R&D funds, with $32 million spent in New Zealand or overseas.

Output classes 18 (electronics and instruments), and 23 (information and communications services) should be considered together. The first includes the "hardware" aspects of computer microprocessor and communications R&D, and the second is "software" R&D, into new programming languages and operating systems. These two areas are closely linked. Together they account for 19 percent of private sector funding for R&D, and 21 percent of all research carried out in the private sector.

Fibre, textiles and skin processing ($14 million), materials and industrial processes ($13 million) and engineering processes ($19 million) are the next largest areas of business enterprise funding.

12 Intramural business sector R&D, by industry group

In Section 10, R&D undertaken by business enterprises is analysed according to science output class. The output class is an indication by respondents of the purpose of the research.

The results of the survey have also been analysed according to the industry to which the enterprises undertaking the R&D belong, using the NZ Standard Industrial Classification (NZSIC). To protect confidentiality, while providing the maximum amount of additional information, enterprises were grouped into eleven industry groups. These are given in Table 7.

In this analysis and throughout this report, the research associations were classified to the industry group that they predominantly serve. As the Department of Statistics Business Directory is updated annually, an enterprise may be reclassified to a new NZSIC if its predominant activity has changed. In the analysis that follows, such changes are taken into account when comparing the figures for successive years.

Table 6. Estimates of business enterprise expenditure on R&D, 1990/91

Science output class	R&D funded, ($000)		
	Intramural	Extramural	Total
01 Sheep Production	2,969	690	3,660
02 Beef Production	1,659	120	1,779
03 Dairy Production	2,456	373	2,830
04 Alternative Animal Species	1,024	50	1,073
05 Generic Animal Research	231	22	253
06 Forage Plants	1,231	211	1,441
07 Horticulture	1,485	3,668	5,153
08 Arable Crops & other Plants	1,261	240	1,501
09 Plantation Forestry	1,400	434	1,834
10 Fisheries	859	0	859
11 Meat Processing	8,286	432	8,717
12 Dairy Processing	27,516	4,458	31,973
13 Other Food Processing	7,315	3,640	10,955
14 Fibre, Textiles & Skin Processing	12,507	1,273	13,780
15 Wood & Paper Processing	7,416	1,849	9,265
16 Materials & Industrial Processing	12,168	1,035	13,203
17 Engineering	17,184	2,122	19,306
18 Electronic & Instruments	16,932	1,714	18,647
19 Construction	4,015	498	4,513
20 Commercial & Trade Services	7,239	486	7,725
21 Energy	5,158	1,813	6,971
22 Transport	2,592	36	2,628
23 Information & Communication	22,467	109	22,576
24 Urban & Rural Planning	262	23	285
25 History, Society & Culture	415	0	415
26 Relationships & Wellbeing	382	1,272	1,654
27 Political & Economic Relationships	2,692	12	2,704
28 Education, Knowledge & Training	386	1	387
29 Environment Protection	1,676	341	2,017
30 Geological Structures & Processes	474	199	673
31 Land use, Flora & Fauna	44	4	48
32 Marine & Fresh Waters	208	12	220
33 Climate & Atmosphere	28	1	29
34 Space	0	0	0
35 Antarctica	0	0	0
36 Fundamental Knowledge	216	2	219
37 Health	8,959	3,846	12,804
38 Defence	562	0	562
TOTAL	181,674	30,984	212,658

As discussed in Section 4, the 1990/91 survey is based on all enterprises responding to the business directory update who claimed to be involved in R&D. In the areas of wholesale and retail trade, community services and health, there were some significant increases in coverage over the sample survey of the previous year, leading to an increase in reported R&D in these areas (see below).

The food, textiles, and plastics production group had the highest R&D expenditure, at $61 million out of the total of $204 million. While food and textile R&D increased by $1.2 million, three enterprises engaged in R&D into rubber and plastic products reduced their R&D activity overall by $1.6 million.

Financial and software development services spent $34.5 million on R&D, an increase of $0.1 million since 1989/90.

Infrastructure services, at $24 million, includes wholesale and retail trade (where the producer boards are classified) with R&D of $14.8 million, electricity, gas and water R&D of $2.5 million, construction R&D of $3.2 million and transport and communication R&D of $3.9 million. In spite of the reclassification of two large R&D providers, which had the net effect of reducing this group overall by $2.5 million, there was an increase of $3.1 million in infrastructure R&D, with the trade group showing a $3.8 million increase and many new respondents from the business directory R&D question.

Industries with large R&D expenditures which reduced their expenditure in 1990/91 are:

- electrical machinery and electronics ($16.3 million, down $2.7 million); one firm sold off its research activity and a number reduced or stopped doing R&D;

- chemicals, including fertilisers, pesticides, paint, and drugs ($14 million, down $1 million); three firms closed down their research activities and one said that the previous year's research was over-stated; and

- other manufacturing, including wood, paper and concrete ($12 million, down $2.3 million); two firms were reclassified to another sector, three ceased trading and one large firm reported a considerable decrease in R&D activity.

R&D in the transport equipment industry would have shown a small increase but for the reclassification of one firm out of this group.

Engineering and scientific services showed an increase of $3.6 million to $16 million. This was largely from gains due to reclassification, as several firms who were in this group last year reduced or dropped their R&D.

The mining, basic metals and metal fabrication group increased R&D by $1.4 million, largely due to one new firm. Two major firms in metal fabrication considered that they had previously overstated the amount of R&D carried out.

Firms are now becoming experienced in responding to the R&D survey, and it is expected that the consistency of reporting will continue to improve. Attempts will be made to adjust the data for previous years where new information becomes available.

Table 7. Intramural business enterprise R&D expenditure, by industry group, 1990/91

NZSIC group	Industry group	Expenditure 1990/91			Expenditure 1989/90	
		Total ($000)	%	* Producer Boards and Research Assns	Total ($000)	%
1000	Agriculture, forestry and fishing	3,722	1.8	n.p.	3,418	1.7
2000,371, 372,381	Mining, basic metals and metal fabrication	9,291	4.5	n.p.	7,923	3.9
351,352, 353,354	Chemicals (fertilizers, pesticides, paint, drugs)	14,323	7.0		15,363	7.5
310,320, 355,356	Food, textiles, plastics production	61,222	30.0	35,274	61,630	30.2
3830,3832	Electrical machinery (electronic, appliances)	16,275	8.0		18,959	9.3
3820,3825, 3850	Machinery (industrial, office, instruments)	11,391	5.6		7,726	3.8
330,340, 360,390	Other manufacturing (wood, paper, concrete)	12,219	6.0	n.p.	14,469	7.1
384	Transport equipment (railroad etc)	1,543	0.8		2,902	1.4
4000 - 7000	Infrastructure services	24,264	11.9	9,195	21,222	10.4
8000 Except 8324	Financial, software development services	34,488	16.9		34,361	16.8
8324,9000	Engineering, scientific services	15,663	7.7	n.p.	12,074	5.9
1000-9000	**TOTAL**	204,400	100.0	52,867	200,047	100.0

* Data also included in the Total column

13 Type of R&D expenditure in the business sector

Enterprises were asked to indicate how they spent their funds on R&D. The results are given in Table 8.

Wages and salaries consumed 54 percent of the $204 million allocated to R&D in the business enterprise sector, a drop from 57 percent in 1989/90 which was matched by lower total R&D personnel. Other current expenditure accounted for 36 percent, compared with 32 percent in 1989/90. Capital expenditure was 10 percent, compared with 11 percent in 1990/91.

14 Number of enterprises and R&D staff, by industry group

In Table 9, statistics are given for eleven industry groupings on the number of enterprises undertaking R&D; expenditure on intramural R&D; and full time equivalent R&D personnel.

The survey shows a drop in personnel doing R&D. There were fewer R&D personnel in 1990/91 in the chemical, electronics and appliances industries. The majority of the decrease was in the number of technicians, (down by 19 percent) rather than in the more highly qualified researchers and scientists (down by 1 percent). Support staff were down by 7 percent.

An indicator of R&D intensity is given in the last column: the expenditure on R&D per full time equivalent R&D staff member. This was highest for software development R&D, foilowed by other manufacturing (wood, paper, concrete).

15 Government sector intramural R&D, by science output class

15.1 Introduction

In 1990/91, the main sources of funds for research in the government sector were allocations from the public good science fund administered by the Foundation for Research, Science and Technology, departmental appropriation of funds by Parliament, and commercial contracts carried out for the business enterprise sector, other government departments, and other clients.

There were some definitional problems with the OECD requirement that S&T services or consulting should not be included in R&D, and some difficulty in separating such consulting or services from R&D in accounts. Data were sought from each Department of Scientific and Industrial Research division separately, to gain more accurate assessments than were available from head office accounts. Some divisions could not provide responses due to lack of resources to undertake the analyses at a time of major organisational restructuring. The data presented here may underestimate the commercial R&D carried out by these divisions. With assistance from the DSIR residual management unit further adjustments to expenditure and personnel numbers were carried out in order to obtain the final estimates. Total intramural government sector R&D (GOVERD), by science output area, is shown in Table 10.

Table 8. Type of R&D expenditure, by industry group, 1990/91

Industry of Enterprise		Type of Expenditure, ($000)			
NZSIC Codes	Description	Wages and Salaries	Other Current Expenditure	Capital Expenditure	Total
1000	Agriculture, forestry and fishing	2,058	1,240	424	3,722
2000,371,372, 381	Mining, basic metals and metal fabrication	4,640	2,920	1,731	9,291
351,352,353,354	Chemicals (fertilizers, pesticides, paint, drugs)	8,180	4,870	1,273	14,322
310,320,355,356	Food, textiles, plastics production	32,867	19,482	8,873	61,222
3830,3832	Electrical machinery (electronic, appliances)	11,004	4,155	1,117	16,276
3820,3825,3850	Machinery (industrial, office, instruments)	6,633	4,201	556	11,391
330,340,360,390	Other manufacturing (wood, paper, concrete)	5,128	4,275	2,817	12,220
384	Transport equipment (railroad etc)	1,000	461	82	1,543
4000 - 7000	Infrastructure services	12,793	9,913	1,559	24,264
8000 Except 8324	Financial, software development services	16,748	16,517	1,222	34,487
8324,9000	Engineering, scientific services	8,872	5,777	1,015	15,663
1000-9000	**TOTAL**	109,922	73,810	20,668	204,400
	Research Associations	25,714	15,289	5,507	46,511
	Percent of Total	53.8	36.1	10.1	100.0
1000-9000	1989/90	114,248	63,599	22,200	200,048
	Percent of Total	57.1	31.8	11.1	100.0

Table 9. Number of enterprises and R&D staff, by industry group, 1990/91

NZSIC Codes	Industry of Enterprise	Enterprises undertaking R&D			R&D Personnel FTE			R&D Expenditure per FTE ($000)		
		1990/91		1989/90	1990/91		1989/90	1990/91		1989/90
	Description	All	Producer Boards & Research Assns	All	All	Producer Boards & Research Assns	All	All	Producer Boards & Research Assns	All
1000	Agriculture, forestry and fishing	22	n.p.	6	57	n.p.	49	65	n.p.	70
2000,371,372,381	Mining, basic metals and metal fabrication	52		76	111	n.p.	97	84	n.p.	82
351,352,353,354	Chemicals (fertilizers, pesticides, paint, drugs)	51		108	188		240	76		64
310,320,355,356	Food, textiles, plastics production	137	5	210	874	532	910	70	66	68
3830,3832	Electrical machinery (electronic, appliances)	47		129	283		360	58		53
3820,3825,3850	Machinery (industrial, office, instruments)	57		55	149		127	76		61
330,340,360,390	Other manufacturing (wood, paper, concrete)	59	n.p.	97	119	n.p.	146	103	n.p.	99
384	Transport equipment (railroad etc)	17		23	27		29	57		100
4000 - 7000	Infrastructure services	106	5	42	251	86	283	97	107	75
8000 Except 8324	Financial, software development services	97		174	310		379	111		91
8324,9000	Engineering, scientific services	91	n.p.	109	234	n.p.	206	67	n.p.	59
1000-9000	**TOTAL**	736	16	1,027	2,603	740	2,826	79	71	71

15.2 In summary

In order to compare the results of the government survey with those of the business enterprise sector, business enterprise R&D by output area is presented with government R&D in Table 10.

The total expenditure on R&D carried out in the government sector was $318 million while that in the business enterprise sector was $204 million. These represent 0.43 percent and 0.28 percent of GDP, respectively.

It is striking that about half (48 percent) of the R&D expenditure in the government sector in 1990/91 was aimed at "Primary production". This involved research in output classes 1 to 10, namely research into new and improved production and management systems related to New Zealand's traditional role as supplier of primary products in agriculture, horticulture, forestry and fisheries. By contrast, in the business enterprise sector, R&D in the area of primary production comprised only 8 percent of the total. In absolute terms, nine times more was spent in this area in the government sector ($154 million) than in the business enterprise sector ($17 million).

About one-fifth (23 percent) of the R&D carried out in the government sector was in the area of "Environment, exploration and assessment of the Earth", namely in output classes 29 to 35 as listed in Annex 3 and summarised in Table 10. This involved research into New Zealand's environment and natural resources. By contrast, this kind of research comprised only 2 percent of the R&D of the business enterprise sector.

Two areas which were major contributors to the R&D of the business enterprise sector, comprising about one-third and one-quarter of the total respectively, are "Primary products and processing" (output classes 11 to 15) and "Materials, engineering and telecommunications" (output classes 16 to 18). These two areas, which are less favoured in government sector R&D (as seen in Table 10), can be described as R&D leading to new and improved processes and products in New Zealand's secondary industries. Such research accounted for 60 percent of the funding in the business enterprise sector but only 16 percent of that in the government sector.

The area of "Infrastructure and services", (output classes 19 to 24) was also more important in the business enterprise sector than in the government sector, with 23 and 2 percent of the total, respectively.

These different distributions in the R&D carried out by the government sector and the business enterprise sector indicate that the former concentrated on New Zealand's primary industries, the environment and natural resources while the latter was focused on secondary industries, infrastructure and services.

Expenditure on research on social development and services, and on defence, is low by OECD standards, in both the government and business enterprise sectors.

The information in Table 10 is discussed in greater detail in sections 15.3 to 15.8.

Table 10. Government sector intramural R&D, 1990/91

Output areas	Govern-ment ($000)	Group			Business ($000)	Group		
		Total	%	% of Group		Total	%	% of Group
Primary production								
01 Sheep (meat)	3,360			2	730			4
01 Sheep (wool)	3,730			2	880			5
01 Sheep (general)	15,640			10	1,520			9
02 Beef Production	1,110			1	1,670			10
03 Dairy Production	3,770			2	2,520			15
04 Alternative Animal Species	7,990			5	1,020			6
05 Generic Animal Research	12,260			8	240			1
06 Forage Plants	22,450			15	1,790			11
07 Horticulture	28,890			19	1,790			11
08 Arable Crops & other Plants	11,580			8	1,620			10
09 Plantation Forestry	10,610			7	1,830			11
10 Fisheries	32,710	154,100	48	21	1,070	16,680	8	6
Primary products and processing								
11 Meat Processing	360			2	10,440			15
12 Dairy Processing	70			0	29,290			42
13 Other Food Processing	9,470			55	7,320			11
14 Fibre, Textiles & Skin Processing	290			2	14,590			21
15 Wood & Paper Processing	7,170	17,360	6	41	7,620	69,260	34	11
Materials, engineering								
16 Materials & Industrial Processing	19,100			62	15,490			29
17 Engineering	3,690			12	18,110			34
18 Electronic & Instruments	8,060	30,850	10	26	19,630	53,230	26	37
Infrastructure								
19 Construction	650			12	5,390			12
20 Commercial & Trade	20			0	8,100			18
21 Energy	450			9	5,660			12
22 Transport Services	2,440			47	3,250			7
23 Information & Communication	1,290			25	23,270			51
24 Urban & Rural Planning	390	5,240	2	7	360	46,030	23	1
Social sciences								
25 History, Society & Culture	2,630			24	420			10
26 Relationships & Wellbeing	1,500			14	440			10
27 Political & Economic Relationships	4,100			38	2,950			70
28 Education, Knowledge & Training	2,540	10,770	3	24	430	4,240	2	10
Environment								
29 Environment Protection	10,740			15	2,160			57
30 Geological Structures & Processes	17,630			24	1,100			29
31 Land use, Flora & Fauna	17,070			23	100			3
32 Marine & Fresh Waters	16,890			23	410			11
33 Climate & Atmosphere	5,030			7	30			1
34 Space	0			0	0			0
35 Antarctica	5,690	73,050	23	8	0	3,800	2	0
Miscellaneous								
36 Fundamental Knowledge	11,000			50	240			2
37 Health	6,220			28	10,340			93
38 Defence	4,780	22,000	7	22	590	11,170	6	5
39 S&T Education	0				0			
40 S&T Services	4,840	4,840	2	100	0	0	0	
TOTAL	318,210	318,210	100		204,400	204,410	100	

15.3 Primary production

The major effort in government sector R&D during 1990/91 was in the area of "Primary production", namely in output classes 1 to 10. Half of the total government research carried out was in this area, and in absolute terms it received nine times more funding than it did in the business enterprise sector ($154 million and $17 million respectively).

Of the ten component output classes, eight are devoted to agricultural, with the remaining two devoted to forestry and fishing.

Output class 7 ("New and improved horticultural crops, including vegetables, and management practices") and output class 10 ("Fisheries") each accounted for about one-fifth of the primary production R&D carried out by the government sector (19 percent and 21 percent respectively). They were followed by R&D related to forage plants (15 percent), and sheep (10 percent).

The distribution of government sector R&D effort was in marked contrast with that in the business enterprise sector. Apart from the nine-fold difference in absolute funds spent, the distribution of funding was different. In particular, dairy production was only a minor field of interest in government sector R&D, but it was second only to sheep production in the business enterprise sector's R&D.

15.4 Primary products and processing

As discussed in 15.2, R&D in the area of "Primary products and processing" (output classes 11 to 15) was a relatively minor component of government sector R&D (5 percent) although it comprised about one-third of the business enterprise sector's R&D. The total effort in the government sector's R&D in this area was $17 million, which is about one-quarter of the R&D carried out in the business enterprise sector ($69 million).

Virtually all the government sector R&D in primary products and processing was concentrated in output classes 13 ("New and improved fruit, crops and other food and beverage processes, storage techniques and products") and 15 ("New and improved wood and paper processes and products"). These comprised 55 and 41 percent of the R&D effort respectively, a total of 96 percent. These two output classes together comprised less than a quarter (22 percent) of the business enterprise sector's R&D.

Output class 12 ("New and improved dairy processes, storage techniques and products") received only 0.4 percent of the government sector's R&D effort ($70,000) while it was the most heavily funded component ($29 million) of the business enterprise sector's R&D, comprising over 42 percent of the effort in the processing area.

15.5 Materials, engineering, computing and communications

Although R&D in the area of "Materials, engineering and telecommunication" (output classes 16 to 18) accounted for one-quarter of the expenditure in the business enterprise sector ($53 million) it was of less importance in the government sector ($31 million, 10 percent of total funding).

Output class 18 ("New and improved computing and electronic, communication and instrumentation processes, systems and products", i.e. computer hardware) was the third most heavily funded class in the business enterprise sector ($20 million). In the government sector it was funded only to the extent of $8 million. However, it must be borne in mind that output class 18 describes only directly funded R&D in this field whereas related research is also funded indirectly by government in many other output areas. This is because information technology (IT) is becoming such a basic tool that it is becoming harder to distinguish whether research is primarily IT-related or whether it is related

to some application of IT. Taking a broader definition of IT-related research would probably result in a large addition to the government sector's expenditure in output class 18.

Similar arguments apply to output 23 ("New and improved information processing software, software and services for electronic communication, media transmission and data exchange"). If the two output classes (18 and 23) are taken together it is clear that computing systems are by far the largest area of business enterprise sector R&D in New Zealand, with a total expenditure of $43 million, or just more than a fifth of all the business enterprise sector's R&D. The comparable value for government sector R&D in these two output classes is only about $9 million, or less than 3 percent of government sector R&D.

In the government sector, output class 16 ("New and improved materials, industrial processes and products") received the majority of the R&D funding within this area (about 62 percent). Output class 17 ("Engineering processes, systems, and production") received 12 percent and output class 18 ("Electronics and Instruments") received about one-quarter (26 percent) of the funding within this area.

By contrast, output classes 16, 17 and 18 each received about one-third of the funding in the business enterprise sector's R&D (29 percent, 34 percent and 37 percent respectively).

15.6 Infrastructure and services

The area of "Infrastructure and services" (output classes 19 to 24) was more important in the business enterprise sector than in the government sector, with 23 and 2 percent of funding respectively. However, this category does include output class 23 (dealing with computer software), which has been discussed above in section 15.5.

It is seen that the major effort in government R&D in this area was in output 22 ("Transport systems and services"), which comprised 47 percent of the effort in this area.

15.7 Social Sciences

Expenditure on research in the social sciences in the government sector was nearly $11 million, 3 percent of the total. The business enterprise sector's expenditure in this area was $4 million, 2 percent of the total. Output 27 "Political and economic relationships" received the most attention in both sectors.

15.8 Environment, exploration and assessment of the Earth

About a quarter (23 percent) of the R&D funding in the government sector was in the area of "Environment, exploration and assessment of the Earth", namely in output classes 29 to 35 as listed in Annex 3 and summarised in Table 10. This involves research into New Zealand's environment and natural resources. By contrast this kind of research comprised only 2 percent of the R&D of the business enterprise sector.

As seen in Table 10, output classes 30, 31 and 32, which deal with "Geological structures", "Land use, flora and fauna" and "Marine and fresh waters" respectively, received about equal funding and together comprised over two-thirds of the government expenditure in this category (71 percent). Output class 29, which deals with R&D in the field of environmental protection, was the next most important (15 percent).

16 Source of funds for government intramural R&D, and R&D funded extramurally

In the survey, government organisations were asked to provide information on the source(s) of the funds for the R&D they undertook. The results are summarised in Table 11.

Table 11. Source of funds for intramural government sector R&D, 1990/91

Source of funds	($000)	Percent
Own Funds	254,118	79.9
Other NZ Central Government Agency	39,914	12.5
NZ Local Government	3,013	0.1
NZ Tertiary Education Sector	23	0.0
Private Sector NZ Enterprises	18,364	5.8
Funds from Abroad	1,275	0.4
Other Sources of Funds	1,502	0.5
TOTAL	318,208	100.0

The bulk of funding (80 percent) came from "own funds", which included funds allocated through the contestable science funding system.

A further 12.5 percent of funding for government research was obtained from other government agencies, and 5.8 percent from private sector enterprises, for research undertaken on contract.

This information can be compared with that in the business enterprise sector (Table 4), namely 89 percent of funding in the business enterprise sector came from their own or other private funds, while 6 percent came from government sources.

With provider information from the three parallel surveys, it is possible to evaluate the total amount of government spending on R&D in the three sectors, while the commercial research done by the government and higher education sectors can be added to the "own funds" R&D described in the business enterprise survey to give the full contribution to R&D of the business enterprise sector in New Zealand (refer to Tables 6 and 16).

Government agencies funded R&D carried out by other organisations in the government, business and university sectors, as shown in Table 12.

Table 12. Extramural R&D funded by the government sector, 1990/91

R&D Provider	($000)	Percent
Other NZ Central Government Agency	60,874	61
NZ Local Government Organisations	2,368	2
NZ Tertiary Education Sector	21,302	21
Private Sector New Zealand Enterprises	14,740	15
Overseas Organisations	39	0
TOTAL	99,323	100

17 Intramural higher education sector R&D

17.1 Introduction

The university sector carries out research as part of its mandate with Vote: Education funds, and receives funds for contract research from the Health Research Council and other Crown and private sources.

A benchmark survey of all Crown-funded research, which was published as "A Profile of Crown-funded R&D in NZ, 1991/92",[3] was conducted by the Ministry of Research, Science and Technology. It provides information for 1991 on all current university research projects, including full time equivalent (FTE) personnel engaged. A subsequent review of the cost of university research, which recalibrated the full time equivalent personnel data for each project from the benchmark survey and asked for further information about the sources of funding, was sponsored by the Ministry and chaired by Dr A.E. Bollard from the Institute of Economic Research. Professor P. Bergquist represented the NZ Vice-Chancellors' Committee and Dr R. Clarke the NZ Government science departments in this review. Following the review, Professor Bergquist has provided further analyses and advice from this source to assist with the estimates required for the purposes of this report.

The estimation of resources used nationally for research in the non-medical university sector was presented in the Bollard review[4]. This analysis was carried out in order to determine the cost of that part of university research which comprises public good science outputs, outside the teaching function which is funded through Vote: Education. The results presented provide the most detailed cost information on university R&D available to date, but some adjustments are necessary in order to obtain the best estimate of total intramural university R&D, and to conform with the OECD definitions.

17.2 The review methodology

The review separated research into "teaching research" - involving the supervision of graduate students' research and personal scholarship, where the primary objective is not directly a published paper, and "non-teaching research". The latter includes research performed by staff and students as part of the staff employment contract with the university, and research performed under contract for an outside party, and research that could be considered to give rise to a public good science output.

University departments were asked to estimate the proportion of academic staff time spent in each of the four categories: graduate student supervision, scholarship, own research, and discretionary research, together with an estimate of the proportion in each category funded by Vote: Education, by other Crown funds and by non-Crown funds. The results varied by department and university, but on average the total time spent on all categories of research was a third of academic staff time.

While academic staff time was weighted according to each departmental estimate, other staff time was weighted as follows:

	Portion of year spent on research
Honours students	0.1
Masters students	0.25
Doctoral students	0.5
Post-doctoral fellows	1.0
Research technicians	1.0
Teaching technicians	0.25

Academic and teaching technician time was divided between projects where more than one project was involved. Average salaries for each staff category were applied to the weighted full time equivalents

to obtain the salary cost. A multiplier of 2.3 was applied to academic and post-doctoral staff salaries to reflect all direct and indirect non-salary costs of research to the university, in line with current university practice for contract research[4].

Full cost = Salary costs + non-salary costs
= 2.3 Average salary x FTE

Indirect costs for technicians and research officers were included in the academic multiplier. The multiplier included indirect costs (overheads, general expenses and departmental grants), payroll costs and depreciation, but did not include funds received from outside organisations for research and equipment.

To bring the review data into line with OECD recommendations:

- only personal scholarship carried out specifically for a research project should be considered an R&D activity;
- administrative and support staff providing direct project linked administration or clerical services within the R&D unit should be included in the count of FTE personnel;
- an allowance for the stipends of post-graduate research students should be included in R&D personnel costs;
- research and equipment grants from external sources should be included; and
- overseas funds for research should be included.

Personal scholarship comprised on average 23 percent of academic staff research time, but an estimate of the proportion of this time which is not related to a research project is not available.

Support staff FTE was not collected for the review, but their cost was included in the overhead multiplier.

The payments on behalf of the Crown to universities for post-graduate scholarships ($6.9 million) and research equipment ($4.8 million) have been added to the Bollard review estimates. Overseas funding for research is not available, but its omission may compensate for the overestimate of scholarship noted above.

The results of the review are presented separately for medical schools and all other departments, by source of funds, in Table 13.

17.3 Additional information from Universities' annual reports, and from funders of R&D

Information on the amount of research funds received by universities from external sources was collated from universities' annual reports, and from registry offices. This indicates that for 1991, the year for which benchmark data were collected, total external funding amounted to $70.4 million, of which $16.3 million was from the Health Research Council.

Table 13. University expenditure on R&D, 1991, based on the Bollard review, $ million

Funding Source	Medical Schools	All other Departments	Total
Non-Crown	1.8	2.9	4.7
Vote: Education	9.6	74.0	83.6
Other Crown	2.7	4.3	7.0
TOTAL	14.1	81.2	95.3

Data from the 1990/91 private sector and government sector R&D surveys indicate that these sources provided only $7.7 million and $21.3 million for university research respectively. There are several possible reasons for these wide variations. The estimates by the universities may be high because they include work carried out for the private sector which involves consulting, or the application of existing knowledge, rather than research. Examples include testing equipment or survey design. As discussed in the government section, only one third of the DSIR's external contracts were considered to involve R&D. If the ratio of R&D to consulting and services is similar for the universities, then one would expect external funds for R&D to be one-third of $70 million, or around $23 million.

Data from R&D funders in the government and business enterprise R&D surveys indicated that these two sectors funded $29 million of university R&D, while the Bollard review result suggested that external funding only amounted to $11.7 million. The Bollard review result is likely to be an underestimate because external funds were not included in the estimation of costs. Another factor is that the review did not attempt to cover all privately funded work, since the focus was public good research.

The R&D survey figures may underestimate the true cost of the research, since some university contracts only cover their marginal costs. For the purposes of these estimates, the business and government sector R&D survey funders' data will be taken as the best available estimates of university R&D funded by these sources.

The Bollard review[4] noted that Health Research Council R&D tended to be coded inconsistently by university respondents, with many coding the source of funds as own research (funded by Vote: Education) instead of discretionary research funded by the Crown. An adjustment has been made by redistributing $5 million of the medical research costs from Vote: Education back to "the Crown" as source, leaving $4.6 million funded by Vote: Education, or General University Funds (or GUF in OECD terminology).

The final estimates for university research funding by source is shown in Table 14.

Table 14. Adjusted estimates of University R&D expenditure 1991, $ million

Funding Source	Medical Schools	Other Departments	Total
Business enterprises	3.4	4.4	7.7
Government sector	16.4	4.9	21.3
General university funds			
Block grant (review estimates)	4.6	74.0	78.6
Post-graduate scholarships	1.5	3.3	4.8
Equipment grant	1.7	5.2	6.9
TOTAL	27.6	91.7	119.3

17.4 Higher education sector R&D by science output class

Full time equivalent researcher time by output class, given in the Profile of Crown-funded research, 1991/92[3], was weighted with a multiplier to provide the estimates of research expenditure per output class shown in Table 15. The social services and fundamental research was weighted with a multiplier that was one-third smaller than that used for other research to take the lower equipment cost for these two areas into account.

When the three sectors of R&D provider data are added together, the result is an estimate of the total R&D carried out in New Zealand in each research area as given in Table 15.

Table 15. Intramural R&D, all sectors, by output class, 1990/91

Output Class	Business ($000)	Government ($000)	Universities* ($000)	TOTAL ($000)
01 Sheep (meat)	730	3,360	1000	5,100
01 Sheep (wool)	880	3,730	n.a.	4,600
01 Sheep (general)	1,520	15,640	n.a.	17,200
02 Beef Production	1,670	1,110	90	2,900
03 Dairy Production	2,520	3,770	300	6,600
04 Alternative Animal Species	1,020	7,990	800	9,800
05 Generic Animal Research	240	12,260	3,300	15,800
06 Forage Plants	1,790	22,450	2,500	26,700
07 Horticulture	1,790	28,890	2,900	33,600
08 Arable Crops & other Plants	1,620	11,580	2,500	15,700
09 Plantation Forestry	1,830	10,610	1000	13,400
10 Fisheries	1,070	32,710	1000	34,700
11 Meat Processing	10,440	360	400	11,200
12 Dairy Processing	29,290	70	900	30,300
13 Other Food Processing	7,320	9,470	1,100	17,900
14 Fibre, Textiles & Skin Processing	14,590	290	500	15,400
15 Wood & Paper Processing	7,620	7,170	500	15,200
16 Materials & Industrial Processing	15,490	19,100	4,900	39,500
17 Engineering	18,110	3,690	2,400	24,200
18 Electronic & Instruments	19,630	8,060	2,500	30,200
19 Construction	5,390	650	2,600	8,600
20 Commercial & Trade	8,100	20	400	8,600
21 Energy	5,660	450	2,700	8,800
22 Transport Services	3,250	2,440	600	6,300
23 Information & Communication	23,270	1,290	4,700	29,200
24 Urban & Rural Planning	360	390	500	1,200
25 History, Society & Culture	420	2,630	1,700	4,800
26 Relationships & Wellbeing	440	1,500	2,300	4,300
27 Political & Economic Relationships	2,950	4,100	3,400	10,500
28 Education, Knowledge & Training	430	2,540	3,200	6,200
29 Environmental Protection	2,160	10,740	7,900	20,800
30 Geological Structures & Processes	1,100	17,630	6,400	25,100
31 Land use, Flora & Fauna	100	17,070	3,800	21,000
32 Marine & Fresh Waters	410	16,890	5,300	22,600
33 Climate & Atmosphere	30	5,030	2,000	7,100
34 Space	0	0	1,400	1,400
35 Antarctica	0	5,690	800	6,500
36 Fundamental Knowledge	240	11,000	13,000	24,300
37 Health	10,340	6,220	27,600	44,200
38 Defence	590	4,780	0	5,400
39 S&T Education	0	0	100	100
40 S&T Services	0	4,840	0	4,800
TOTAL	204,400	318,210	119,300	641,900

* University data are estimates for 1991.
See Sections 17.3 and 17.4

18 Estimates of R&D funded by each sector, from provider data

Data from R&D providers in each sectoral survey is summarised in Table 16. Each column represents the total R&D provided by that sector. Reading across the rows it is possible to estimate the total R&D funded by each sector. This will differ from the estimates obtained by using each sector's provider and funder data in isolation, as was done for example to obtain the estimates in Table 6.

Table 16. Gross expenditure on R&D carried out in or funded by NZ, 1990/91

Source of funds	Sector of performance					Done in NZ or funded by NZ
	Done by Business	Done by Government	Done by University	Total Done in NZ	Done Overseas	
Business	182,003	21,377	7,661	211,041	13,012	224,053
Government contracts	12,488	295,534	21,300	329,322	39	329,361
University block grant			90,300	90,300		90,300
Sub-total Govt	12,488	295,534	111,600	419,622	39	419,661
University (own funds)	105	23		128		128
Overseas Funds	9,785	1,275		11,060		11,060
TOTAL	204,381	318,209	119,261	641,851	13,051	654,902

Thus from this table it is estimated that the business enterprise sector spent $224 million on R&D (compared with the sector estimate of $212 million), the government sector spent $329 million (compared with the sector estimate of $334 million) and the universities spent $90 million. Of the total of $655 million, $13 million was spent overseas, while overseas funds paid for $11 million of the R&D carried out in New Zealand.

19 R&D personnel

19.1 Occupations

Business enterprises and government agencies were asked to provide information on the total number of R&D personnel, as well as breakdowns by gender and occupation. The university review obtained similar data by occupational group, but not by gender. Figures were provided in full time equivalent (FTE) staff numbers, and are given in Table 17.

Government figures are subject to problems of re-classification. One major agency reclassified senior technicians as researchers because of their involvement in the preparation of bids for contestable

funding, and also reclassified field officers from support staff to technicians. With the subsequent restructuring it has not been possible to obtain the exact figures, but an indicative correction is shown in the final column of Table 17.

Government figures including personnel engaged in research and consulting and services are shown in the shaded column. These data are indicative only, and only includes science agencies.

The total number of personnel employed in R&D came to 8,809 FTE. Not including the universities, 4,592 (71 percent) were male and 1,891 (29 percent) were female.

Using the adjusted figures there are 0.57 technical staff for each researcher. This may be compared to an Australian survey (1987/88) which showed this ratio at 0.47 across all sectors.

Amongst the women in business enterprise and government sector R&D, 28 percent are researchers, while 55 percent of the men are researchers.

19.2 Qualifications

Business enterprises and government agencies were asked to provide information on the highest qualifications of their R&D personnel, as well as breakdowns by gender. Figures were provided in full time equivalent (FTE) staff numbers, and are given in Table 18. University figures have been estimated from occupation data, and are only indicative.

Among R&D staff in the private and government sectors 19 percent had PhD qualifications in engineering or science. Only 4 percent of the women had PhDs, and 17 percent of the men.

Staff who held Bachelor degrees or higher (excluding engineering or science PhDs) made up 41 percent of R&D staff. This was the most common qualification level amongst R&D personnel.

People holding technical qualifications represented 17 percent of R&D personnel. People holding trade qualifications represented four percent of R&D staff.

R&D staff with "other post-secondary" qualifications represented one percent, those with "secondary" qualifications, 11 percent, and "other/none" came to 9 percent of R&D staff. Only 10 percent of male employees had other or no qualifications, whilst 18 percent of female staff fell within this category.

Table 17. Full time equivalent personnel engaged in R&D, all sectors, by occupation, 1990/91

Occupation	Gender	Business enterprise	Govt (includes non-R&D)	Govt R&D estimate	Universities	Total FTE in R&D ●	Total (adjusted) FTE in R&D ●
Researchers	M	1220	1760	1552		2772	2507
	F	275	333	303		578	523
	Total	1495	2093	1855	1872	5222	4902
Technicians	M	594	1094	936		1531	1644
	F	197	520	442		639	686
	Total	791	1614	1378	454	2624	2784
Support staff	M	139	378	240		378	441
	F	178	603	407		585	682
	Total	317	982	647	n.a.	963	1123
All FTE	M	1953	3232	2728	n.a.	4681	4592
	F	650	1456	1152	n.a.	1802	1891
	Total	2603	4689	3881	*2326	8809	8809

* University FTE in R&D:
460 academic staff
242 research officers
171 post-doctoral fellows
86 teaching technicians
386 research technicians
450 Masters students (at 25%)
549 PhD students (at 50%)

● Gender sub-totals do not include university FTE

Table 18. Full time equivalent personnel engaged in R&D, all sectors, by qualifications, 1990/91

Qualification	Gender	Business	Government (includes non-R&D)	Govt R&D estimate	Universities •	Total
PhD	M	177	795	701	n.a.	878
	F	21	77	59	n.a.	81
	Total	198	872	760	516	1474
Degrees	M	796	992	846	n.a.	1643
	F	211	425	394	n.a.	604
	Total	1007	1417	1240	1401	2247
Technical	M	373	454	444	n.a.	817
	F	107	137	133	n.a.	241
	Total	481	591	577	409	1058
Trade	M	231	71	65	n.a.	296
	F	34	71	57	n.a.	91
	Total	265	142	122	n.a.	4263
Other post-secondary	M	48	22	20	n.a.	68
	F	24	25	22	n.a.	46
	Total	72	47	41	n.a.	113
Secondary	M	195	398	321	n.a.	515
	F	146	343	266	n.a.	412
	Total	341	741	587	n.a.	927
Other/none	M	133	501	332	n.a.	465
	F	107	379	221	n.a.	328
	Total	239	880	553	n.a.	792
All FTE	M	1952	3233	2728	n.a.	4681
	F	650	1457	1151	n.a.	1801
	Total	2602	4689	3880	2326	8808

n.a. = data not available
• indicative estimates only

20 Type of expenditure, business and government sectors

Government agencies were asked to indicate how they spent their funds on R&D. The results are contrasted with those from business enterprise in Table 19.

Wages and salaries consumed 52 percent of the $318 million allocated to R&D in the government sector, compared with 54 percent in the business sector. Other current expenditure accounted for 36 percent, the same as in business. Capital expenditure was 12 percent, (which included a part payment for a new fisheries research vessel), compared with 10 percent in the business sector.

Table 19. Type of R&D expenditure, business and government sectors, 1990/91

Type of Expenditure	Sector					
	Government $ million	Percent	Business $ million	Percent	Total $ million	Percent
Wages & Salaries	164.9	52	109.9	54	274.8	53
Current	115.6	36	73.8	36	189.4	36
Capital	37.5	12	20.7	10	58.2	11
TOTAL	318.0	100	204.4	100	522.4	100

21 Technological balance of payments

Government and business sector payments and receipts abroad for technical know-how are shown in Table 20. The business sector paid out $2.9 million more than it received, while the government sector received a net amount of $4.6 million from abroad.

The national balance of payments for international transactions relating to trade in technical know-how for the business enterprise and government sectors was a surplus of $1.7 million.

Technical know-how includes patents, licences and technical and engineering services that increase the existing technical knowledge in a business. For a full definition refer to Section 5.

Table 20. Technological balance of payments, 1990/91

	Business sector ($000)	Government sector ($000)
Receipts	31,484	4,616
Payments	34,413	20
Balance received	-2,929	4,596

ANNEX 1

Members of the advisory group to the business enterprise R&D survey

1990/91		Area of Expertise
Dr David Bryant	General Manager, Scientific Services, Carter Holt Harvey	Building, Forestry Research
Dr Kelly Mara	The Management Edge, Thorndon	Manufacturers' Federation R&D Survey
Dr George Stuart	Manager Research, Wool Board	Manufacturing, Agricultural R&D
Mr William Howie	Director, Aoraki Corporation Ltd	Computer Software R&D
Dr John Hogben	Head of Applied Biochemistry, NZ Dairy Research Institute	Dairy Research
Department of Statistics:		
Mr David Archer	Senior Manager	Economic and Business Surveys
Mr Geoff Mead	Senior Research Officer	Economic and Business Surveys
Mr Roger Parkes	Senior Survey Officer	R&D Surveys
Ministry of Research, Science and Technology:		
Dr Margriet Theron	Manager, Science Review (Chair)	Science Management
Mr Mike Doig	Manager, Priorities and Funding	Science Funding
Ms Pamela Walker	Science Resource Analyst (Convener)	Statistics

ANNEX 2

Government sector organisations undertaking and funding R&D

A. Government sector organisations undertaking R&D

Accident Compensation Corporation
Alcohol Advisory Council
Audit Office
Department of Conservation
Department of Health
Department of Internal Affairs
Department of Inland Revenue
Department of Justice
Department of Labour
Department of Social Welfare
Department of Scientific & Industrial Research (replaced by CRI's)
Forest Research Institute
Hillary Commission
Law Commission
MAF Marine and Freshwater Research
MAF Technology (no longer exists)
MAF Policy
Maori Language Commission
Ministry of Commerce
Ministry of Defence, Defence Scientific Establishment
Ministry for the Environment
Ministry of External Relations and Trade
Ministry of Maori Affairs (no longer exists)
Ministry of Transport
National Museum
NZ Council for Educational Research
NZ Historic Places Trust
NZ Lottery Grants Board
NZ Tourism Department
Race Relations Conciliator
Securities Commission
Waitangi Tribunal

B. Government sector organisations funding R&D

Agricultural & Marketing R&D Trust
Earthquake & War Damage Commission
Foundation of Research Science and Technology
Health Research Council
Human Rights Commission
Lottery Grants Board
Ministry of Youth Affairs
Road Traffic Safety Council
Transit NZ

ANNEX 3 Science output classes

Agriculture, horticulture, forestry and fisheries

New and improved

1 Sheep and sheep production systems
2 Beef animals and beef production systems
3 Dairy animals and dairy production systems
4 Other animal species, animal products and primary production systems
5 Generic animal and animal production information bases, systems and products
6 Forage plants and forage management practices
7 Horticultural crops (including vegetables) and management practices
8 Arable crops, ornamental, amenity, shelter, conservation and other plants and management practices
9 Trees and plantation management systems
10 Fish harvesting and production systems for marine and freshwater fisheries

Secondary industries

New and improved

11 Meat processes, storage techniques and products
12 Dairy processes, storage techniques and products
13 Fruit, crops and other food and beverage processes, storage techniques and products
14 Fibres and skin processes and products
15 Wood and paper processes and products
16 Materials, industrial processes and products (includes mineral processing)
17 Engineering processes, systems and products (including transport engineering)
18 Computing and electronic, communication and instrumentation processes, systems, and products (hardware).
19 Construction processes, systems and products (including roading construction)

Commercial and trade services

New and improved

20 Information bases, processes and systems for commercial and trade services

Energy

New and improved

21 Information bases for prospecting, production and use of all energy sources

Transport

New and improved

22 Information bases, processes and systems for transport

Information processing and communications services

New and improved

23 Information processing software, software and services for electronic communication, media transmission and data interchange.

Urban and rural planning

New and improved

24 Urban and rural planning information bases, processes and systems

Social development and services

Information bases on

25 New Zealand history, society, culture and Te Ao Maori

26 Social and personal development, relationships and wellbeing

27 Political, economic and international relationships

28 Knowledge, education and training

Environment

New and improved

29 Protection and management technologies for the environment

Exploration and assessment of the earth

Information Bases on

30 Geological structures and resources, and solid earth processes (including mineral prospecting - see output 16 for mineral processing)

31 The properties, distribution, and potential uses of types of land and land based flora and flora

32 Marine and fresh waters, their substrate, flora and fauna

33 Climate and the atmosphere

34 Properties, uses and technologies for space

35 The natural environment of Antarctica

General advancement of knowledge

Information bases on

36 Fundamental information in the natural sciences, engineering, social sciences and humanities (where no end use has been identified)

Health

New and Improved

37 Information bases, systems and products in health

Defence

New and Improved

38 Information bases, systems and technologies for defence

S&T Education and Services

39 Further education/training of those already active in the science community.

40 Provision of scientific and technological services eg museums, zoological and botanical gardens; publishing and primary measurement standards.

ANNEX 4 New Zealand Standard Industrial Classification

(Grouped for the purposes of R&D statistics)

Industry Groups	Component Industries	NZSIC codes
Agriculture	Agriculture, forestry, fishing	11,12,13
Mining	Mining and quarrying	2
Basic metals	Ferrous Metals	371
	Non-ferrous Metals	372
	Fabricated Metal Products	381
Chemical group	Chemicals (industrial and other chemicals)	351, 352 except 3522
	Drugs	3522
	Petroleum refining	353, 354
Chemical-linked	Food, drink and Tobacco	31
	Textiles, Footwear and Leather	32
	Rubber and Plastic Products	355, 356
Electrical group	Electrical Machinery	383 except 3832
	Electronic Equipment and Components	3832
Machinery	Instruments	385
	Office and Computing Machinery	3825
	Machinery n.e.c.	382 except 3825
Other manufacturing	Stone, Clay, Glass	36
	Paper and Printing	34
	Wood, Cork and Furniture	33
	Other Manufacturing	39
Transport equipment	Motor Vehicles	3843
	Ships	3841
	Other Transport	3842,3844,3849
Infrastructure services	Utilities (electricity, gas and water)	4
	Construction	5
	Wholesalers (industrial machinery, electrical and professional equipment) and Producer Boards	61
	Transport, Storage	71
	Communication	72
Financial, software services	Business and Financial services (trading banks)	8 except 8323,8324
	Computer Bureaux and Consultancy,Software development	8323
Engineering, scientific services	Community, Social and Personal Services including Research and Scientific Institutes, Charities, Local Authorities	9
	Engineering, Architectural and Technical Services	8324

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3. Ministry of Research Science and Technology, 1992, "A Profile of Crown-funded R&D in New Zealand, 1991/92 A bench-mark analysis of Crown-funded scientific and technological research conducted in New Zealand during 1991/92". *Publication No.5.*

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Other Research and Development Publications

The Ministry of Research, Science and Technology is conducting annual surveys of research and development (R&D) in the business enterprise, government and university sectors. The results of the surveys which have been undertaken are published in the following reports:

"New Zealand Research and Experimental Development Statistics: Business Enterprise Sector, 1989/90", Ministry of Research, Science and Technology, Wellington 1991. *Publication No.1.*

"New Zealand Research and Experimental Development Statistics: Government Sector, 1989/90", Ministry of Research, Science and Technology, Wellington 1992. *Publication No.3.*

"A Profile of Crown-Funded R&D in New Zealand 1991/92", Ministry of Research, Science and Technology, 1992. *Publication No.5.*