New Zealand research and experimental development statistics : all sectors, 1992/93 / Ministry of Research, Science and Technology.

New Zealand Research and Experimental Development Statistics

All Sectors

1992/93

Ministry of Research, Science and Technology

Te Manatu Putaiao

Publication No. 13

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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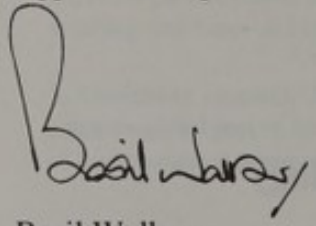
This document is the report of the joint survey of business and government sector R&D carried out by the Ministry of Research, Science and Technology and Statistics New Zealand, and the Ministry's own survey of R&D in the higher education sector.

Approved for general release



Basil Walker
Chief Executive

FOREWORD

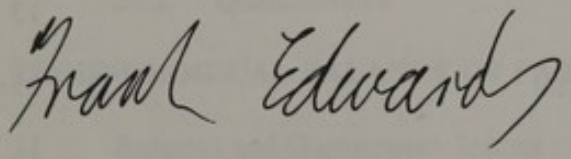
This survey of research and development in the business enterprise sector is the fourth of a series of R&D surveys to be undertaken by the Ministry of Research, Science and Technology. It was carried out jointly with the Economic and Business Surveys Division of Statistics New Zealand, in Auckland, and should provide valuable information to policy makers in government and business. This survey used a reduced sample of the top 100 R&D performing firms, and therefore required the development of a number of specialised techniques and methodologies to handle this different survey approach.

The process for carrying out these R&D expenditure surveys was developed with the valuable assistance of an advisory group whose members were drawn from key sectors of the science and science user communities. I would like to thank the advisory group again for their informed comment and attention to detail which have helped to ensure the acceptance of and good response to the survey.

The government and business sectors were generally very willing to provide the information and to participate in the survey. I would like to thank Guy Sanders, Ron Maddox and Rob Tinkler at Statistics New Zealand who managed, along with this Ministry, the large number of queries and checks which a complex and technical survey of this nature could be expected to generate. A new survey of universities was developed this year which was conducted by the Ministry in conjunction with the Vice-Chancellors' Committee. I would like to thank Professor Warren Young in particular for his invaluable assistance with this survey.

The tabulations presented here are designed to make as much information as readily available as possible. Further analysis of the information, especially in relation to economic indicators, will be made available in separate reports.

The value of this information on R&D increases the longer the time frame over which it is available. This survey will therefore be repeated at least every two years. The 1993/94 questionnaire was sent out in October 1994 and the report on these survey results will be made available early in 1996.



Frank Edwards
Manager, Information Services
Ministry of Research, Science and Technology

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This report documents the fourth annual survey of Research and Development (R&D) undertaken in New Zealand. It provides data on research in the higher education, business and government sectors.

This year marks a transition phase in R&D in New Zealand, encompassing the change from a departmental to Crown Research Institute (CRI) structure. Survey results are an amalgam of responses from government departments with responses from CRIs at the end of their first full year of trading.

Another thing to bear in mind when interpreting data is that the business sector survey results are from the top 100 companies (in terms of R&D expenditure); results for the total business sector are extrapolated figures.

It is estimated that the business enterprise sector spent $245 million on R&D (including $19 million overseas), government spent $443 million, and universities spent $47 million of their own funds. Of the total of $754 million research carried out in New Zealand, $19.4 million was paid for with funds from overseas and a further $19 million with private non-profit funds.

New Zealand's ratio of gross domestic R&D expenditure to GDP was 0.98 percent (using 1992 GDP as in OECD main science and technology indicators[12] of $77,067 million). The latest figure for the six OECD reference countries (see section 6) is 1.85 percent. R&D performed by the private sector was 0.28 percent (1.1 percent for OECD reference countries) or 28 percent of the total (56 percent in OECD reference countries). The Government sector performed R&D worth 0.41 percent of GDP, while university R&D came to 0.3 percent of GDP. Together the latter two sectors performed R&D worth 0.71% of GDP, compared to an average of 0.76% for government and university sectors in OECD reference countries.

The overall breakdown of how the money was spent has not changed since 1991/92; 51 percent on wages and salaries, 40 percent on current expenditure, and 9 percent on capital expenditure. Business R&D spent relatively more on salaries and wages and capital than government or university R&D, and less than them on current expenditure.

Government R&D tends to be concentrated in a few areas; 44 percent in Primary Production (a drop from 1991/92), and 22 percent in the Environment and Natural Resources.

Business R&D expenditure was concentrated in: Primary Products and Processing (37 percent), Materials Engineering and Telecommunications (26 percent), and Infrastructure and Services (18 percent). These results illustrate the focus on secondary industry by business R&D and primary-production by government R&D.

Looking at trends over the four years, Primary Production and Primary Products & Processing are seen to be the only major sectors to have shown a consistent increase in business R&D expenditure since 1989/90. Combined they comprise 46 percent of intramural business enterprise R&D in 1992/93, up from 40 percent in 1989/90.

The total number of personnel in all sectors employed in R&D as researchers, technicians or support staff came to 19,557 FTE. Overall, 51% of their time was spent on R&D. Excluding universities, 31 percent were female.

Since 1990/91 the technology balance of payments for business has reversed from -$3 million to a positive balance. For 1992/93 the business sector received a net amount (receipts - payments) of $15.1 million for overseas trade in technical know-how. Government received a net amount of $2.6 million.

Figure 1. R&D performed by each sector in 1992/93, by the groupings used for priority setting 1995 ($000)

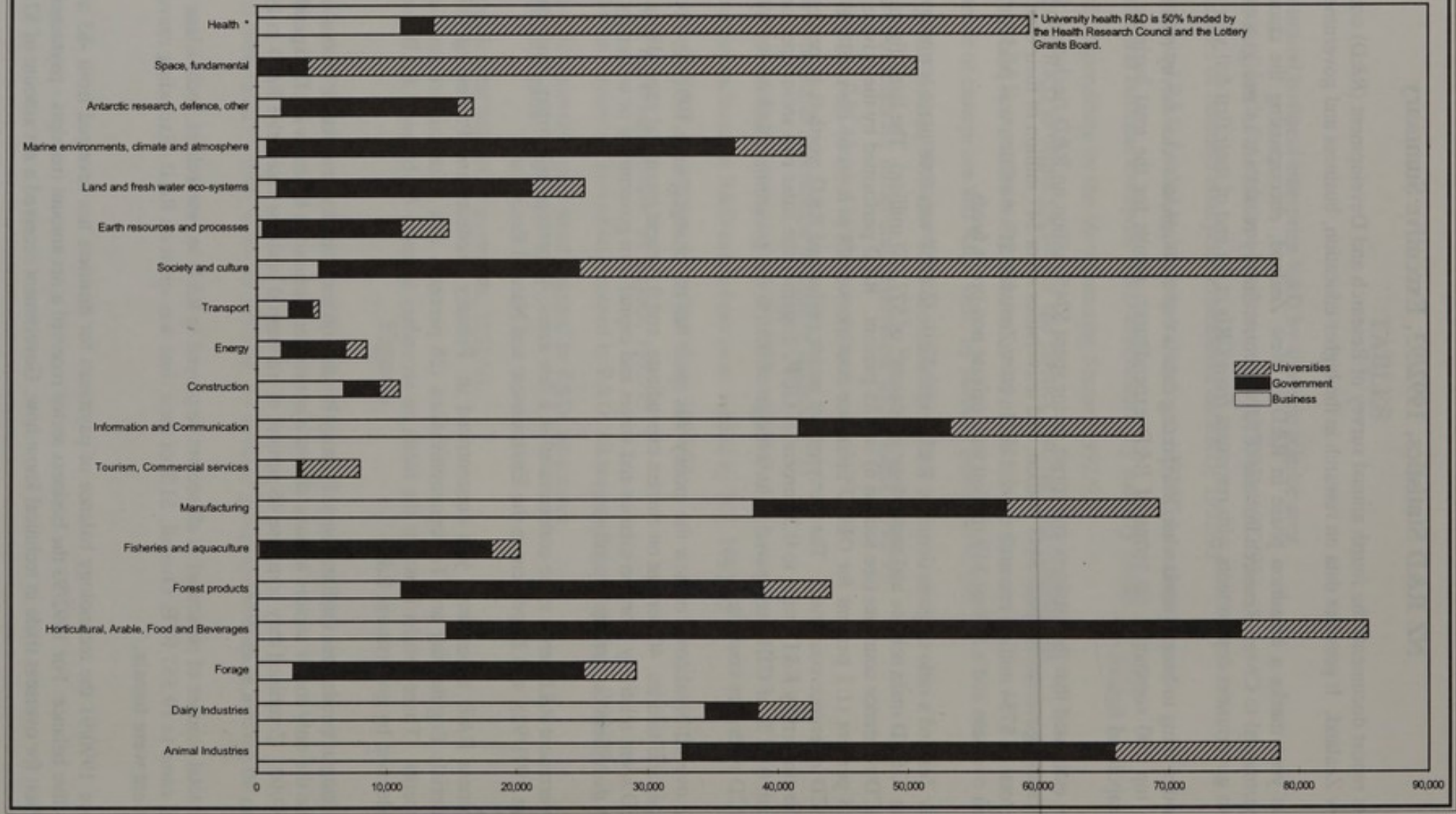
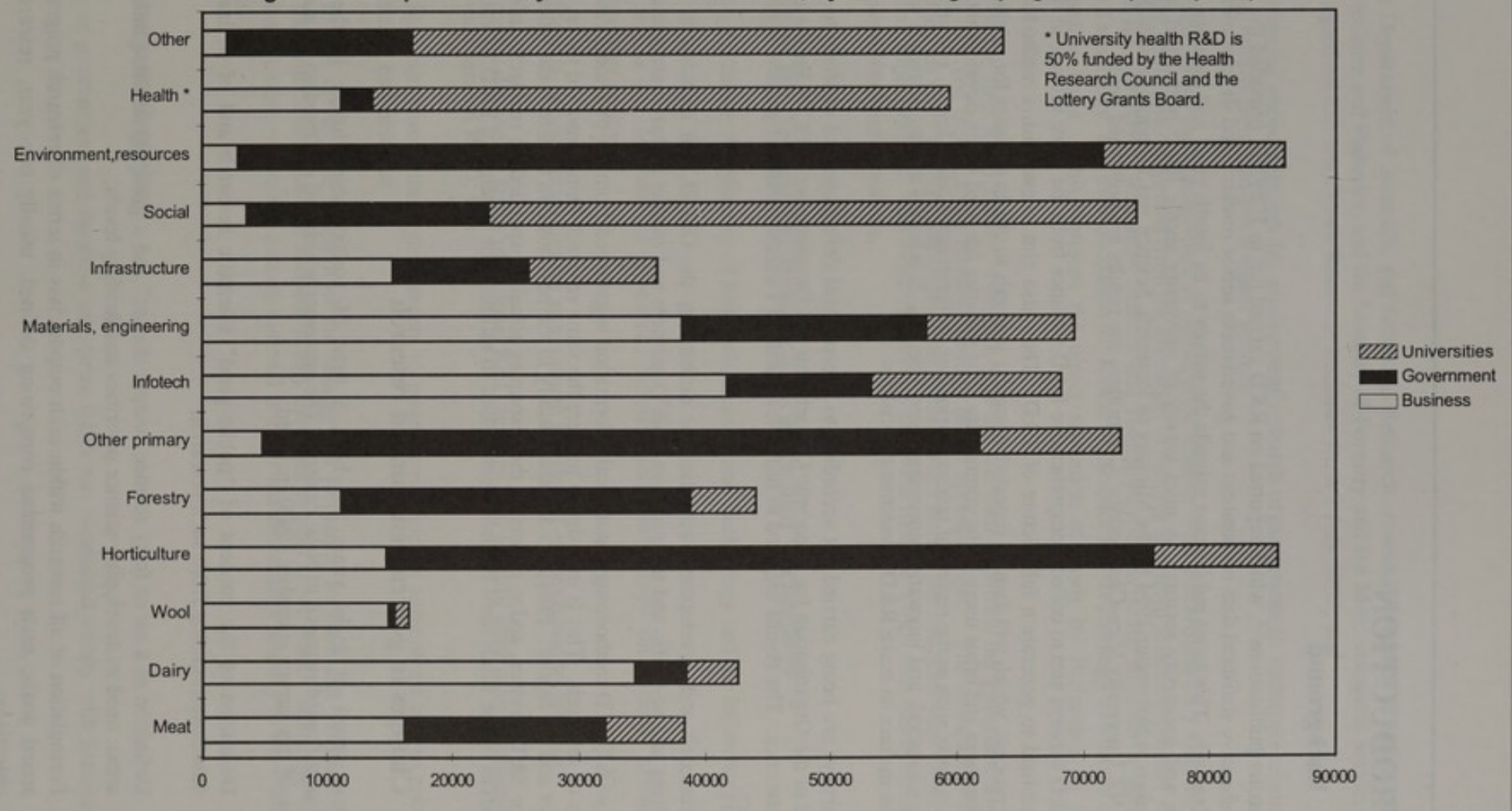


Figure 2. R&D performed by each sector in 1992/93, by selected groupings of outputs ($000)



INTRODUCTION

1 Background

Two earlier publications[1,2], which reported on R&D carried out in 1989/90, provided the first year of comprehensive statistical data on business and government sector research and development (R&D) in New Zealand. This latest publication extends the survey to its fourth year, and includes government private and university sectors. A pilot survey of university sector R&D performed in 1993 was undertaken in November 1994 by the Ministry of Research, Science and Technology with the assistance of the NZ University Vice-Chancellors' Committee; the results are published here.

The R&D surveys aim to collect comprehensive R&D statistics from the three sectors so that they can be combined to generate a full picture of R&D. 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. It is hoped that the statistics will also help decision makers to make R&D investment decisions.

The surveys are being carried out according to international definitions and conform to the Frascati manual 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 and market research 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 funding of R&D by each sector.

2 Changes in government-funded research

The past seven or eight 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 (October 1993) 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" and a grouping of these into 24 science areas, 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;

- The Department of Scientific and Industrial Research, research branches of the Ministry of Agriculture and Fisheries, and the Ministry of Forestry and the Meteorological Service, were re-organised into ten Crown Research Institutes from 1 July 1992; and

- Continuing 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 from 1991/92. The 1992/93 survey year is the first for which data has been received from the Crown Research Institutes.

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 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 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 Statistics New Zealand.

The survey of the business enterprise sector for 1992/93 was sent to the top 100 providers of R&D, together with the major funders. These firms were estimated to carry out 75 percent of all business sector R&D.

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.

Questionnaires and covering information were posted to survey respondents in October and followed up by reminder notices to non-respondents in the new year. This was followed by telephone calls with the objective of achieving a 100 percent response from all government agencies and business enterprises employing more than 100 full-time equivalents.

The final sample population of respondents was 177 enterprises, of which 119 were business enterprises and 58 were government agencies (government departments, statutory authorities and Crown Research Institutes). The top 100 R&D providers were taken from the 1991/92 population, which comprised:

- all those who answered "Yes" to a question in Statistics New Zealand's 1991 Annual Business Directory Update survey which asked if they undertook R&D;
- those who answered "Yes" to any of the questions in the 1990/91 R&D survey;
- all large enterprises involved in manufacturing, "large" being defined as those enterprises with more than 100 full-time equivalent persons engaged;
- respondents were also added to the survey when replies to the question "if you paid another organisation(s) to undertake R&D on your behalf, please list the organisation(s) below" identified research providers not already included in the survey; and

To these were added major funders from the same population.

The government sector survey comprised:

- those government departments and Crown agencies undertaking public good research, or operational research to support their own outputs, including positive respondents to the 1991/92 government sector R&D survey[2].

To obtain a complete private sector population for 1992/93, respondents were matched with their previous record in 1991/92. Factors looked at were R&D personnel, expenditure and funding; these were used to rate up or down all variables for all non-surveyed members of the population. The rated-up non-surveyed population data was added to the 1992/93 survey response to give the population data reported here. The "top 100" firms surveyed covered 73% of R&D carried out by business in 1991/92.

5 Definitions used in the survey

This report follows the convention used in OECD publications of standard abbreviations for the measures of R&D. 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 income from student fees and other sources, including 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 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 refers 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.

The survey population covers a wide range of industries from NZSIC 11214 *Landscape Planting and Maintenance Services* to NZSIC 95991 *Funeral Directors*, and between all divisions from *Forestry and Logging* to *Personal and Household Services*. The survey sampled industries from a total population of 153,996 separate government and private sector enterprises (virtually the entire economy, excluding Agriculture).

Farming enterprises (i.e. industries in major group 111 of the *New Zealand Standard Industrial Classification (NZSIC)*, 1987 edition) were not included in the Statistics New Zealand 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.

For the purposes of R&D statistics, the OECD recommends that research institutes be classified according 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 institute.

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 OECD reference countries

Six countries from within the OECD have been identified by the NZ Institute of Economic Research (also see Edwards, 1992[9]) 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

The major limitation of this year's survey is that it is only a partial survey in respect of the business enterprise sector. This was simply to cut costs, and the 1993/94 survey results will cover the whole population.

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, or they may 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. It needs to be borne in mind that 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, the next two surveys had full coverage, and the current survey only includes the top providers and funders, plus rated-up estimates for the rest. Sampling error will no doubt contribute to the fluctuations noted between the two full surveys and the current partial survey, and this must be taken into account when making comparisons.

BUSINESS

8 The business enterprise sector

8.1 Introduction

The business sector provided $213 million worth of research (equivalent to 0.28 percent of GDP; compared to the OECD average of 1.3 percent). Some of the money for this research came outside the sector, from government, from local bodies, or from overseas. The business sector funded $222 million worth of research. Some of this research was carried out in the government and university sectors, or overseas.

The R&D full-time equivalents (FTE) of all personnel engaged in research (researchers, technicians and support staff) numbered 1,820. In addition, 690 R&D FTEs were engaged in research associations and producer boards. The total, 2,510 FTEs, represents the R&D effort of 3,033 staff full-time equivalents in the business sector. On average, therefore, personnel are engaged in R&D for 83 percent of their time.

In the first year of the survey, a stratified random sample of 2,508 firms was surveyed, representing a population of 7,904 firms, research associations and producer boards, in areas of the manufacturing and service sectors which could be expected to engage in R&D. In the second and third years, a brief question on R&D activity was sent to the population of about 150,000 firms (all non-government firms in the Statistics New Zealand Business Directory). There were 2,156 firms who said they conducted or funded R&D in 1991/92; these firms all received the full R&D questionnaire.

In response to the full questionnaire, where R&D was precisely defined, 941 firms (0.6 percent of the population) stated that they provided or funded R&D or traded in technology.

R&D was being done by 765 (including imputes), and 286 were funders, compared with estimates from the second year's sample of 736 providers and 265 funders. For the current survey, only the top 119 providers and funders were surveyed. The remainder were inputed from their 1991/92 data.

Total research personnel in the business sector comprised 1.5 per 1000 labour force.

Persons engaged in R&D in the business enterprise sector represented 25 percent of the national total of R&D personnel, compared with an average of 48 percent for the six OECD reference countries.

8.2 Concentration of R&D in firms

Excluding research associations and producer boards, the distribution of R&D expenditure was heavily concentrated in a small number of firms. Of the total of $222 million spent on research by the business sector, $59 million was spent by research associations and producer boards. The remaining $163 million was spent as follows:

The top 5 firms spent $ 34 million, or 21 percent.
The top 10 firms spent $ 46 million, or 28 percent.
The top 70 firms spent $ 100 million, or 61 percent.

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

9.1 Overview of R&D by output

In addition to classifying firms by NZSIC, R&D in New Zealand can be 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, either individually or grouped. Forty statistical output classes have been used for collecting data since 1989/90. Twenty-four science areas were used to develop science strategies in 1992/93. A more recent priority setting exercise used 17 "outputs". These (with the addition of categories for health and space, fundamental) are illustrated in Figure 1.

Each firm in the survey was asked to state the output class which best described the purpose of its R&D. In some instances firms may confuse this with the nature of the R&D, e.g. R&D developing agricultural machinery may be coded to Output Class 18 instead of the appropriate agricultural output.

Table 1 shows expenditure on all R&D carried out between 1990/91 and 1992/93 by business enterprises. Note: this is not the same as amount *funded* by the private sector in each output category. Business enterprises include industry research associations and producer boards (see Table 5) which provided $54 million of intramural R&D in 1992/93 ($46 million in 1991/92).

The information is grouped by the 24 strategic science areas. These groups combine science output areas for the same sector (in terms of production and processing). This table, therefore, is useful for comparing expenditure levels in each vertically integrated sector. The same forty statistical outputs are set out in numerical order in Table 10, which shows the total R&D performed in each output area by business and government in 1992/93. Descriptive detail of the forty science output classes is given in Annex 3.

The total expenditure on R&D carried out by the business enterprise sector increased between 1991/92 and 1992/93, by $8.2 million, to $209.7 million. The way in which enterprises responded to the survey definitions may account for small fluctuations in the total expenditure, or for changes within output classes. So, the significance of small variations must be evaluated carefully.

Now that figures for four consecutive years are available and trends can be inferred, primary processing and primary products are seen to be the only major sectors to have shown a consistent increase in business R&D expenditure since 1989/90. Combined, they comprised 46 percent of intramural business enterprise R&D in 1992/93, 43 percent in 1991/92 and 42 percent in 1990/91 and 40 percent in 1989/90.

Table 1 shows that over a quarter of the R&D 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 group increased by $1.7 million to $55.7 million after a $0.8 million increase in 1991/92.

A fifth of the research 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 these areas showed a small increase, coming after a $7 million drop to $38.5 million in 1991/92.

In 1992/93, business enterprises targeted $11 million (5 percent of total) at health research, a small increase over the previous year. Research aimed at the protection of the environment (which includes pollution and waste management), research into natural resources and the environment, and research into fundamental knowledge has been declining. These comprised 3.3 percent of total intramural BERD in 1989/90, 2.0 percent in 1990/91, 1.9 percent in 1991/92 and 1.4 percent in 1992/93. Reported research on social development, including economic research, declined further to $3.6 million in 1992/93.

9.2 Primary production (Output Classes 01 to 10)

Table 10 shows that private sector R&D in primary production received a proportionately low level of funding compared to other areas of research. Expenditure increased by $4.2 million to $21.0 million in 1992/93. Internationally, primary production R&D is not normally well funded by the private sector.

Primary production involves 10 output classes. Eight of these are agricultural with one each devoted to forestry and fishing. Generic animal research increased slightly in 1992/93.

9.3 Primary products and processing (Output Classes 11 to 15)

The substantial expenditure in this group of output classes 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. Expenditure in this group increased by $6.5 million to $74.7 million.

Within this overall group of output classes, the largest class is research into the development of New and Improved Dairy Processes, Storage Techniques and Products (Output Class 12). Overall, business enterprises spent $34.4 million on this research, an increase of 7 percent. R&D into processing and products from natural and artificial fibres, textiles, clothes and skin products, including leather (New and Improved Fibres and Skin Processes and Products - Output Class 14) rose to $13.9 million, though this is still below the earlier 1990/91 figure of $14.6 million. In 1991/92 the figure was $12.6 million.

Decreases occurred in research into New and Improved Meat Processes, Storage Techniques and Products (Output Class 11), and other food processing (Fruit, Crops and Other Food and Beverage Processes, Storage Techniques and Products - Output Class 13). The former decreased by $1.4 million to $12.6 million, the latter decreased by $0.5 million to $9.6 million. Wood and Paper Processes and Products (Output Class 15) rose slightly to $6.3 million, but was still short of the 1990/91 level of $7.6 million.

9.4 Materials, engineering, computing and communications (Output Classes 16 to 18)

Expenditure in this group has been increasing since 1990/91, with a $1.7 million increase in 1992/93. Of the $55.7 million in this group, $17.6 million goes on research aimed at New and Improved Computing and Electronic, Communication and Instrumentation Processes, Systems and Products (Output Class 18). This is $0.1 million less than was reported in 1991/92. In 1989/90 this was the highest expenditure on intramural R&D of all the output classes. However, the wording of Output

Table 1. Intramural business enterprise R&D by strategic science area

Strategic Science Areas	1992/93	1991/92		1990/91
Output Aggregation	R&D Expenditure ($000)	Number of firms	R&D Expenditure ($000)	R&D Expenditure ($000)
01 Sheep Production 02 Beef Production 11 Meat Processing 14 Fibre, Textiles & Skin Processing	30,770	86	31,110	29,822
03 Dairy Production 12 Dairy Processing	34,360	52	32,600	31,808
04 Alternative Animal Species	220	13	480	1025
05 Generic Animal Research	1,610	n.p.	n.p.	n.p.
06 Forage Plants	2,730	14	2,850	1,785
07 Horticulture 08 Arable Crops & other Plants 13 Other Food Processing	14,550	93	14,130	10,725
09 Plantation Forestry 15 Wood & Paper Processing	11,030	74	8,630	9,445
10 Fisheries	240	13	490	1,071
16 Materials & Industrial Processing 17 Engineering 18 Electronic & Instruments	55,720	309	54,030	53,235
19-24 Infrastructure	39,140	218	38,480	46,036
19 Construction	6,680	44	6,810	5,392
20 Commercial & Trade	3,050	51	4,490	8,099
21 Energy	1,880	31	3,580	5,665
22 Transport Services	2,490	26	2,790	3,246
23 Information & Communication	23,940	95	20,500	23,271
24 Urban & Rural Planning	1,090	7	310	364
25 History, Society & Culture 26 Relationships & Wellbeing 27 Political & Economic Relationships 28 Education, Knowledge & Training	3,630	34	4,080	4,237
29 Environment Protection 30 Geological Structures & Processes 31 Land Use, Flora & Fauna 32 Marine & Fresh Waters 33 Climate & Atmosphere	2,720	43	3,630	3,794
34 Space 36 Fundamental Knowledge	n.p.	7	160	245
37 Health	11,040	41	9,970	10,342
38 Defence	n.p.	n.p.	n.p.	n.p.
TOTAL (includes "Other")	209,730	760	201,520	204,400

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

Classes 18 and 23 both relate to R&D in information processing and communications. It is sometimes difficult to be sure that a change in amount of R&D reported in these areas is due to classification difficulties or to a real change. Because software services apply to many different industries, a particular piece of software research may be classified with the industry area it serves.

New and Improved Materials, Industrial Processes and Products - Output Class 16 - from chemicals, petroleum and coal, base metals and glass, including plastics, rubber and pharmaceutical, accounted for R&D of $17.2 million in 1992/93, a rise of $4.2 million. Engineering Processes, Systems and Products - Output Class 17 (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) is still the largest sector in this group, although it has decreased significantly by $2.4 million.

9.5 Infrastructure and services (Output Classes 19 to 24)

There has been an $0.7 million increase in intramural business expenditure in this grouping in 1992/93.

This grouping includes R&D in construction and building ($6.7 million), commercial and trade services including tourism (down $1.4 million to $3.1 million), energy ($1.9 million, a drop of $3 million over the last three years), transport ($2.5 million), and urban and rural planning ($1.1 million). Intramural expenditure in commercial and trade services is principally in financial and software development and in engineering scientific services. In 1990/91 this increased by $3.3 million, but this year it has declined for the second consecutive year in a row.

Over half of the $39.1 million of R&D in this grouping ($23.9 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. This is the same proportion as last year but there was an increase in intramural R&D expenditure on financial and software services of $3.4 million. 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 $41.6 million in 1992/93 ($38.3 million in 1991/92), or 19.5 percent of all the business enterprise R&D.

9.6 Social sciences, environment, natural resources and fundamental knowledge

Social sciences, environment, natural resources and fundamental knowledge are not well funded by the business enterprise sector. Overall, the social sciences received a similar level of funding to last year, although there was an increase in the area of politics and the economy (up $680,000), and a decrease in the social relationships and well-being category (down $700,000). There was another decrease in money spent on environmental research (down by $320,000 in 1992/93 after a $380,000 decline in 1991/92). Intramural 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, decreased for the second year in a row, to $2.9 million. Effort on geology and marine ecosystems are the main losers from this reduction in expenditure.

9.7 Health and defence

Expenditure on R&D in health increased a further 10.8 percent to $11.0 million in 1992/93. Questionnaire results for the Business Directory Update (published by Statistics New Zealand) identified several enterprises, not identified in the 1989/90 survey, engaged in health research; further enterprises were added to the 1993 survey, after discussions with the Researched Medicines Association.

Expenditure on R&D for defence decreased by 91 percent.

10 Funding of R&D expenditure in the business sector

10.1 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 2.

The business enterprise sector used its own funds, the funds of other firms and government, and overseas sources in order to carry out its intramural R&D of $209.7 million.

Since 1989/90 the proportion of business enterprise R&D that has been funded from the resources of the organisation doing the research has decreased. In 1991/92 the proportion of "own funds" was 65 percent, in 1992/93 it was 63 percent, although the actual level of funds provided was maintained. In 1992/93, a further 15.4 percent came from related New Zealand private sector enterprises, a considerable increase, and 9.6 percent from unrelated enterprises. (Related enterprises are those which share with the survey respondent a direct investment relationship and/or a common management structure.)

Eleven percent of the research performed in the business enterprise sector was funded from outside the sector (from overseas and government), which was slightly less than last year. The contribution from the New Zealand central government increased to 8.0 percent in 1992/93. Contributions from related private enterprises abroad was 1.8 percent, down from 2.6 percent in 1991/92, and unrelated private enterprises abroad contributed 1.1 percent.

Of the funds coming from outside the business enterprise sector, $11.7 million came from the Foundation for Research, Science and Technology (FRST) and $6.0 million from central and local government. A further $6.0 million came from overseas. The equivalent 1991/92 figures are $10.9 million from FRST and $4.1 from the rest of government, and $9.0 million from overseas. Firms have maintained funding from their own sources and there appears to be an increase in funds (up $3.7 million) from related firms within New Zealand. There has also been an increase in funds from unrelated firms (up $3.6 million). While there was a decrease in funds from overseas (by $1.3 million from related firms and $1.6 million from unrelated firms) there were small increases in funds from other sources - enterprises' own funds ($0.9 million), NZ government funds ($1.9 million), and other unspecified sources ($0.3 million).

The proportion of industry funds used for R&D carried out by the New Zealand business enterprise sector (88 percent) is in line with 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 (including local government) is 8.2 percent, lower than the average OECD reference country figure (9 percent).

10.2 Additional research funded but not performed in the sector (extramural R&D)

In addition to the R&D carried out within the business enterprise sector, business enterprises reported they funded $15.8 million worth of research by government organisations, $0.6 million by local authorities, $8.7 million by the universities, $18.8 million overseas, and $2.2 million by other organisations. A total of $46.1 million was research funded by the business sector and carried out outside the sector. This compares with $48.0 million in 1991/92.

Table 2. Source of funds for intramural business enterprise R&D, 1992/93

Source of funds	1992/93		1991/92		1990/91	
	($000)	%	($000)	%	($000)	%
Own Funds	132,270	63.1	131,390	65.1	138,005	67.5
Related Private NZ Firm	32,300	15.4	28,590	14.2	28,557	14.0
Unrelated Private NZ Firms	20,150	9.6	16,550	8.2	14,777	7.2
Foundation for Research Science & Technology	11,680	5.6	10,850	5.4		
NZ Central Government	4,990	2.4	3,130	1.6	12,593	6.2
NZ Local Government	930	0.4	940	0.5	347	0.2
Overseas Funds From Related Firms	3,820	1.8	5,150	2.6	7,689	3.8
Overseas Funds From Un-related Firms	2,240	1.1	3,840	1.9	2,096	1.0
Other Sources of Funds (PNP)	1,350	0.6	1,090	0.5	317	0.2
TOTAL	209,730	100.0	201,520	100	204,400	100

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

PNP: Private non-profit

10.3 Extramural R&D, by industry group

Table 4 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 had already been reported as intramural R&D by the provider. A total of $89.9 million was spent on extramural R&D, if funds circulating within the sector are included. This is an 11.5 percent drop from last year.

Funders of R&D stated that other business enterprises were funded a total of $44 million, of which $30 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.

Another way of estimating this is to aggregate information from the business, government and university surveys about the sources of their funds. This is done in Table 15, where the estimate of business-funded R&D is $227 million for R&D carried out in NZ plus $18.8 million of R&D carried out overseas.

Of the total of $18.8 million spent on R&D carried out overseas, $17.5 million went to an overseas enterprise related to the funder.

Most of the R&D carried out extramurally was funded by the producer boards ($51.6 million). Producer boards spent $32 million funding R&D at private sector enterprises, $10 million in the government sector, $3 million at universities, and $7 million overseas.

Infrastructure services were the next largest funder of extramural R&D. Other enterprises were the main research providers to this industry group. Engineering and scientific services funded $6.2 million, more that half of which was spent at the universities.

10.4 Total R&D funded by the business enterprise sector

Total research funding by the business enterprise sector increased from $219.0 million in 1991/92 to $230.8 million. This is obtained from total R&D performed ($209.7 million) by subtracting R&D funded from outside ($25.0 million) and adding R&D funded by but not performed in the sector ($46.1 million).

This may also be calculated by aggregating each firm's "own funds" and "total funded". This gives total research funding of $132.3 plus $89.9 or $222.2 million; the difference is due to a difference of $8.5 million between the aggregate of what firms said they received from other firms, and the aggregate of what they said they funded to other firms.

10.5 Intramural estimate of total R&D funded by the business enterprise sector, by output class

Table 3 shows estimates of the amount of business sector funds going to R&D in each output area.

Table 3. Estimates of business enterprise expenditure on R&D, 1992/93

Science output class	R&D funded, ($000)		
	Intramural	Extramural	Total
01 Sheep Production	6,480	1290	7,770
02 Beef Production	220	610	830
03 Dairy Production	1,550	2,980	4,520
04 Alternative Animal Species	230	520	740
05 Generic Animal Research	280	470	750
06 Forage Plants	2,140	450	2,590
07 Horticulture	5,500	1,660	7,170
08 Arable Crops & other Plants	1,420	210	1,630
09 Plantation Forestry	2,620	40	2,660
10 Fisheries	220	n.p.	n.p.
11 Meat Processing	5,100	4,940	10,050
12 Dairy Processing	9,340	25,240	34,580
13 Other Food Processing	8,570	4,260	12,830
14 Fibre, Textiles & Skin Processing	12,180	370	12,550
15 Wood & Paper Processing	7,480	750	8,230
16 Materials & Industrial Processing	17,530	1,610	19,140
17 Engineering	17,270	1,470	18,730
18 Electronic & Instruments	17,270	140	17,420
19 Construction	3,070	30	3,110
20 Commercial & Trade Services	4,150	1,130	5,280
21 Energy	1,420	2,540	3,970
22 Transport	1,600	160	1,760
23 Information & Communication	23,150	30	23,180
24 Urban & Rural Planning	950	0	950
25 History, Society & Culture	30		30
26 Relationships & Wellbeing	50	1,780	1,830
27 Political & Economic Development	990	10	1,000
28 Knowledge Education & Training	40	n.p.	n.p.
29 Environmental Protection	940	500	1,440
30 Geological structures	n.p.		n.p.
31 Land based flora & fauna	20		20
32 Marine & Fresh waters	n.p.		n.p.
33 Climate & atmosphere	n.p.		n.p.
34 Space	n.p.		n.p.
35 Antarctica	n.p.		n.p.
36 Fundamental Research	78,534		78,534
37 Health	10,990	1,730	12,720
38 Defence	n.p.		n.p.
Other	2,260		2,260
TOTAL	165,610	56,140	221,750

n.p. = Not published for reasons of confidentiality

To obtain the estimates for intramural R&D funded solely by business enterprises (see column 2, Table 3), funding from all sources outside the firms was deducted from the value of each enterprise's intramural R&D, in the same proportion per output class as the proportion for total research carried out.

Business financed extramural R&D carried out by firms, 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 larger producer boards were asked for more information. The resulting estimates, total extramural expenditure on R&D in each output by the business enterprise sector, are shown in the third column.

Dairy processing is the largest single target of private sector R&D funds, with $34.6 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 18 percent of private sector funding for R&D, and 19.5 percent of all research carried out in the private sector.

Materials and industrial processing - Output Class 16 ($19.1 million), and engineering processes - Output Class 17 ($18.7 million) are the next largest areas of business enterprise funding.

11 Intramural business sector R&D, by industry group

In Sections 9 and 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 11 industry groups. These are given in Table 5.

In this analysis, and throughout this report, the research associations are classified to the industry group that they predominantly serve. As the Statistics New Zealand Business Directory is updated annually, an enterprise may be reclassified to a new NZSIC if its predominant activity has changed.

The expenditure, in all levels combined, showed an increase of 4.1 percent. However, within industry groups, major differences were seen. Of the 11 industry groups, five showed increased expenditure:

- Electrical machinery showed a massive increase ($9.9 million - 55.7 percent), to $27.8 million;
- The next largest percentage increase (56 percent) occurred, for the second year in a row, in Agriculture, Forestry and Fisheries ($4.5 million to 7.0 million);
- Foods, textiles, and plastics (the largest area of expenditure) increased by $4 million, (5.9 percent) to $72.8 million; and
- Other increases occurred in Financial, Software Development Services; and Producer Boards and Research Associations.

Seven categories showed reduced R&D expenditure:

- Transport Equipment decreased by $626 thousand, to $1.2 million (34.4 percent);
- Mining, basic metals and metal fabrication dropped in funding by 31.4 percent - $9.5 million to 6.5 million; and
- Reductions also ocurred in Other Machinery, Other Manufacturing, Infrastructure Services (a drop of 31.4 percent), and Engineering Scientific Services (last year, this area showed the largest increase; this year, it dropped by 12.4 percent).

Firms are now becoming experienced in responding to the R&D survey, and it is expected that consistency of reporting will continue to improve. In the future, improved consistency of reporting may mean that data from earlier surveys may need adjusting, if long-term trends are to be extrapolated.

Table 4. Extramural R&D funded by business enterprises, 1992/93 by industry group

Industry of Enterprise		Number of Enterprises	Sector of Recipient of R&D Funding, ($000)					Increase since 1991/92
NZSIC Codes	**Description**		**Government ***	**Universities**	**Other Business Enterprises**	**Overseas Organisations**	**Total** ($000)**	**($000)**
1000	Agriculture, forestry and fishing	22	550	n.p.	1,150	n.p.	1,950	520
2000,371,372, 381	Mining, basic metals and metal fabrication	11	n.p.	90	n.p.	n.p.	420	(140)
351,352,353,354	Chemicals (fertilizers, pesticides, paint, drugs)	21	510	180	830	2,400	3,920	(260)
310,320,355,356	Food, textiles, plastics production	50	630	410	1,420	2,730	5,580	(250)
	Producer bds: Food, textiles, Plastics	11	9,610	2,780	31,810	7,410	51,600	20
330,340,360,382-385,390	Electrical and oth. machinery, and oth. manufacturing	38	2,040	50	1,370	380	4,190	(1,640)
4000 - 7000	Infrastructure services	62	1,170	1,360	3,940	2,830	10,700	(1,630)
8000 except 8324	Financial, Software development services	14	n.p.	n.p.	1,520	430	2,450	980
8324,9000	Engineering, scientific services	62	1,710	3,380	n.p.	n.p.	6,200	(12,210)
1000-9000	Total 1992/93	291	16,380	8,680	43,850	18,830	89,940	(11,670)
1000-9000	Total 1991/92	286	19,488	8,771	55,183	18,169	101,611	+19,052§
1000-9000	Total 1990/91	265	10,366	7,661	51,519	13,012	82,559	+5,564•

* Local authorities are included in the Government column.

** Excludes n.p. (not published)

• Increase since 1989/90.

Table 5. Intramural business enterprise R&D expenditure, by industry group, 1992/93

NZSIC group	Industry group	Number of Firms	Expenditure 1992/93	Expenditure 1991/92	Expenditure 1990/91
			Total ($000)	Total ($000)	Total ($000)
1000	Agriculture, forestry and fishing	26	7,020	4,500	3,722
2000, 371, 372, 381	Mining, basic metals and metal fabrication	45	6,520	9,510	9,291
351, 352, 353, 354	Chemicals (fertilizers, pesticides, paint, drugs)	50	12,820	13,140	14,323
310, 320, 355, 356	Food, textiles, plastics production	135	72,813	68,770	61,222
3830, 3832	Electrical machinery (electronic, appliances)	55	27,750	17,820	16,275
3820, 3825, 3850	Machinery (industrial, office, instruments)	55	9,580	12,250	11,391
330, 340, 360, 390	Other manufacturing (wood, paper, concrete)	61	7,510	8,820	12,219
384	Transport equipment (railroad etc)	11	1,200	1,830	1,543
4000 - 7000	Infrastructure services	91	18,140	18,300	24,264
8000 Except 8324	Financial, software development services	98	28,680	26,380	34,488
8324,9000	Engineering, scientific services	126	17,690	20,200	15,663
Producer Boards and Research Associations*		13	* 53,810	* 45,892	* 52,867
1000-9000	**TOTAL**	753	209,730	201,520	204,090

* Data also included in the Total column

12 R&D as a percent of output in the manufacturing sector

Table 6 provides information supplied to the Ministry by the Manufacturers' Federation on output and net profit by industry. This has been matched with the R&D survey data to provide ratios for each industry of R&D expenditures and output.

Table 6. R&D Expenditure by the Manufacturing Sector, 1992/93

	Output * $m	Net profit $m	Profit to Sales ratio	R&D expenditure $m	R&D as % of Output
Primary food processing	10,702	349.2	3.3%	46	0.43%
Other food, beverages & tobacco	6,346	722.4	11.4%	18	0.29%
Textile, apparel & leather goods	2,903	248.1	8.5%	16	0.54%
Wood and furniture	3,425	408.3	11.9%	2	0.06%
Paper products, printing & publishing	4,346	387.4	8.9%	4	0.10%
Chemicals. petroleum, coal, rubber & plastic products	5,244	514.6	9.8%	21	0.40%
Non-metallic mineral products	1,108	167.9	15.2%	2	0.14%
Fabricated metals, machinery & equipment	10,589	625.2	5.9%	44	0.41%
Other manufacturing	410	43.7	10.7%	1	0.15%
Total manufacturing	45,073	3466.8	7.7%	153	0.34%

* Output and net profit for yr ended Dec 93

Research associations and producer boards included.

Industry groups with a high ratio of R&D to output include the textile industry (0.54%), primary food processing (0.43%), and fabricated metals and electrical machinery (0.41%).

More detailed R&D statistics for the plastics and the electronics industries show some interesting contrasts. Plastics R&D increased from $4.8 million to $5.9 million from 1992 to 1993, whereas electronics R&D went from $17.8 to $27.8 million (see Table 5). Total output in the plastics industry was $1,001 million, in electronics $1,471 million, giving R&D to output ratios of 0.6% and 1.9% respectively.

The electronics industry has experienced staff growth of 20% and export growth of 45% since 1991, and most companies have strategic planning for continued growth (Marion Rogers, Tritech).

A recent study carried out at Massey University concluded that the plastics industry as a whole was under-investing in R&D. While the largest companies (more than 100 staff) invest in R&D at 3% of sales, industry wide the percentage is only 0.6%.

International comparisons are available for rubber and plastics. These statistics are for the most recent available year for each country, where this ranges from 1989-1993.

Table 7 Ratio of R&D to output for rubber and plastics, international comparisons

Country	R&D as % of output
Australia	0.25
Denmark	0.6
Finland	1.96
Netherlands	0.55
Norway	0.67
Sweden	0.95
UK	0.35
USA	0.82
NZ	0.34

The NZ plastics industry is competing on the world market. It is paying wages at rates lower than Taiwan, indicating that there is little further room to cut costs. There are problems with the availability of leading edge tool and dye making skills in NZ, resulting in reliance on importing the necessary products from Singapore.

Sources of information:
Plastics: Study carried out at Massey University, Professor Don Barnes, Manufacturing and Production Systems, Faculty of Technology.
Electronics: Tritech consultant, Marion Rogers.

13 Type of R&D expenditure in the business sector

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

Wages and salaries consumed 54.6 percent of the $209.7 million allocated to R&D in the business enterprise sector, a marginal increase to the previous period. Other current expenditures accounted for 35.8 percent, compared with 37 percent in 1991/92. Capital expenditures were 9.6 percent, compared with 9 percent in 1991/92.

Table 8. Type of R&D expenditure, by industry group, 1992/93

Industry of Enterprise		Type of Expenditure, ($000)			
NZSIC Codes	Description	Wages and Salaries	Other Current Expenditure	Capital Expenditure	Total
1000	Agriculture, forestry and fishing	2,950	3,530	540	7,020
2000,371,372,381	Mining, basic metals and metal fabrication	4,610	1,620	300	6,520
351,352,353,354	Chemicals (fertilizers, pesticides, paint, drugs)	7,110	4,800	910	12,820
310,320,355,356	Food, textiles, plastics production	37,950	25,490	9,370	72,810
3830,3832	Electrical machinery (electronic, appliances)	15,550	8,390	3,810	27,750
3820,3825,3850	Machinery (industrial, office, instruments)	6,040	3,160	370	9,580
330,340,360,3843,90	Other manufacturing (wood, paper, concrete)	3,630	3,550	330	7,510
	Transport	630	380	200	1,200
4000 - 7000	Infrastructure services	9,330	6,760	2,060	18,140
8000 Except 8324	Financial, software development services	16,220	11,490	960	28,680
8324,9000	Engineering, scientific services	10,430	5,860	1,390	17,690
1000 - 9000	**TOTAL (1992/93)** (Includes Research Associations)	114,450	75,030	20,240	209,720
	Percent	54.6	35.8	9.6	100.0
	Research Associations	28,860	17,200	7,750	53,810
1000-9000	**TOTAL (1991/92)** (Includes Research Associations)	108,738	74,553	18,229	201,520
	Percent	54.0	37.0	9.0	100.0
1000-9000	**TOTAL (1990/91)** (Includes Research Associations)	109,922	73,810	20,668	204,400
	Percent	53.8	36.1	10.1	100.0

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

In Table 9, statistics are given for 11 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 of 146 in personnel doing R&D (5.5 percent). The largest overall drop (84, or 32 percent) occured in Infrastructure Services. The largest increase in R&D FTE occured in Electrical Machinery (up 24 percent). There was no significant shift in numbers within any of the enterprises undertaking R&D.

The last columns show the expenditure on R&D per full-time equivalent R&D staff member, an indicator of R&D intensity. This increased, in total, by 10.4 percent over last year. The highest expenditure, per person, was in Financial, Software Development Services followed by that of Transport Equipment. The largest proportionate increase, however, was a 46.3 percent jump in Agriculture, Forestry and Fishing.

Table 9. Number of enterprises and R&D staff, by industry group, 1992/93

NZSIC Codes	Industry of Enterprise	Enterprises undertaking R&D				R&D Personnel FTE				R&D Expenditure per FTE ($000)			
		1992/93		1991/92	1990/91	1992/93		1991/92	1990/91	1992/93		1991/92	1990/91
	Description	All	Producer Boards & Research Assns*	All	All	All	Producer Boards & Research Assns*	All	All	All	Producer Boards & Research Assns*	All	All
1000	Agriculture, forestry and fishing	26	n.p.	28	22	60	n.p.	57	57	117	n.p.	80	65
2000,371,372, 381	Mining, basic metals and metal fabrication	45	n.p.	48	52	90	n.p.	139	111	72	n.p.	75	84
351,352,353,3 54	Chemicals (fertilizers, pesticides, paint, drugs)	50		53	51	130		178	188	99		79	76
310,320,355,3 56	Food, textiles, plastics production	135	7	133	137	970	610	883	874	79	75	68	70
3830,3832	Electrical machinery (electronic, appliances)	55		55	47	380		307	283	73		58	58
3820,3825,385 0	Machinery (industrial, office, instruments)	55		56	57	120		170	149	80		72	76
330,340,360,3 90	Other manufacturing (wood, paper, concrete)	61	n.p.	60	59	70	n.p.	79	119	107	n.p.	112	103
384	Transport equipment (railroad etc)	11		11	17	10		21	27	120		85	57
4000 - 7000	Infrastructure services	91	n.p.	96	106	180	n.p.	264	251	101	n.p.	100	97
8000 Except 8324	Financial, software development services	98		100	97	230		289	310	125		98	111
8324,9000	Engineering, scientific services	125	n.p.	125	91	250	n.p.	269	234	71	n.p.	72	67
1000-9000	**TOTAL**	752	13	765	736	2510	690	2,656	2,603	85	78	77	79

* Producer Boards and Research Associations are also included in "All" data

n.p. = Not published for reasons of confidentiality.

GOVERNMENT

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

15.1 Introduction

The government sector provided $312.4 million worth of research (equivalent to 0.41 percent of GDP). By far the majority of these funds came from within the sector (mostly from FRST funding). By far the majority of extramural R&D funded by government was provided by other agencies of the NZ central government. A total of 3,751 R&D FTEs were employed in CRIs and government departments; in addition, 3,735 R&D FTEs were employed in the university sector (including post-graduate students).

During 1991/92 the main government science departments underwent major restructuring. On the 1st of July 1992, 10 Crown Research Institutes (CRI's) commenced operations and the DSIR, MAF Technology, FRI and the Met Service ceased to exist. As this report covers a major transition period (ie, the setting up of the CRIs) some caution is needed in comparing this year's results with those of last year. This is the first year that CRIs have responded to the survey and it is possible there may be different interpretations of just what constitutes R&D as distinct from scientific and technological services.

During this year, 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.

Total intramural government sector R&D (GOVERD), by science output area, is shown in Table 10.

15.2 Primary production

As in 1991/92, the major effort in government R&D (44 percent) was in this area (Output Classes 1 to 10). In absolute terms it received seven times more funding in the government sector than in the business enterprise sector ($138 million versus $21 million). However, government provided $14 million less research than last year. This was partly offset by a $4 million increase in the amount of R&D done by business.

Of the 10 component output classes, eight are devoted to agriculture, with the remaining two devoted to forestry and fishing.

Table 10. Government sector intramural R&D, 1992/93

Output areas	Govern-ment ($000)	Group			Business ($000)	Group		
		Total	%	% of Group		Total	%	% of Group
Primary production								
01 Sheep (meat)	0			0	170			1
01 Sheep (wool)	0			0	940			5
01 Sheep (general)	11,020			8	2,960			14
02 Beef Production	{4,480 }			{3}	220			1
03 Dairy Production	{ }			{ }	1,970			9
04 Alternative Animal Species	5,340			4	220			1
05 Generic Animal Research	11,360			8	1,610			8
06 Forage Plants	22,310			16	2,730			13
07 Horticulture	33,220			24	2,970			14
08 Arable Crops & other Plants	15,900			11	2,000			10
09 Plantation Forestry	16,950			12	4,790			23
10 Fisheries	17,850	138,430	44	13	240	21,020	10	1
Primary products and processing								
11 Meat Processing	3,500			13	12,600			17
12 Dairy Processing	1,290			5	32,380			43
13 Other Food Processing	11,920			43	9,580			13
14 Fibre, Textiles & Skin Processing	n.p.			1	13,880			19
15 Wood & Paper Processing	10,830	27,940	9	39	6,240	74,680	36	8
Materials, engineering								
16 Materials & Industrial Processing	15,810			56	17,220			31
17 Engineering	3,600			13	20,860			37
18 Electronic & Instruments	8,990	28,400	9	32	17,640	55,720	27	32
Infrastructure								
19 Construction	{3,140}			{24}	6,680			17
20 Commercial & Trade	{ }			{ }	3,050			8
21 Energy	4,980			37	1,880			5
22 Transport Services	1,820			13	2,490			6
23 Information & Communication	2,650			20	23,940			61
24 Urban & Rural Planning	920	13,510	4	7	1,090	39,130	19	3
Social sciences								
25 History, Society & Culture	5,860			31	240			7
26 Relationships & Wellbeing	4,030			21	330			9
27 Political & Economic Relationships	4,110			21	2,820			78
28 Education, Knowledge & Training	5,180	19,180	6	27	240	3,630	2	7
Environment								
29 Environment Protection	9,980			15	1,460			53
30 Geological Structures & Processes	10,720			16	400			14
31 Land use, Flora & Fauna	16,960			25	660			24
32 Marine & Fresh Waters	19,310			28	170			6
33 Climate & Atmosphere	9,270			13	30			1
34 Space	{2,440}			{4}	n.p.			0
35 Antarctica	{ }	68,680	22	{ }	n.p.	2,780	1	2
Miscellaneous								
36 Fundamental Knowledge	3,170			18	n.p.			1
37 Health	2,550			15	11,040			85
38 Defence	{11,650}			{67}	n.p.			0
Other	{ }	17,370	6	{ }	1,750	12,960	6	14
TOTAL	312,510	312,510	100		209,720	209,720	100	

n.p. = Not published

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Output Class 7 (new and improved horticultural crops, including vegetables and management practices) accounted for 24 percent of primary production R&D, followed by forage plants (16 percent), fish harvesting (13 percent), trees and plantations (12 percent), and arable crops (11 percent).

The amount of R&D carried out in each output area was quite different for government and business enterprise sectors. Horticulture was the largest area in the government sector and forestry was the largest in the business enterprise sector.

15.3 Primary products and processing

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 (9 percent) although it comprised 36 percent of the business enterprise sector's R&D. The total effort in the government sector's R&D in this area was $27 million, which is about one third of the R&D carried out in the business enterprise sector ($75 million). This is $10.6 million more research done by government (62 percent), and $4 million more by business (9.8 percent) than in 1991/92.

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 43 and 39 percent of the R&D effort, respectively.

Output Class 12 (new and improved dairy processes, storage techniques and products) received only 5 percent of the government sector's R&D effort. However, it was the most heavily funded component ($32.4 million) of the business enterprise sector's R&D, comprising 43 percent of the total effort in the processing areas.

15.4 Materials, engineering, computing and communications

Although R&D in the area of materials, engineering and telecommunication (Output Classes 16 to 18) accounted for 27 percent of the expenditure in the business enterprise sector ($55.7 million) it was of less importance in the government sector ($28.4 million, 9 percent of total funding). Compared to last year's results, the business figures remain virtually unchanged; government R&D in this area has dropped by about $2 million (6.5 percent).

Output Class 18 (new and improved computing and electronic, communication and instrumentation processes, systems and products, i.e. computer hardware) was the fourth most heavily funded class in the business enterprise sector ($17.6 million). In the government sector it was funded only to the extent of $9 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.

Similar arguments apply to Output Class 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 the largest area of business enterprise sector R&D in New Zealand, with a total expenditure of $41.5 million, or 19.8 percent all the business enterprise sector's R&D. The comparable value for government sector R&D in these two output classes is only about $11 million, or less than 4 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 group (about 56 percent). Output Class 17 (new and improved engineering processes, systems, and production) received 13 percent and Output Class 18 received 32 percent of the funding within this group.

By contrast, Output Classes 16, 17 and 18 each received about one-third of the business enterprise sector's funding R&D for this group (31 percent, 37 percent and 32 percent, respectively).

15.5 Infrastructure and services

Infrastructure and services (Output Classes 19 to 24) was better funded in the business enterprise sector than in the government sector, with 19 and 4 percent of funding, respectively. However, this masks the interesting trend that government R&D has actually gone up in this area ($8 million or 160 percent), while business R&D has dropped ($2 million or 5 percent). The major effort in this area was in energy production, comprising 37 percent of the total, followed by construction and commercial and trade (24 percent) and information and communication (20 percent).

15.6 Social Sciences

The government sector provided $19 million dollars of research (up $8 million) in this area, private enterprise provided $3.6 million worth of research (78 percent of which was in political and economic relationships). The most noticeable change in the government sector is in the relationships and wellbeing category. This trend is somewhat misleading, however, as the figures actually represent a reclassification of policy work as research by one major department.

15.7 Environment, exploration and assessment of the Earth

About a quarter (22 percent) of the R&D funding in the government sector was in the area of environment, exploration and assessment of the earth, i.e. in Output Classes 29 to 35. By contrast, this kind of research comprised only 1 percent of the R&D of the business enterprise sector (equivalent to 4.0 percent of government funding). Government research in this area has dropped by $3 million (4 percent); business research in the environment has dropped as well ($1 million or 27 percent).

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, together comprised about two-thirds of the government expenditure in this group (69 percent). Output Class 29, which deals with R&D in the field of environmental protection, was the next most important (15 percent) closely followed by Output Class 33 (climate and atmosphere -13 percent).

15.8 Miscellaneous

Within the miscellaneous sector the main trends to note were the drop in government input into fundamental research ($7 million or 70 percent) and a drop in health research ($4 million or 63 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. There seem to be significant differences in the figures for various sources of funds for this report, compared to the figures quoted in the report for 1991/92. The differences are more apparent than real, however (indeed, the main point to bear in mind is that there is only a 1.4 percent difference in total funding). There are three reasons that could account for the differences. There seems to be an almost $20 million drop-off in FRST funding between the two years; this is not so, as the "missing" money is allocated as non-specific output funding. This goes to the CRIs and is, in effect, a 10 percent addition on top of what they receive from the contestable bidding process. It allows the CRI management to fund research which would not otherwise be funded. Secondly, the 1992 figures were provided by the residual management units of the old government departments, now reconstituted as the new CRIs. The 1993 figures are reported by the CRIs as companies after the first full year of trading. Hence, many of the differences may simply reflect the new accounting systems of the CRIs. And thirdly, capital expenditure is required instead of depreciation.

The bulk of funding (64 percent) came from the Foundation for Research, Science and Technology, which allocates funds through the public good science fund.

A further 5.5 percent of funding came from "own funds", and 10.4 percent from private sector enterprises, for research undertaken on contract.

Table 11. Source of funds for intramural government sector R&D, 1992/93

Source of Funds	$000)	Percent
Own Funds	17,310	5.5
Foundation of Research Science and Technology	199,680	63.9
Other NZ Central Government Agency	53,410	17.1
NZ Local Government	2,480	0.8
Tertiary Education Sector	200	0.1
Private Sector NZ Enterprises	32,600	10.4
Funds from Abroad	4,350	1.4
Other Sources of Funds	2,350	0.8
TOTAL	312,390	100.0

With provider information from the three sector surveys, it is possible to evaluate the total amount of government spending on R&D in the three sectors. 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. This gives the full contribution to R&D of the business enterprise sector in New Zealand (refer to Tables 3 and 15).

Government agencies funded R&D carried out by other organisations in the government, business and university sectors, as shown in Table 12. By far the majority of extramural R&D research (81 percent) was carried out by central government agencies, including CRIs.

Table 12. Extramural R&D funded by the government sector, 1992/93

R&D Provider	($000)	Percent
Other NZ Central Government Agency	220,410	81.3
NZ Local Government Organisations	2,800	1.0
NZ Tertiary Education Sector	25,960	9.6
Private Sector New Zealand Enterprises	19,050	7.0
Overseas Organisations	650	0.2
Other Organisations	2,430	0.9
TOTAL	271,310	100.0

UNIVERSITIES

1 Intramural higher education sector R&D

1.1 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.

Over the last few years, a number of projects have been undertaken to gather better information on R&D expenditure in the higher education sector. Two publications, in particular, have analysed this information. The first of these, *A profile of Crown-funded R&D in New Zealand, 1991/92*[3], provides information for 1991 on all current university research projects, including full-time equivalent (FTE) personnel engaged.

The next major study, the Bollard review[4], estimated resources used nationally for research in the non-medical university sector. It concentrated on costing that part of university research comprising public good science outputs, i.e. outside of teaching, which was funded by Vote: Education. The methodology is further described in last year's "New Zealand R&D Statistics"[11]

For statistics on university research for 1993 a new survey was developed and carried out by this ministry with the assistance of the NZ University Vice-Chancellors' Committee. The statistics collected covered a wider range of disciplines than any of the earlier surveys. As recommended by the OECD, research in the social sciences and humanities were included, and all university overheads were taken into account. All research which was externally funded was also included.

1.2 The survey methodology

All heads of university departments were asked to estimate the proportion of time academic staff in their department spent on research. The responses indicated that the total time spent on research was between 20% and 30% of academic staff time.

University registries supplied expenditure data for each department in three categories; salaries and wages, operating expenditure, and capital expenditure. Any research expenditure which could not be allocated by department was supplied for the university as a whole, and was added in after department data had been aggregated. The source of external funds for research was also provided.

To obtain the results in tables 13, 14 and 16, total teaching and research expenditure was multiplied by the departmental estimate of the proportion of time spent by academic staff on research, and any "research only" expenditure added to give the total expenditure on research for each department. Each department also estimated the percentage of its research which was carried out in 9 different fields of science (see table 13) and aimed at each of 38 socio-economic output areas (see table 16). Total departmental research expenditure was allocated to fields of science and socio-economic areas according to the percentages supplied by each department.

Each department was also asked to provide personnel full-time equivalents by occupation in four categories; academic staff, technicians, post-graduate students and support staff. Whereas academic staff, technician and support staff full-time equivalents were weighted according to each departmental research estimate, post-graduate student time was weighted as follows:

	Portion of year spent on research
Masters students	0.25
Doctoral students	0.5

To bring the review data into line with OECD recommendations:

- Only personal scholarship carried out specifically for a research project was to be considered an R&D activity;
- Administrative and support staff providing direct project linked administration or clerical services within the R&D unit were included in the count of FTE personnel;
- An allowance for the stipends of post-graduate research students was included in R&D personnel costs, by university if not available by department;
- Research and equipment grants from external sources were included; and
- Overseas funds for research were included.

1.3 Results

Table 13. University R&D expenditure by field of science, 1993

Field of science	($ 000)
Physical Sciences	8,450
Chemical Sciences	10,890
Biological Sciences	26,080
Earth Sciences	6,360
Engineering & Applied Sciences	29,350
Agricultural Sciences &Forestry	20,130
Medical Sciences	49,820
Social Sciences	58,600
Humanities	22,700
TOTAL	232,380

Table 13 shows in what fields of science the universities spent money on R&D. Almost half of the total expenditure was in two fields: Medical Sciences, and Social Sciences.

Sources of funds for university research were provided by each department for externally funded research. Each university provided figures for the total government operating grant and all income from other sources for teaching and research, including student fees. This was used to estimate research expenditure sourced from general university funds from government (GUF) versus other university income. The results are shown in table 14.

Table 14. Source of funds for intramural university sector R&D, 1993

Source of funds	($ 000) NSE (natural sciences & engineering)	SSH (social science & humanities)
Own funds (includes student fees)	29,710	15,990
General university funds (GUF)	78,360	42,170
NZ Govt (includes FRST, HRC)	20,040	10,780
Local Government	710	380
NZ tertiary education sector	730	390
Private sector NZ enterprises (includes SOEs, RAs, PBs)	5,990	3,220
Funds from abroad	5,890	3,170
Private non-profit (LGB,Cancer society,etc)	9,660	5,200
TOTAL	151,090	81,300

GUF = General University funds
FRST = Foundation for Research, Science and Technology
HRC = Health Research Council
SOE = State-owned Enterprise
RA = Research Association
PB = Producer Board
LGB = Lottery Grants Board

Compared with previous surveys[10], the total figure obtained for the university sector R&D from the 1993 surveyis considerably higher than before. There are several reasons for this. The 1993 survey is the first one to be carried out according to OECD recommendations. This resulted in the addition of the following: the medical faculty, all of the humanities, support staff, funding from external sources, and all overheads associated with libraries, computers, and administration. All of these were not fully included in the total R&D expenditure requested in the previous survey.

ALL SECTORS

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.

2 Source of R&D funds, sector of performance and output class, from provider data

Data from R&D providers in each sectoral survey is summarised in Table 15. 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 3.

Table 15. Gross expenditure on R&D carried out in or funded by NZ, 1992/93

Source of funds	Sector of performance ($ 000)						Done in NZ or funded by NZ
	Done by Business	Done by Government	Done by University	Total Done in NZ (GERD)	%of GDP	Done Overseas	
Funded by Business	184,720	32,600	9,210	226,530	0.29	18,830	245,360
Government (FRST)	17,600 (11,700)	272,880 (199,700)	31,910 (500)	322,390 (211,900)		650	323,083
General University Funds (GUF)			120,530	120,530			120,588
Total Funded by Government (includes GUF)				442,920	0.57		
University (own funds)		200	46,810	47,010			47,016
PNP	1,350	2,350	14,860	18,560			18,565
Overseas Funds	6,060	4,350	9,060	19,470			19,477
Total other funds				85,040	0.11		
TOTAL	209,730	312,380	232,380	754,490	0.98	19,480	773,970
% GDP	0.28	0.41	0.30	0.98			
OECD 6 reference countries	1.01	0.30	0.46	1.85			
%of GERD	28.1	41.2	30.7	100.00			
OECD 6 reference countries	56.5	17.9	24.8				

GDP 1992 MSTI $77,067 million
Totals rounded to nearest 10,000
MSTI: Main Science & Technology Indicators[12]
PNP: Private Non-Profit

Thus, from this table it is estimated that the business enterprise sector spent $227 million on R&D carried out in NZ, the government sector spent $443 million (including GUF), and the universities spent $47 million of their own funds. Of the total of $754 million, of research carried out in NZ, $19.5 million was paid for with funds from overseas and a further $ 19 million with private non-profit funds. A further $19 million was spent on research carried out overseas.

Total intramural R&D, by output class, is summarised in Table 16.

Table 16. Intramural R&D, all sectors, by output class, 1992/93

Output Class	Business ($000)	Government ($000)	Universities* ($000)	TOTAL ($000)	
01 Sheep (meat)	170	0		170	
01 Sheep (wool)	940	0		940	
01 Sheep (general)	2,960	11,020	3,090	17,070	
02 Beef Production	{1,970}	{4,480}	1,950	{10,890}	
03 Dairy Production	{ }	{ }	2,070	{ }	
04 Alternative Animal Species	220	5,340	2,630	8,190	
05 Generic Animal Research	1,610	11,360	2,640	15,610	
06 Forage Plants	2,730	22,310	3,950	28,990	
07 Horticulture	2,970	33,220	4,730	40,920	
08 Arable Crops & other Plants	2,000	15,900	2,120	20,020	
09 Plantation Forestry	4,790	16,950	3,710	25,450	
10 Fisheries	240	17,850	2,070	20,160	
% of total primary production R&D	11	73	15	188,210	25
11 Meat Processing	12,600	3,500	1,160	17,260	
12 Dairy Processing	32,380	1,290	1,940	35,610	
13 Other Food Processing	9,580	11,920	2,920	24,420	
14 Fibre, Textiles & Skin Processing	13,880	n.p.	n.p.	15,400	
15 Wood & Paper Processing	6,240	10,830	1,460	18,530	
% of total, primary products processing R&D	68	24	8	111,220	15
16 Materials & Industrial Processing	17,220	15,810	6,160	39,190	
17 Engineering	20,860	3,600	5,580	30,040	
18 Electronic & Instruments	17,640	8,990	11,160	37,790	
% of total, materials, engineering R&D	52	27	21	107,020	14
19 Construction	6,680	{3,140}	1,500	{18,870}	
20 Commercial & Trade	3,050	{ }	4,500	{ }	
21 Energy	1,880	4,980	1,510	8,370	
22 Transport Services	2,490	1,820	420	4,730	
23 Information & Communication	23,940	2,650	3,670	30,260	
24 Urban & Rural Planning	1,090	920	2,130	4,140	
% of total, infrastructure R&D	59	20	21	66,370	9
25 History, Society & Culture	240	5,860	12,860	18,960	
26 Relationships & Wellbeing	330	4,030	6,110	10,470	
27 Political & Economic Relationships	2,820	4,110	16,480	23,410	
28 Education, Knowledge & Training	240	5,180	15,980	21,400	
% of total, social sciences R&D	5	26	69	74,240	10
29 Environmental Protection	1,460	9,980	2,630	14,070	
30 Geological Structures & Processes	400	10,720	3,640	14,760	
31 Land use, Flora & Fauna	660	16,960	2,980	20,600	
32 Marine & Fresh Waters	170	19,310	2,710	22,190	
33 Climate & Atmosphere	30	9,270	1,140	10,440	
34 Space	n.p.	{2,440}	240	{3,840}	
35 Antarctica	n.p.	{ }	1,100	{ }	
% of total, environment & resources R&D	3	80	17	85,900	11
36 Fundamental Knowledge	n.p.	3,170	46,590	49,870	
37 Health	11,040	2,550	45,660	59,250	
38 Defence	n.p.	{11,650}	n.p.	{13,560}	
Other	1,750	{ }		{ }	
% of total, fundamental, health & defence R&D	11	14	75	122,680	16
TOTAL	209,720	312,390	232,390	754,500	100

* University data are estimates for 1991
n.p. = Not published for reasons for confidentiality
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3 Type of expenditure, all 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 17.

Wages and salaries consumed 50 percent of the $312 million allocated to R&D in the government sector, compared with 55 percent in the business sector. Other current expenditure accounted for 42 percent in the government sector and 36 percent in business. Capital expenditure was 8 percent, compared with 10 percent in the business sector. In these three areas the proportion of expenditure allocated by universities was similar to that of government.

Table 17. Type of R&D expenditure, all sectors, 1992/93

Type of Expenditure	Sector					
	Business ($ million)	Percent	Government ($ million)	Percent	University ($million)	Percent
Wages & Salaries	114.3	55	155.1	50	119.0	51
Redundancies	n.a.	n.a.	1.5	0	na	0
Other current	75.0	36	131.7	42	94.8	41
Capital - land & Buildings	n.a.	0	2.7	1	n.a.	n.a.
Capital - Plant, machinery, etc.	20.4	10	21.5	7	18.6	8
TOTAL	209.7	100	312.4	100	232.4	100

n.a. = not available separately (included in following row)

PERSONNEL

20 R&D personnel

20.1 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. For the first time, full-time equivalent (FTE) staff numbers, essentially the number of staff full-time equivalents on the payroll, are given (see Table 18, staff FTE). The proportion of these FTE spent doing researching is also given (R&D FTE). This gives a much better estimate of the R&D effort than does head-counts of personnel. This is the reason that statistical data is collected in R&D FTE for the OECD.

Research associations and producer boards are included in the business sector (previously, they were treated separately).

Table 18. Full-time equivalent personnel engaged in R&D, all sectors, by occupation, 1992/93

Occupation	Gender	Business Enterprise		CRI's		Other Government		Univer-sities		Total all sectors •	
		Staff FTE	R&D FTE	Staff FTE	R&D FTE	Staff FTE	R&D FTE	Staff FTE	R&D FTE	Staff FTE	R&D FTE
Researchers	M	1,326	1,154	1,203	1,093	224	180			2,752	2,427
	F	226	193	198	173	128	110			552	476
	Total	1,551	1,347	1,401	1,266	352	291	4,322	1,173	7,627	4,076
PhD and Masters Students								5,780	1,852	5,780	1,852
Technicians	M	746	618	972	857	140	127		0	1,858	1,602
	F	279	231	558	407	33	24		0	870	661
	Total	1,025	849	1,530	1,263	173	151	1,260	497	3,987	2,760
Support staff	M	155	130	314	276	33	22		0	502	427
	F	302	183	464	426	80	56		0	846	666
	Total	457	312	778	702	113	79	815	213	2,163	1,306
All FTE	M	2,226	1,902	2,489	2,225	397	329		0	5,112	4,456
	F	807	606	1,220	1,006	242	191		0	2,268	1,803
	Total	3,033	2,508	3,709	3,231	639	520	12,176	3,735	19,557	9,994
Total government:						4,347	3,751				

• Gender sub-totals do not include university FTE

The total number of staff FTE spending at least part of their time in R&D came to 19,557 FTE. These staff carried out a total of 9,994 FTE in R&D. Excluding universities, 5,112 (69 percent) were male and 2,269 (31 percent) were female. Aside from universities, 80 to 90 percent of a researcher's time was spent in research. The highest figure (90 percent) came from CRIs.

In universities, R&D effort accounted for 27 percent of a staff member's time (much of the rest was spent on teaching). Universities also provided information on PhD and Masters students, who spent an average of 32 percent on research (this figure includes research in the humanities and social sciences).

Women make up 27 percent of R&D staff in the business sector (while doing 24 percent of the research), 33 percent in CRIs (undertaking 28 percent of the research), and 38 percent in other government departments (and doing 37 percent of the research).

Women, excluding universities, account for 17 percent of researchers (while doing 16 percent of the research), 32 percent of technicians, and 63 percent of support staff. The highest proportion of women researchers are found in other government departments (almost equally lowest in business and CRIs). The highest proportion of women technicians are found in CRIs and the lowest in other government departments. The highest proportion of women support staff are found in other government departments (the lowest in CRIs).

Using the "all sector" figures (measured in terms of FTEs actually spent in research) there are 0.52 technical staff for each researcher. This may be compared to an Australian survey (1990) which showed this ratio to be 0.34 across all sectors. In CRIs the figure is 0.99 technicians per researcher, in business the figure is 0.63, in other government departments 0.52, and in universities the figure is 0.16.

20.2 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 are shown in Table 19. There was no data from universities. The information shows:

- The highest proportion of PhDs among R&D staff occurs in CRIs (23 percent). The lowest proportion occurs in business (9.0 percent);

- Forty-four percent of staff in the business sector have some kind of Batchelors degree; the equivalent figure for CRIs is 29 percent and 50 percent in other government departments. Thus, in these three groups combined, Batchelor degrees are the most common qualification among R&D staff (at 37 percent);

- People holding technical qualifications represented 13 percent of R&D personnel (ranges from 9 to 19 percent over the sectors). People holding trade qualifications represented 5 percent of R&D staff.

- R&D staff with "other post-secondary" qualifications represented 5 percent, those with "secondary" qualifications 17 percent (roughly equal across all sectors), and "other" came to 7 percent.

- Excluding universities, women made up 10.3 percent of PhDs and 26.7 percent of batchelors degrees (while making up 29.2 percent of all staff).

Table 19. Full-time equivalent personnel engaged in R&D, all sectors, by qualifications, 1992/93

Qualification	Gender	Business		CRI's		Other Government		Total (Business+ Govt)	
		Staff FTE	R&D FTE	Staff FTE	R&D FTE	Staff FTE	R&D FTE	Staff FTE	R&D FTE
PhD	M	248	185	729	692	77	64	1,053	941
	F	26	18	83	70	19	14	128	101
	Total	274	203	811	761	96	78	1,182	1,042
Degrees	M	1,093	872	742	672	182	146	2,016	1,690
	F	258	212	327	292	142	117	726	620
	Total	1,351	1,084	1,069	963	324	263	2,742	2,310
Technical	M	448	366	261	221	35	29	744	617
	F	142	113	92	76	11	7	244	197
	Total	590	480	353	298	46	37	988	814
Trade	M	150	191	50	42	45	43	244	276
	F	40	30	20	18	np	3	np	np
	Total	190	221	70	60	45	45	304	326
Other post-secondary	M	57	43	166	137	np	3	np	np
	F	28	23	101	69	5	2	134	94
	Total	85	66	267	206	5	5	357	277
Secondary	M	206	191	347	274	45	36	598	501
	F	255	170	365	318	52	36	672	524
	Total	461	361	713	592	97	73	1,270	1,026
Other/none	M	35	53	199	184	np	9	np	np
	F	47	41	228	166	np	11	np	np
	Total	82	94	427	350	0	20	509	464
All FTE	M	2,237	1,902	2,494	2,222	397	329	5,126	4,453
	F	797	606	1,215	1,009	246	191	2,256	1,806
	Total	3,033	2,508	3,709	3,231	643	520	7,381	6,259

n.p = data not available

No qualifications data available for universities

TECHNOLOGICAL BALANCE OF PAYMENTS

21 Business and Government Sectors

Government and business sector payments and receipts abroad for technical know-how are shown in Table 20. The major trend is seen in the business sector. In 1990/91, business paid out $2.9 million more than it received; in 1991/92 it received a net amount of $4.8 million. This year, the business sector received a net amount of $15.1 million, where the increase was partly due to lower payments (-$7 million) as well as increased receipts (+$3 million). Current government figures have dropped by $2 million, to $2.6 million.

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 $17.7 million (compared to $9.4 million last year).

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, 1992/93

$millions				
	1991/92		1992/93	
	Sales-purchase	Net receipts	Sales-purchase	Net receipts
Business	31.2-26.4	4.8	34.0-19.0 *	15.1
Government	4.6-0.06	4.6	3.0-0.4	2.6
Total net receipts		9.4		17.7

* (estimated from top 100)

ANNEX 1

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

1992/93		Area of Expertise
Dr Rob Whitney	Director, Coal Research	Research Associations
Mr Cliff Gibson	Consultant, 15 Waikare St, Karori	Software Research
Ms Gisela Ahlborn	Research Manager, Fresh Fruit Exports	Horticultural Research (pipfruits)
Ms Janine Cowling	NZ Wool Board	Wool and Fibre Research
Dr Paul Atkinson	NZ Pastoral Agricultural Research Ltd	Pastoral Agricultural Research
Mr Don Killick	Client and Liaison Manager, Industrial Research Ltd	Technology Uptake and Industrial Research
Mr Guy Sanders	Statistics New Zealand	Financial Surveys Section
Ministry of Research, Science and Technology:		
Dr Margriet Theron	Chair	Research Services
Mr Mike Doig	Group Manager, Policy	Priorities and Funding
Ms Pamela Walker-Mulcahy		Convenor Science Resource Analysis

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 e.g. 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

n.e.c. = not elsewhere classified

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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.*

"New Zealand Research and Experimental Development Statistics", All Sectors, 1990/91, Ministry of Research, Science and Technology, Wellington, 1993. *Publication No.7.*

"New Zealand Research and Experimental Development Statistics", All Sectors, 1991\92, Ministry of Research, Science and Technology, Wellington, 1994. *Publication No. 12.*