

Business Expenditure on
Research and Development
(BERD), 2001

*Survey of Research and Development
in the Business Sector, 2001*

Business Expenditure on Research and Development (BERD), 2001

Survey of Research and Development
in the Business Sector, 2001

September 2003

Foreword

This report presents the findings of a survey of R&D performers in the business sector relating to 2001 and updates a regular series on Business Expenditure on Research and Development (BERD) produced by Forfás. The survey relies on the co-operation of R&D performing enterprises in the country and special thanks is due to all of the enterprises that participated in the most recent survey.

If you require further information about this survey please contact:

**Dr. Rhona Dempsey,
S&T Indicators Unit,
Science & Technology Division,
Forfás,
Wilton Park House,
Wilton Place,
Dublin 2,
Ireland.**

Contents

Summary	2
Section 1. Aggregate Levels of Business Expenditure on Research and Development (BERD)	5
Section 2. Analysis by Industrial Sector	9
Section 3. Analysis by Ownership	14
Section 4. Government Funding of BERD	20
Section 5. Human Resources	22
Section 6. Sources of R&D Funding and Types of Costs	25
Section 7. Co-operative Research Ventures and Out-sourced R&D Activity	28
Section 8. Type of R&D Activity and Aims of R&D	33
Section 9. Patents	38
Section 10. Innovation Indicators	45
Appendix 1: Detailed Tables	47
Appendix 2: Methodology	50
Reports Published by Forfás 2002/2003	52
Functions of Forfás	54
Board Members	55

Summary

The field work for the survey was undertaken on behalf of the S&T Indicators Unit in Forfás by the survey unit of the Economic and Social Research Institute (ESRI) during 2002.

Key results from the survey are:

- ▶ R&D activity in aggregate terms in the business sector continued to grow between 1999 and 2001. Total BERD amounted to €917m in 2001, up from €784m in 1999. The average annual growth rate of BERD in the two year period was 8.2%, compared to a rate of 13.2% in the 1997-1999 period. In real terms, allowing for inflation, the average annual growth rate was 4% for 1999-2001 and 11.8% for the previous period (1997-1999). These growth rates reflect a real slowdown in expansion of R&D activity.
- ▶ BERD amounted to 0.95% of GNP in 2001, compared with 1.03% in 1999. The EU average (2000) was 1.21% GDP and the OECD average (2000) 1.56% GDP.
- ▶ A small number of sectors dominate business R&D activity in Ireland, viz. Electrical & Electronic equipment; Software & Computer related services; Pharmaceuticals; Instruments; Food, Drink & Tobacco. An important trend over the past decade has been the systematic and substantial increase in Software & Computer related services as well as the decline in the share of BERD accounted for by the Pharmaceuticals sector.
- ▶ R&D intensity in the manufacturing sector, as measured by the level of R&D related to industry output, continues to be low and has declined relative to 1999 levels. The low intensity in Pharmaceuticals and Electronics is particularly worrying. This is further evidence of the lack of integration of multi-nationals in these sectors into the national economy, as they dominate these sectors.
- ▶ Foreign-owned enterprises accounted for 65% of BERD in 2001, up slightly on 1999.
- ▶ The number of firms spending significant amounts of money (more than €1.3m) on R&D increased from 98 in 1999 to 111 in 2001. Of these, 65 were foreign owned (55 in 1999) and 46 Irish owned (43 in 1999).
- ▶ The number of researchers in the business sector increased from 5,291 in 1999 to 5,971 in 2001. Normalised by industrial employment numbers this amounts to 4.3 researchers per 1000 in 1999, rising marginally to 4.5 researchers per 1000 in 2001, and is above the EU average of 4.1. The gender balance in Ireland is above the EU average also (23.4% female versus 13% across the EU).
- ▶ In addition to in-house R&D measured by BERD, enterprises in Ireland also commissioned a considerable amount of R&D outside their companies. This totalled €110m in 2001. Over 70 per cent of this was commissioned by overseas companies operating in Ireland. Nearly half (€53.2m) was R&D outsourced by the Electrical & Electronic equipment sector.
- ▶ The reported levels of R&D collaboration by firms in 2001, either with other firms or with the public sector research system, are almost the same as those reported in the 1993 BERD survey. The intervening period has not led to any significant increase in co-operative behaviour, particularly with the higher education sector, despite numerous policy initiatives aimed at raising such co-operation.

Key findings from the Community Innovation Survey (2000) for Ireland are:

▶ Ireland, on par with the EU average, saw half of all firms surveyed introduce new or improved **products** during the 1998 to 2000 period. This represents a decline from the 62% of firms introducing new or improved products reported for the 1994 to 1996 period.

▶ Forty percent of firms had introduced or developed at least one new or improved process in the 1998 to 2000 period. This is lower than the EU average where the latest available data shows that 53% of firms introduced new or improved processes. The current Irish level is also lower than the levels of 52% and 58% reported over the 1992 to 1996 period.

(It is important to note that these products and processes are not necessarily new to the market.)

▶ In terms of annual turnover of a company the growing importance of innovative products (new or improved) is quite striking. 42% of the survey population's turnover in 2000 was due to the introduction of new/improved products. The proportion of turnover contributed to by new/improved products has risen significantly since the early 1990's and Ireland lies significantly above the EU average (31%).

▶ Lack of financing and relatively high innovation costs are ranked as the greatest barriers to innovation in both manufacturing and service sectors. Complying with regulations and standards was also perceived as a significant barrier to innovation in the service sector.

1 Aggregate Levels of BERD

1.1 Introduction

The Business Sector Research & Development Survey 2001 continues a series of biennial surveys carried out by Forfás and its predecessors for over two decades. The most recent survey was carried out in 2002. The reference period for most of the data collected was the calendar year 2001. The field work for the survey was performed on behalf of Forfás by the Economic and Social Research Institute (ESRI) in the period July – December 2002. A methodological note on operational procedures including sampling, fieldwork procedures, re-weighting and analysis of the data is included as an appendix to this report (see Appendix 2).

This section provides a broad overview of the aggregate level of BERD in Ireland in 2001 along with trends therein over the last decade. In addition, the relative share of R&D in terms of total output is discussed and also the position in terms of level of R&D activity and intensity compared to other OECD and EU member states.

1.2 Aggregate Levels of BERD in Ireland, 1993-2001

Table 1.1 and Figure 1.1 present details on the aggregate level of BERD in Ireland from 1993 to 2001. From this it can be seen that a total of €916.8m was spent on R&D activity in Ireland in 2001 by the business sector. This represents a growth in nominal figures of 167 per cent between 1993 and 2001. In constant 2001 terms the 1993 base is €392. This means that there has been a real growth BERD of 134 per cent over the period in question. It is clear that very high levels of growth were recorded in the early to mid 1990's – biennial rates of the order of 30 per cent.

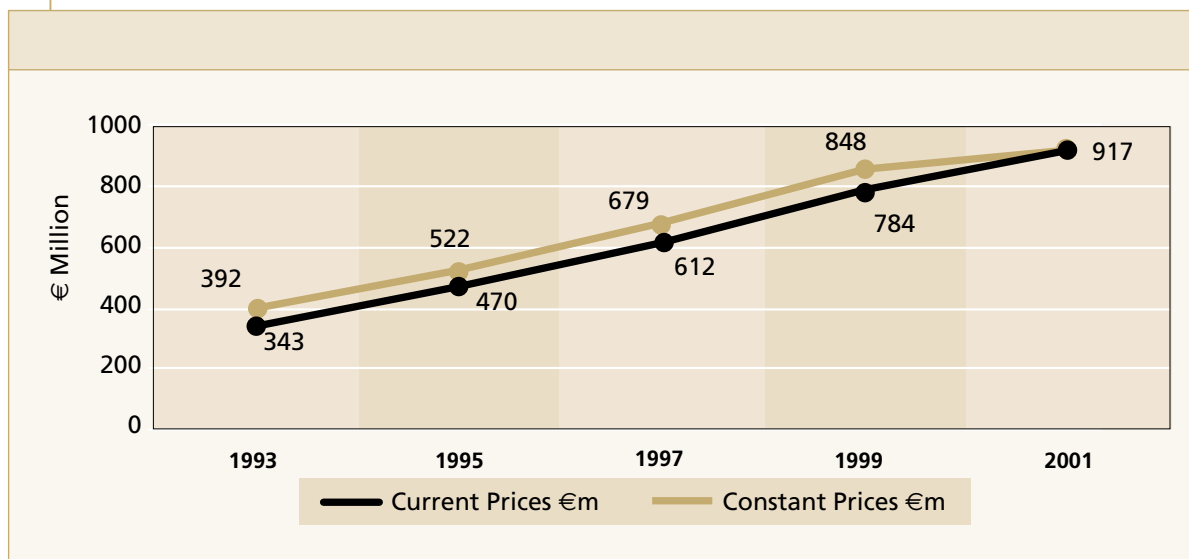
Table 1.1: Trends in BERD in Ireland 1993 – 2001

	1993	1995	1997	1999	2001
€ Million (current)	343	470	612	784	916.8
% change	-	37.0%	30.2%	28.1%	16.9%
€ Million (constant 2001) ¹	392	522	679	848	916.8
% change	-	33.2%	30.1%	24.9%	8.1%

This growth rate slowed somewhat between 1997 and 1999 (to 25 per cent) and stood at 8 per cent in real terms between 1999 to 2001 (representing a nominal growth of 17 per cent over that period). It would clearly be extremely difficult to sustain biennial growth rates comparable to the levels experienced in the early 1990's, coming off such a rapidly expanding base. As the aggregate level increases each year it becomes increasingly difficult to return the levels of increase experienced during the earlier years of the decade.

¹ (General Wholesale price index used to bring to constant 2001. 2001 to 1993 deflator – 100.0; 97.8; 92.5; 91.5; 90.1; 90.5; 90.1; 88.3; 87.4).

Figure 1.1: Trends in Business Expenditure on Research & Development 1993-2001 in constant and current prices



1.3 Relative Importance of BERD and International Comparisons

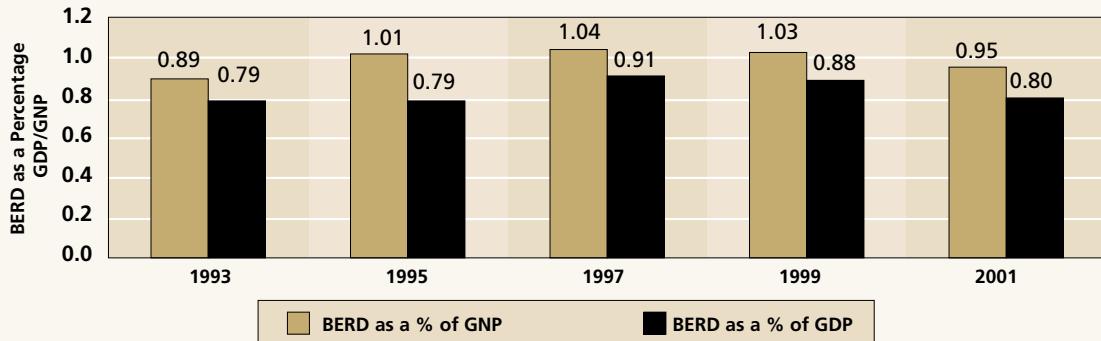
To assess the overall relative importance of BERD to the national economy it is important to consider its size relative to Gross Domestic Product (GDP) and Gross National Product (GNP). The results are outlined in Table 1.2 and Figure 1.2. From these it can be seen that in 2001, BERD represented 0.95 per cent of Irish GNP or 0.80 per cent of GDP. The pattern in regard to both measures is comparable over the 1990's. For example, BERD as a percentage of GNP rose from 0.89 per cent in 1993 to peak at 1.04 in 1997/99 before falling back somewhat to 0.95 per cent in 2001. The use of GNP for Ireland is preferred as GDP data are inflated by the transfer pricing policies of large multinationals. Very few other developed economies have such high levels of net factor payments. Accordingly, the differences between their GNP and GDP figures are, in fact, insignificant in most cases.

Table 1.2: Changes in the contribution of BERD to GNP and GDP, 1993 – 2001

	1993	1995	1997	1999	2001
BERD (current €m)	343	470	612	784	917
BERD as percentage of GNP (%)	0.89	1.01	1.04	1.03	0.95
BERD as percentage of GDP (%)	0.79	0.79	0.91	0.88	0.80
EU average as percentage of GDP (%)	1.18	1.18	1.13	1.19	1.21
OECD average as percentage of GDP (%)	1.44	1.44	1.48	1.52	1.56
Rank among 26 OECD countries as % of GDP*	15	13	13	14	15

*GNP used for Ireland

Figure 1.2: Trends in BERD in Ireland as a percentage of GDP and GNP, 1993-2001



It is particularly clear from table 1.2 that Ireland has lagged behind the EU and OECD averages over the 1990's. In 2001 our figure of 0.95 per cent compares with an EU average figure of 1.2 per cent and an OECD average figure of almost 1.6 per cent.

Table 1.2 also shows Ireland's ranking in terms of BERD as a percentage of GNP/GDP among 26 OECD countries. This shows that we currently stand 15th out of the 26 countries in question. This has remained relatively consistent over the 1990's. (See Appendix Table A1.1 for detailed figures for each of the 26 OECD countries in question).

Figure 1.3: Trends in BERD as a percentage of GDP/GNP for Ireland; EU and OECD, 1993-2001

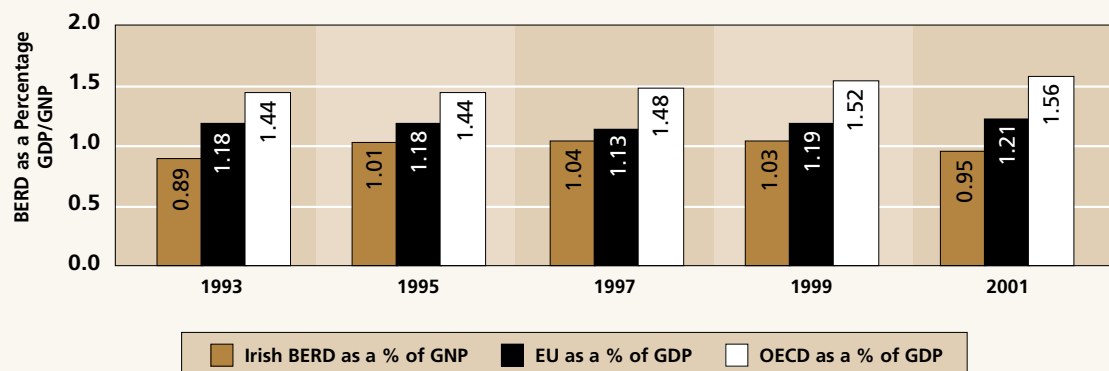


Table 1.3 provides further comparative figures for BERD levels as a percentage of GDP for a number of countries. It can be seen, for example, that R&D activity in Sweden, which is ranked first among the OECD, accounts for 2.84 per cent of GDP; in Finland it accounts for 2.39 and in the Netherlands (ranked 13th in the OECD) it accounts for 1.13 per cent of GDP. This would seem to underline the need to advance policies to promote R&D activity in Ireland among the business sector.

Table 1.3: *Business R&D Expenditure as a percentage of GDP, 1993 - 2001*

	1993	1995	1997	1999	2001
OECD Average	1.44	1.45	1.48	1.52	1.56
EU Average	1.18	1.12	1.13	1.19	1.21
Sweden	2.28	2.57	2.75	2.84	2.84
Finland	1.27	1.45	1.79	2.19	2.39
Netherlands	0.99	1.04	1.11	1.14	1.13
Ireland (GNP)	0.89	1.01	1.04	1.03	0.95

1.4 Summary

In 2001, BERD levels in Ireland reached €917m. After a period of sustained high levels of growth over the early 1990's there has, in recent years, been nominal growth levels of 17 per cent (1999-2001) and of 8 per cent in real terms over the same period. Whilst it would be difficult to continue to grow almost exponentially at the high biennial growth rates of 30 per cent as were experienced in the first half of the 1990's, growth levels of recent years do reflect a slowdown in the expansion of R&D activity. This was further indicated by the decline in the percentage of GDP and GNP accounted for by BERD over the recent period of unprecedented economic development in Ireland. In 2001 BERD stood at 0.95 per cent of GNP (0.80 per cent of GDP). This represents a decline in its relative importance to output.

2. Analysis by Industrial Sector

2.1 Introduction

This section presents information on the level of R&D activity broken down by industrial sector. It focuses on the relative importance of R&D within each sector and, where feasible, provides international comparisons on trends over time.

2.2 BERD by Industrial sector

Table 2.1 and Figure 2.1 present information on R&D expenditure broken down by industrial sector. Five main sectors accounted for as much as 85 per cent of BERD in 2001. These were: Electrical & Electronic equipment (37 per cent); Software & Computer related activities (27 per cent); Pharmaceuticals (8 per cent); Instruments (7 per cent); Food, Drink & Tobacco (6 per cent).

Table 2.1: Sectoral share of BERD, 2001

Sector	R&D €m	Share of Total %
Electrical & Electronic equipment	343.9	37.5
Software & Computer related	252.3	27.5
Pharmaceuticals	70.7	7.7
Instruments	59.3	6.5
Food, Drink & Tobacco	50.0	5.5
Other Services	37.9	4.1
Machinery & Equipment	21.6	2.4
Chemicals	19.6	2.1
Rubber & Plastics	11.8	1.3
Non-metallic minerals	10.8	1.2
Basic & Fabricated Metal	9.4	1.0
Wood & Wood Products	8.8	1.0
Transport Equipment	6.5	0.7
Textiles/Clothing	6.0	0.7
Other Manufacturing	4.2	0.5
Paper, Print & Publishing	3.9	0.4
Total	916.8	100

Figure 2.1: *Distribution of BERD in 2001 by main sector*

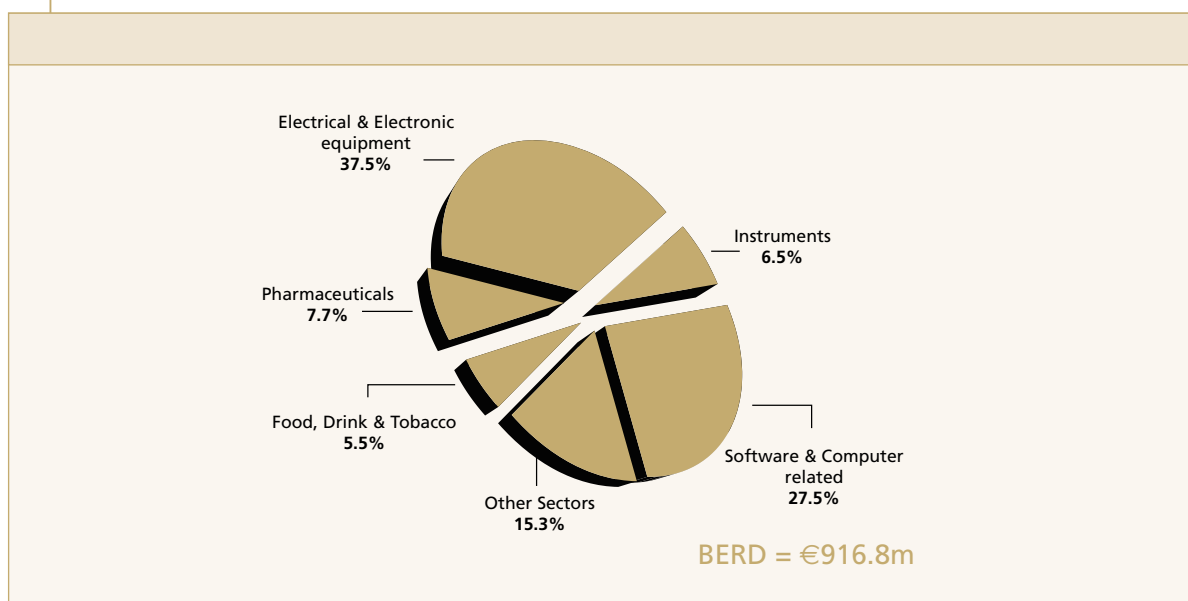


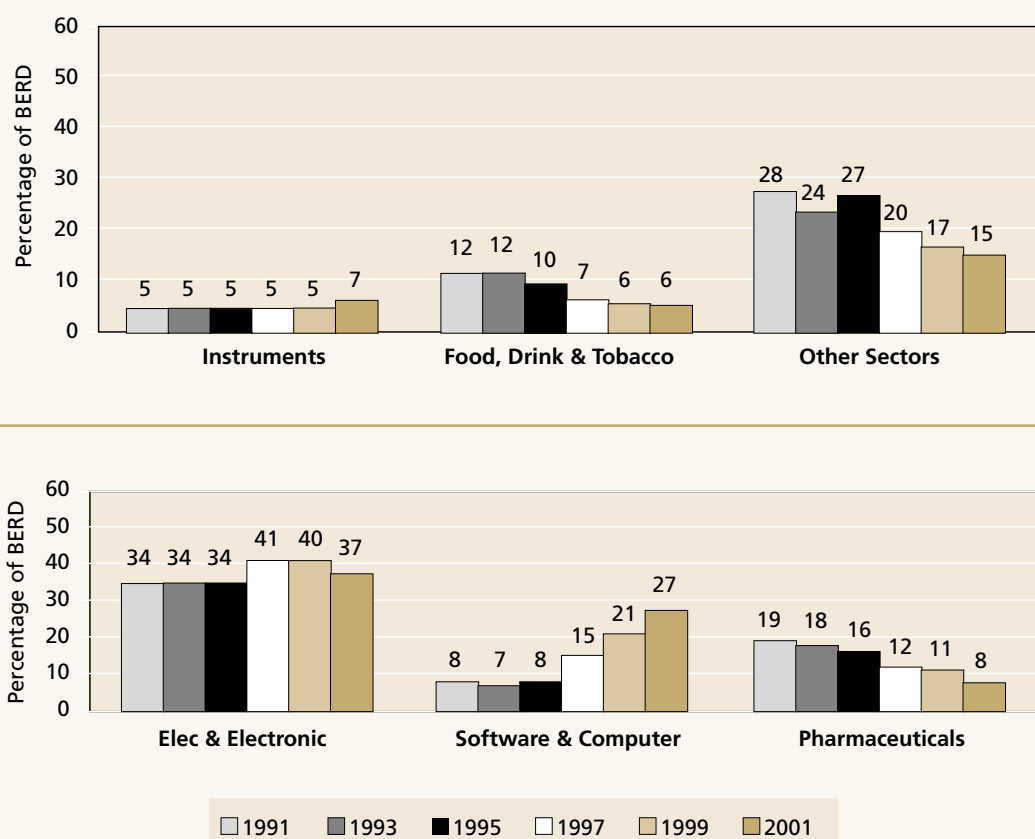
Table 2.2 and Figure 2.2 summarise trends in the broad sectoral breakdown of R&D throughout the 1990's. There have been some changes in terms of the relative importance of some sectors over the decade. The predominance of the Electrical & Electronic equipment sector is clear from the table. The share of this sector has increased from 34 per cent in the early 1990's, peaking at 40 per cent by the end of the decade and then recording a share of 38 per cent in 2001.

The most substantial changes over the last decade in terms of share are apparent in the Software & Computer related as well as the Food, Drink & Tobacco sectors. The share of the Software & Computer related sector in BERD in Ireland has increased substantially throughout the 1990's. In 1993 it contributed only 7 per cent to total R&D expenditure by the business sector. By 2001 the relative importance of the sector had increased by a full 20 percentage points. In contrast, the role of Food, Drink & Tobacco has fallen back from 12 per cent of total in the early 1990's to 5 per cent by the end of the decade. The Pharmaceuticals sector has also declined in terms of its share of BERD, from a high of 18 per cent in 1993 to 8 per cent in 2001.

Table 2.2: *Trends in BERD by main sector, 1993 to 2001*

	1993	1995	1997	1999	2001
	(percentage by sector)				
Electrical & Electronic equipment	34	34	41	40	37
Software & Computer related	7	8	15	21	27
Pharmaceuticals	18	16	12	11	8
Instruments	5	5	5	5	7
Food, Drink & Tobacco	12	10	7	6	6
Other Sectors	24	27	20	17	15
Total	100%	100%	100%	100%	100%

Figure 2.2: Trends in BERD by main sector, 1991 to 2001



2.2.1 Sectoral Intensities of BERD

Whilst examining trends in the absolute levels of BERD is clearly of interest it is possibly of greater importance to consider the contribution of BERD to the output of each sector and changes therein over time. Table 2.3 outlines details on the percentage of output in each manufacturing sector in 2001 accounted for by R&D activity². In aggregate, BERD accounted for 0.6 per cent of total manufacturing output in 2001, compared to an OECD average intensity of 2.4%.

It is evident from Table 2.3 that the manufacturing sectors of key importance in terms of expenditure on R&D in Ireland tend to have higher R&D intensities internationally. The Irish data show that the Electrical & Electronic equipment sector (€343.9m) recorded a 1.4% R&D level; Pharmaceuticals (€70.7m) and Instruments (€59.3m) each recorded a 1.3% R&D intensity. The OECD average R&D intensities for these sectors are 5.6% for Electrical & Electronic equipment; 11.5% for Pharmaceuticals and 7% for Instruments, each sector strikingly higher in R&D levels compared to Ireland.

² Sectoral output figures were derived from the 1999 Census of Industrial Product (CIP). Provisional results from the 2000 CIP (CSO); and Industrial Production index to end December 2001 (CSO Statistical release March 2002).

Table 2.3: *Expenditure on R&D, R&D intensities (% of output) and OECD average R&D intensities classified by sector for 2001*

	R&D €m	% of output	OECD average (estimate)
Electrical & Electronic equipment	343.9	1.4	5.6
Pharmaceuticals	70.7	1.3	11.5
Instruments	59.3	1.3	7.0
Food, Drink & Tobacco	50.0	0.3	0.3
Machinery & Equipment	21.6	1.4	2.1
Chemicals	19.6	0.1	3.2
Rubber & Plastics	11.8	0.9	1.2
Non metallic minerals	10.8	0.7	0.8
Basic & Fabricated Metal	9.4	0.5	0.7
Wood & Wood products	8.8	1.2	0.2
Transport Equipment	6.5	0.5	4.5
Textiles/Clothing	6.0	0.7	0.3
Other manufacturing	4.2	0.3	1.0
Paper, Print & Publishing	3.9	0.0	0.4
Total Manufacturing	626.6	0.6	2.4
Software & Computer related	252.3	-	-
Other Services	37.9	-	-
Total	891.8	-	-

Given the relative importance of these sectors to Ireland's recent economic performance – notably Pharmaceuticals – it is a source of concern that their R&D intensity should be so low. It does, of course, reflect the predominance of manufacturing activities here in those sectors, associated with high sectoral output levels magnified by transfer pricing in multinational companies. The Food & Drink & Tobacco sector is generally not associated with high R&D levels. Ireland recorded an R&D intensity of 0.3% which is at the OECD level for this sector. The relative importance of this sector in the economy (accounting for around 50% of the output of the indigenous manufacturing sector) is one reason why overall R&D intensity for the manufacturing sector in Ireland is low.

Table 2.4 further highlights our performance in terms of R&D intensities relative to OECD averages. The table presents details on the differentials between Ireland's performance and the OECD average as well as the OECD lead country for each of our 5 most important manufacturing R&D sectors. This shows, for example, that in Pharmaceuticals there is a 10 percentage point gap between Ireland's R&D intensity and that of the OECD as a whole. This gap widens to over 21 points if one considers our out-turn relative to Sweden which is the OECD lead country for the sector. At an aggregate level for the manufacturing sector Ireland, at 0.6%, is one-quarter of the OECD average 2.4% R&D intensity.

Table 2.4: *BERD as a percentage of gross outputs (R&D intensities) – Ireland compared with OECD average and lead countries for main R&D performing sectors.*

	Ireland's R&D as % output	OECD average(e) R&D as % output	Lead country R&D as % output	Percentage point gap - Ireland vs. OECD average	Percentage point gap – Ireland vs. Lead Country
Electrical & Electronic equipment	1.4	5.6	9.8	4.2	8.4
Pharmaceuticals	1.3	11.5	22.6	10.2	21.3
Instruments	1.3	7.0	n.a	5.7	n.a
Food, Drink & Tobacco	0.3	0.3	0.7	0.0	0.4
Machinery & Equipment	1.4	2.1	4.3	0.7	2.9
Total Manufacturing Sector	0.6	2.4	3.7	1.8	3.1

2.3 Summary

A small number of sectors dominate R&D activity in Ireland, viz. Electrical & Electronic equipment; Software & Computer related; Pharmaceuticals; Instruments; and Food, Drink & Tobacco. There have been some changes in terms of the share of each sector in total R&D activity in Ireland over the last decade. The most important of these have been the systematic and substantial increase in Software & Computer related along with a progressive decline in Pharmaceuticals.

Our relative performance in terms of R&D performance in the business sector in an international context remains low. This low intensity in key sectors such as Pharmaceuticals and Electronics (which have contributed to recent economic success) is of concern. The dominance of multinationals in these sectors combined with their low R&D intensity points to the need to further integrate multinationals into the national economy. Our overall performance in terms of R&D intensities underlines the need to advance policy in this area to stimulate R&D activity in the business sector.

3 Analysis of BERD by Ownership

3.1 Introduction

This section presents the breakdown for BERD between indigenous industry and foreign-owned industry. It begins by considering BERD levels and intensities (measured as a percentage of total output) before discussing briefly R&D expenditure per capita engaged in this type of activity.

3.2 Levels and Intensity of BERD by Ownership

Table 3.1 provides details on the breakdown of BERD in 2001 according to ownership. Indigenous industry accounted for €318.7m in 2001 (35 per cent of BERD) compared with €598m (65 per cent) in foreign-owned companies.

It is clear that expenditure on R&D in some sectors is largely dominated by foreign owned companies – almost to the exclusion of Irish enterprises. For example, 84 per cent of R&D expenditure in the Electrical & Electronic equipment sector is attributable to foreign owned companies and 88 per cent in Pharmaceuticals. The table also outlines details on R&D expenditure as a percentage of gross output. In overall terms, BERD among indigenous companies accounts for 0.8 per cent of total manufacturing output. The highest R&D intensities amongst Irish companies are in the Electrical & Electronic equipment and Pharmaceuticals sectors (4.2 and 2.3 per cent, respectively). These are followed by the Instruments and Machinery & Equipment sectors (each 1.8 per cent). Intensities in these sectors are higher in indigenous than in foreign companies.

At an aggregate level BERD among foreign companies accounts for 0.6 per cent of their total manufacturing output. Among foreign-owned enterprises the sectors with the highest intensities are generally the same as those for Irish-owned companies namely Electrical & Electronic equipment; Pharmaceuticals; Instruments and Machinery & Equipment (all in the range of 1.0 – 1.2 per cent).

Table 3.1: *Analysis of BERD in 2001 classified according to ownership of company*

	Irish Owned €m	Irish Owned Companies R&D as a % of Gross Output	Foreign Owned €m	Foreign Owned Companies R&D as a % of Gross Output
Electrical & Electronic equipment	53.6	4.2	290.3	1.2
Pharmaceuticals	8.6	2.3	62.1	1.2
Instruments	8.2	1.8	51.1	1.2
Food, Drink and Tobacco	33.7	0.3	16.3	0.2
Machinery & Equipment	12.7	1.8	9.0	1.0
Chemicals	4.1	0.4	15.5	0.1
Rubber & Plastics	8.7	1.2	3.1	0.5
Non-metallic minerals	7.3	0.6	3.5	1.4
Basic & Fabricated Metal	7.1	0.6	2.3	0.3
Wood & Wood Products	5.1	1.0	3.7	1.5
Transport Equipment	3.0	0.7	3.5	0.4
Textiles/Clothing	3.1	0.7	2.9	0.7
Other Manufacturing	3.2	0.3	1.0	0.2
Paper, Print & Publishing	3.4	0.2	0.4	0.0
Total Manufacturing	161.8	0.8	464.8	0.6
Software & Computer related	123.9		128.4	
Other Services	33.0		4.8	
Grand Total	318.7		598.0	

Tables 3.2 and 3.3 provide detail on trends over time separately for Irish-owned and foreign-owned companies for the period 1993 – 2001.

Aggregate intensity levels for the indigenous manufacturing sector stood at 0.7% in 1993, rising to 0.9% throughout the decade up to 1999, and back to 0.8% by 2001.

Table 3.2: *BERD in Irish-owned companies, 1993 – 2001 (current prices)*

	1993		1995		1997		1999		2001	
	R&D €m	% output	R&D €m	% output	R&D €m	% output	R&D €m	% output	R&D €m	% output
Electrical & Electronic equipment	15.4	3.7	27.8	5.0	44.1	5.1	58.2	6.7	53.6	4.2
Pharmaceuticals	4.4	6.5	3.9	4.8	4.8	4.8	5.0	4.6	8.6	2.3
Instruments	1.8	2.4	4.2	4.4	4.9	3.3	13.7	9.0	8.2	1.8
Food, Drink & Tobacco	33.8	0.5	27.5	0.3	26.8	0.3	26.8	0.3	33.7	0.3
Machinery & Equipment	6.6	1.9	12.3	2.7	11.5	1.9	15.4	2.3	12.7	1.8
Chemicals	2.3	0.5	2.9	0.5	3.5	0.5	3.8	0.5	4.1	0.4
Rubber & Plastics	2.6	0.9	8.1	2.0	7.7	1.5	8.3	1.5	8.7	1.2
Non-metallic minerals	4.4	0.7	7.7	1.0	7.1	0.8	4.9	0.5	7.3	0.6
Basic & Fabricated Metal	5.4	0.9	10.3	1.4	8.6	0.9	7.1	0.7	7.1	0.6
Wood & Wood Products	0.3	0.2	1.3	0.4	2.8	0.8	4.2	1.1	5.1	1.0
Transport Equipment	3.1	0.9	3.4	0.8	5.1	1.0	7.2	1.3	3.0	0.7
Textiles/Clothing	3.2	0.8	8.4	1.9	7.9	1.7	3.6	0.7	3.1	0.7
Other Manufacturing	1.4	0.2	5.2	0.7	2.5	0.3	3.5	0.4	3.2	0.3
Paper, Print & Publishing	0.2	4.5	0.3	4.9	0.3	3.2	0.2	3.4	0.2	
Total Manufacturing	87.7	0.7	127.5	0.9	142.2	0.9	164.9	0.9	161.8	0.8
Software & Computer related	11.3	n.a.	18.9	n.a.	53.4	n.a.	92.3	n.a.	123.9	n.a.
Other Services	12.7	n.a.	9.2	n.a.	13.6	n.a.	23.4	n.a.	33.0	n.a.
Total Business Sector	111.7		155.6		209.2		280.6		318.7	

It is clear from the table that the greatest change in R&D intensity levels were recorded in the Electrical & Electronic equipment and Pharmaceuticals sector. The former sector increased from 3.7 per cent in 1993 to 6.7 per cent in 1999 before falling back to 4.2 per cent in 2001. The trend in intensity in the Pharmaceuticals sector indicates slightly longer term decline throughout the 1990's. At the beginning of the decade the R&D intensity stood at 6.5 per cent. This level fell to a reasonably constant level of 4.6 per cent throughout the latter half of the decade before continuing its decline in 2001 to an R&D intensity of 2.3 per cent.

Table 3.2 also shows that the main growth in share of BERD has been in the Software & Computer related sector. This sector accounted for just over 10 per cent of total BERD among Irish firms in 1993. By 2001 Software & Computer related accounted for a share of 38 per cent of BERD. This represents a 996 per cent growth in nominal levels in this sector compared with a 192 per cent growth in total R&D expenditure across all sectors over the period in question.

Table 3.3 presents comparable figures for foreign-owned companies. R&D expenditure accounted for 0.6 per cent of gross output in 2001. There has been a substantial reduction in both the absolute amount and the intensity of the Pharmaceuticals sector; with the level of R&D decreasing from €77.5m in 1999 to €62.1m in 2001.

Table 3.3: *BERD in Foreign-owned companies, 1993-2001 (current prices)*

	1993		1995		1997		1999		2001	
	€m	% output	€m	% output	€m	% output	€m	% output	€m	% output
Electrical & Electronic equipment	102.1	1.6%	132.2	1.2%	206.1	1.5%	257.9	1.2%	290.3	1.2%
Pharmaceuticals	57.8	7.6%	72.2	4.6%	70.1	3.8%	77.5	2.6%	62.1	1.2%
Instruments	16.9	1.7%	19.9	1.7%	23.4	1.5%	25.2	1.0%	51.1	1.2%
Food, Drink & Tobacco	7.9	0.2%	18.9	0.4%	14.3	0.3%	17.3	0.2%	16.3	0.2%
Machinery & Equipment	3.5	0.6%	9.2	1.0%	8.0	0.8%	7.2	0.5%	9.0	1.0%
Chemicals	14.2	0.4%	16.9	0.4%	15.2	0.2%	20.3	0.2%	15.5	0.1%
Rubber & Plastics	1.1	0.3%	4.3	0.8%	3.9	0.7%	3.6	0.4%	3.1	0.5%
Non-metallic minerals	1.9	1.4%	2.8	1.9%	2.9	1.8%	2.1	0.8%	3.5	1.4%
Basic & Fabricated Metal	1.2	0.3%	2.1	0.4%	2.9	0.5%	1.9	0.2%	2.3	0.3%
Wood & Wood Products	0.009	0%	1.3	1.1%	1.6	1.2%	1.5	0.7%	3.7	1.5%
Transport Equipment	4.8	2.7%	6.8	2.7%	8.9	2.9%	5.4	1.1%	3.5	0.4%
Textiles/Clothing	3.9	0.8%	6.4	1.2%	2.9	0.5%	0.6	0.1%	2.9	0.7%
Other Manufacturing	0.074	0%	0.3	0.1%	0.7	0.1%	1.4	0.2%	1.0	0.2%
Paper, Print & Publishing	0.7	0.1%	1.1	0%	1.4	0%	0.5	0%	0.4	0.0%
Total Manufacturing	216.2	1.2%	294.5	1.1%	362.2	1.0%	422.3	0.8%	464.8	0.6%
Software & Computer related	11.3	n.a.	16.8	n.a.	36.5	n.a.	70.3	n.a.	128.4	n.a.
Other Services	0	n.a.	0	n.a.	1.4	n.a.	7.1	n.a.	4.8	n.a.
Total Business Sector	227.5		311.3		400.1		499.7		598.0	

As with the indigenous sector, R&D activity among overseas companies in the Software & Computer related sectors has shown strong growth since the early 1990's. In 1993 Software & Computer related sector accounted for €11.3m (5.0 per cent). By 2001 it had increased to €128.4m (21.5 per cent of total). This represents nominal growth in the level of BERD of over 1000 per cent over the period – compared with an aggregate nominal growth of 163 per cent across all sectors.

3.3 Scale of BERD within companies

Table 3.4 outlines the number of companies in Ireland spending in excess of €1.3m on R&D activity as recorded in 1997, 1999 and 2001. The number of firms has increased from 75 in 1997 to 111 by 2001. This increase in numbers of firms has been experienced by both the indigenous and foreign-owned sectors. Indeed, the pace of growth (in both absolute and proportionate terms) of firms spending very large amounts on R&D has been higher over recent years among Irish companies.

Table 3.4: *Scale of BERD by Irish and foreign companies*

	1997	1999	2001
Foreign-Owned Companies	€400m	€500m	€598m
Irish-Owned Companies	€212m	€284m	€318.7m
Total	€612m	€784m	€916.7m
No. of firms spending more than €1.3m			
Foreign-Owned Companies	50	55	65
Irish-Owned Companies	25	43	46
Total	75	98	111

3.3.1 R&D spend per researcher

Table 3.5 outlines information on total expenditure on R&D activity; numbers of full-time equivalent (FTE) persons engaged in R&D and the corresponding expenditure per capita FTE involved. The table shows, for example, that among all firms BERD expenditure amounts to €100,453 per person engaged (on a full-time equivalent basis). Per capita spend is highest in the Pharmaceuticals, Electrical & Electronic equipment and Instruments sectors (each in the region of €120,000). It is clear from the table that BERD per capita among indigenous companies is generally lower than among their overseas counterparts. In general, the per capita spend for Irish-owned companies is 60 per cent that of foreign companies. The reasons for the difference in per capita spending on R&D between foreign-owned and Irish-owned firms are not known. It is likely that the scale of R&D may be greater in foreign-owned firms which would result in better equipped labs and a higher expenditure on research equipment and consumables. There may also be a higher density of R&D support staff. These factors will result in a higher per capita spend.

Table 3.5: *R&D per capita for Irish-owned and foreign-owned companies, 2001*

	€ Million	FTE	€BERD/FTE*	Ratio Foreign/Irish+
Sector				
Irish-owned Firms				
Electrical & Electronic equipment	53.6	719	74,583	
Software & Computer related	123.8	1713	72,326	
Pharmaceuticals	8.6	126	68,114	
Instruments	8.2	125	65,928	
Food, Drink & Tobacco	33.7	420	80,239	
Other Sectors	90.7	1,197	75,773	
All Sectors	318.7	4,299	74,144	
Sector				
Foreign-owned Firms				
Electrical & Electronic equipment	290.3	2,294	126,541	
Software & Computer related	128.4	1,069	120,113	
Pharmaceuticals	62.1	427	145,383	
Instruments	51.1	377	135,538	
Food, Drink & Tobacco	16.3	147	110,907	
Other Sectors	49.8	512	97,337	
All Sectors	598.0	4,827	123,887	
Sector				
All Firms				
Electrical & Electronic equipment	343.9	3,013	114,142	0.6
Software & Computer related	252.3	2,783	90,656	0.6
Pharmaceuticals	70.7	553	127,778	0.5
Instruments	59.3	501	118,441	0.5
Food, Drink & Tobacco	50.0	568	88,035	0.7
Other Sectors	140.5	1,709	82,234	0.8
All Sectors	916.8	9,126	100,455	0.6

+ Derived figures rounded to one decimal place

* Derived figures rounded to nearest whole number

3.4 Summary

The analysis undertaken shows that R&D intensity levels among Irish companies are 0.8 per cent compared to 0.6 per cent among foreign-owned firms. The R&D intensity of the Pharmaceuticals sector appears to have experienced the most substantial fall of the major R&D spending sectors. In general, the very strong growth in output associated with the boom years of the late 1990's was not matched by comparable increases in expenditure on R&D activity among both the foreign-owned and indigenous sectors.

4 Government Funding of BERD

4.1 Introduction

Government incentive schemes for R&D activity have played a part in encouraging R&D activity in the business sector. These schemes take the form of grants for specific R&D projects and for feasibility studies. This section considers trends in the level of government funding for BERD in Ireland over the latter half of the 1990's up to 2001.

4.2 Government Funding For BERD 1995 – 2001

Table 4.1 outlines trends in levels of government grants for R&D activity over the period 1995 to 2001. Government allocations have increased from €30m in 1995 to €43m in 2001. In contrast, the share of government allocations as a percentage of total BERD have continued to decrease from a high of 6.4% in 1995 to a current level of 4.9%. This reflects international trends as evident from the EU and OECD averages which each indicate a fall over recent years.

Table 4.1: *Trends in the role of government grants allocated as funding for Business Sector R&D in Ireland, 1995 – 2001 (current prices).*

	1995	1997	1999	2001
Total BERD (€m)	470	612	784	916.8
Government allocations for Industry R&D (€m)	30.1	36.7	39.8	43.3
Government allocations for Industry R&D as a % of BERD	6.4%	6.0%	5.1%	4.9%
Rank among 24 OECD countries	13	14	16	17
OECD average Government funding as a % of BERD	11.5%	10.1%	8.9%	7.5%
EU average Government funding as a % of BERD	10.4%	9.1%	8.5%	8.0%

In terms of Ireland's relative ranking within the OECD for government funding Ireland is ranked 17th out of 24 OECD countries in 2001. This compares with a ranking of 13th place in 1995. Government supports for R&D are generally either through grants and/or tax credits or other fiscal incentives. Hence there are wide variations between countries in the levels of grant supports. In Ireland there are as yet no tax credits for R&D.

Detailed figures on the percentage of BERD accounted for by government allocations in each of 24 OECD countries are presented in Table 4.2 for the period 1995 to 2001.

Table 4.2: *International comparison of the proportion of business sector R&D financed by Government, 1995 – 2001.*

	1995		1997		1999		2001	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank
Australia	2.4	22	2.4	22	3.4	21	3.7	19
Belgium	4.3	19	5.1	17	6.3	13	6.2	14
Canada	6.2	14	5.0	18	3.7	20	3.7	19
Czech Republic	4.5	18	7.9	12	14.1	3	12.2	4
Denmark	6.1	15	5.3	16	4.4	18	4.4	18
Finland	5.6	16	4.1	21	4.2	19	3.5	21
France	12.7	4	10.4	6	10	6	9.9	5
Germany	8.8	10	9.2	9	7.6	12	6.9	13
Hungary	16.2	3	14.6	3	5.7	15	6.1	15
Iceland	3.3	21	5.0	18	2.4	22	2.4	22
Ireland	6.4	13	6.0	14	5.1	16	4.9	17
Italy	16.7	2	13.1	4	13.0	4	12.3	3
Japan	1.6	24	1.3	24	1.8	24	1.7	24
Korea	3.6	20	4.8	20	5.8	14	7.0	12
Netherlands	6.6	12	5.4	15	5.1	16	5.1	16
New Zealand	6.9	11	8.7	10	9.6	8	9.6	7
Norway	11.9	5	11.0	5	9.7	7	9.7	6
Poland	33.8	1	29.2	1	26.5	1	30.4	1
Portugal	5.1	17	9.4	8	8.1	10	8.1	9
Slovak Republic	10.8	7	16.5	2	24.4	2	20.6	2
Spain	9.2	9	8.7	10	8.6	9	7.2	11
Sweden	9.5	8	7.6	13	7.8	11	7.8	10
Switzerland	2.4	22	2.4	22	2.3	23	2.3	23
United Kingdom	11.3	6	9.6	7	10.2	5	8.8	8
OECD Average	11.5		10.1		8.9		7.5	
EU Average	10.3		9.1		8.5		8.0	

Source: MSTI OECD 2002 Volume 2, nearest year used if data not available.

5 Human Resources in Industrial R&D

5.1 Introduction

This section considers the number of persons employed in R&D in the Business sector in Ireland in 2001. This includes researchers, technical staff and support staff. The data are also provided according to gender. The data are full-time equivalents (FTE) which take into account the actual time spent by staff on R&D. The text refers to FTE data.

5.2 Trends in R&D Personnel 1993 – 2001

Table 5.1 summarises details of recent trends in full-time equivalent R&D employment in the business sector in Ireland. Total R&D personnel³ rose from 4,500 in 1993 to 9,126 in 2001. This represents a growth of 103 per cent over the period in question. The pace of increase in personnel slowed between 1999 to 2001 to a level of 9.7% (805 FTE) from a 19.4% (1,351 FTE) increase between 1997 and 1999. In terms of international ranking, the number of full-time equivalent R&D personnel per 1000 industrial employment increased from 5.9 to 6.9 over the period 1995 to 2001. Ireland is ranked 12th out of 24 OECD countries in terms of FTE personnel engaged in R&D.

(Detailed figures for the 24 OECD members are outlined in Appendix Table A1.2 and A1.3).

The numbers of researchers involved in R&D activity stood at 5,971 in 2001. This represented a growth of 132% from 2,576 researchers in 1993. The numbers of researchers increased by 12.9% (680 FTE) over the period 1999 to 2001, compared to a corresponding increase of 22.5% (971 FTE) between 1997 and 1999. The level of researchers increased from 3.5 to 4.5 per 1000 industrial employment over the period 1995 to 2001. Ireland is ranked 11th out of 25 OECD countries for this indicator.

Table 5.1: *Human Resources Employed in R&D in the Business Sector, 1993 - 2001*

	1993	1995	1997	1999	2001
Total R&D personnel (FTE)	4,500	5,680	6,970	8,321	9,126
Total R&D Personnel (FTE) per 1000 industrial employment	-	5.9	6.7	6.8	6.9
Rank of FTE R&D Personnel per 1000 industrial employment among 24 OECD countries	-	12	12	12	12
Total R&D Researchers (FTE)	2,576	3,400	4,320	5,291	5,971
Total R&D Researchers (FTE) per 1000 industrial employment	-	3.5	4.2	4.3	4.5
Rank of FTE R&D Researchers per 1000 industrial employment among 25 OECD countries	-	12	11	12	11

³ *In addition to researchers, R+D Personnel also includes technicians and support staff.*

5.3 Distribution of R&D Personnel in 2001

Table 5.2 summarises business sector employees categorised as Ph.D. qualified researchers, researchers, technical staff and support staff in 2001. This table shows that 65% of personnel engaged in R&D activity are researchers. A total of 6.5% of all personnel are Ph.D. researchers. A further 19% (1,748 FTE) are employed as technical staff (including laboratory technicians, draftspersons etc.), whereas the remaining 16 per cent (1,407 FTE) are support personnel. This latter category includes administrators, clerical support staff etc. Figure 5.1 illustrates the distribution of R&D personnel according to employment category.

The figures in Table 5.2 also show that over three-quarters of business sector R&D personnel are male. The concentration of males is particularly strong in the researcher and technician grades (76 – 79 per cent male). The highest percentage of female staff involved in R&D activity are in support categories where just over one-third of relevant staff are female.

Table 5.2: *Distribution of R&D Personnel, 2001*

	PhD Researchers	Non PhD Researchers	Technical	Support Personnel	Total
FTE	597	5,374	1,748	1,407	9,126
% of Total	6.5%	58.9%	19.2%	15.4%	100%
% Male	82.9%	79.1%	76.5%	64.7%	76.6%
% Female	17.1%	20.9%	23.5%	35.3%	23.4%
Total	100%	100%	100%	100%	100%

Figure 5.1: *Distribution of all Personnel (FTE) engaged in in-house R&D*

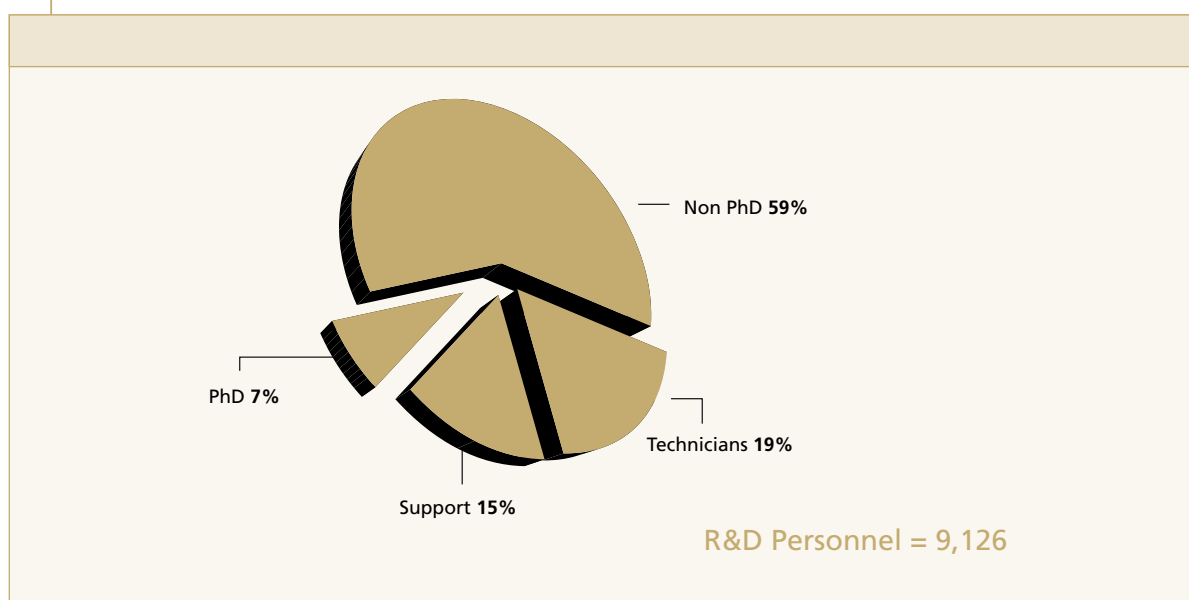


Table 5.3 provides a detailed breakdown of R&D personnel classified according to industrial sector. At an aggregate level the Electrical & Electronic equipment and the Software & Computer related sectors accounted for nearly two-thirds (63.5 per cent) of all R&D personnel employment (33.0% and 30.5% respectively). Three other sectors accounted for more than 5 per cent of R&D-related employment, namely, Food, Drink & Tobacco (6.2 per cent), Pharmaceuticals (6.1 per cent) and Instruments (5.5 per cent). This means that 81 per cent of all R&D employment is concentrated in these 5 key sectors.

Table 5.3: *Distribution of R&D Personnel by Industrial Sector, 2001*

	PhD		Non PhD		Technicians		Support		Total	
	FTE	%	FTE	%	FTE	%	FTE	%	FTE	%
Electrical & Electronic equipment	258	43.2	2,066	38.5	270	15.4	419	29.8	3,013	33.0
Software & Computer related	91	15.3	1,832	34.1	568	32.5	291	20.7	2,783	30.5
Pharmaceuticals	89	15.0	249	4.6	96	5.5	119	8.4	553	6.1
Instruments	29	4.8	288	5.4	114	6.5	70	5.0	501	5.5
Food, Drink & Tobacco	38	6.4	262	4.9	148	8.5	119	8.5	568	6.2
Other Services	30	5.0	232	4.3	112	6.4	66	4.7	441	4.8
Machinery & Equipment	12	1.9	112	2.1	134	7.6	61	4.3	319	3.5
Chemicals	31	5.2	64	1.2	60	3.4	24	1.7	179	2.0
Rubber & Plastics	2	0.3	61	1.1	48	2.8	31	2.2	141	1.5
Non-metallic Minerals	10	1.6	74	1.4	26	1.5	28	2.0	137	1.5
Basic & Fabricated Metals	1	0.2	25	0.5	42	2.4	52	3.7	119	1.3
Wood & Wood Products	1	0.1	10	0.2	25	1.4	25	1.8	60	0.7
Transport Equipment	2	0.4	42	0.8	38	2.2	24	1.7	106	1.2
Textiles/Clothing	3	0.5	16	0.3	22	1.3	21	1.5	62	0.7
Other Manufacturing	0	0.0	16	0.3	27	1.5	32	2.3	75	0.8
Paper, Print & Publishing	0	0.0	25	0.5	19	1.1	25	1.8	69	0.8
Total	597	100	5,374	100	1,748	100	1,047	100	9,126	100

5.4 Summary

A total of 9,126 full time equivalents were employed in R&D in 2001. This represents an increase of 9.7 per cent (just over 800 FTE) over the preceding two years. The majority of those engaged in R&D are employed at the non-PhD researcher grade (59 per cent) with a further 6 per cent at PhD researcher grades. Technical and other Support staff account for 19 and 15 per cent of all R&D personnel respectively.

The number of R&D staff have increased steadily since the early 1990's. In terms of our international rankings of R&D personnel per 1000 industrial employment among 25 OECD countries and Ireland is currently in 12th place.

6 Sources of R&D Funding and Types of costs

6.1 Introduction

This section considers the different types of funding used by firms to cover their intramural R&D expenditure in Ireland. A number of sources of funding are available to a firm in undertaking Research & Development activity. These include sources such as the firm's own internal resources; funding by other companies (i.e. R&D performed on their behalf), EU grant aid (e.g. under the Framework Programme), Government grants etc.

In addition to issues relating to funding of in-house BERD this section also provides a breakdown of expenditure according to current and capital costs.

6.2 Sources of Funding for in-house BERD

Table 6.1 presents details on sources of funds as reported by firms for their R&D activity in Ireland. In 2001 almost 91 per cent of funding came from the companies' own resources or internal funds. This was higher among foreign-owned companies than for Irish companies (94 per cent and 86 per cent, respectively). It is evident from the table that expenditure of State grants on in-house R&D represented a substantially higher proportion of total funding among Irish-owned companies as compared to foreign-owned enterprises (5.8 per cent and 1.0 per cent, respectively). EU and 'Other Irish' sources were also of greater relative importance as funding sources for Irish-owned firms. In contrast, 'Other foreign' sources played a more significant role for the non-indigenous sector (4.7 per cent compared with 2.4 per cent for Irish-owned companies). In interpreting these last figures it should be noted that although companies were not meant to do so some foreign-owned firms may have reported transfers from their overseas parent under 'Other foreign sources'. This may explain the higher figure for foreign-owned companies in this category.

Table 6.1: Sources of funding for in-house R&D expenditure in 2001. classified according to ownership

Source of funding	Irish (€m)	Foreign (€m)	Total (€m)
Own company/internal funds	274.8	560.7	835.5
Payments from other companies in Ireland	4.3	0.5	4.8
Government Grants	18.6	6.0	24.6
Other Irish sources	9.6	1.0	10.6
Direct funding from EU	3.9	2.0	5.9
Other Foreign sources	7.6	27.9	35.5
Total	318.7	598.1	916.8

6.3 Breakdown of R&D Costs in 2001

Table 6.2 and Figure 6.1 provide details of BERD broken down by major current and capital costs. Table 6.2 provides a further analysis at an industrial sectoral level. Current expenditure accounted for almost 93 per cent of total BERD in 2001. Figure 6.1 charts the proportional breakdown by major cost and shows that labour costs accounted for 58 per cent of all costs. Other current costs including R&D overheads, materials, supplies, literature and subscriptions etc. accounted for an additional 35 per cent giving a total expenditure of 92.7% of BERD on current costs. Capital costs account for the remaining 7.3% per cent of which instruments and equipment accounted for 5.6% of total BERD and 1.7% of total expenditure funded land purchases and new buildings. The low level of capital expenditure may be indicative of a lack of vertical integration of the R&D process into business activity in Ireland. If this is so, one may find that R&D activity in the private sector could be one of the first casualties of an economic or business downturn. In almost all situations of economic retrenchment labour costs are more easily re-allocated to other areas of productive output, or shed completely.

Table 6.2: *Breakdown of 2001 BERD according to main current and capital items by industrial sector.*

	Current		Capital		Total	BERD
	Labour Costs	Other Current Items	Land & Buildings	Instruments & Equipment		€m
	(As percentage of Total)					
Electrical & Electronic equipment	51.5%	43.5%	0.3%	4.7%	100%	343.9
Software & Computer related	75.1%	20.5%	1.4%	3.0%	100%	252.3
Pharmaceuticals	41.2%	48.0%	0.7%	10.0%	100%	70.7
Instruments	49.3%	32.2%	6.3%	12.2%	100%	59.3
Food, Drink & Tobacco	50.9%	36.7%	7.5%	4.9%	100%	50.0
Other Services	65.2%	27.4%	1.1%	6.3%	100%	37.9
Machinery & Equipment	57.2%	34.5%	3.1%	5.1%	100%	21.6
Chemicals	56.6%	30.1%	3.7%	9.6%	100%	19.6
Rubber & Plastics	47.9%	39.5%	0.7%	12.0%	100%	11.8
Non-metallic Minerals	72.3%	22.8%	1.9%	3.1%	100%	10.8
Basic & Fabricated Metals	59.0%	27.5%	4.4%	9.1%	100%	9.4
Wood & Wood Products	30.5%	57.3%	1.1%	11.1%	100%	8.8
Transport Equipment	60.5%	35.9%	0.8%	2.9%	100%	6.5
Textiles/Clothing	45.4%	38.9%	8.6%	7.1%	100%	6.0
Other Manufacturing	55.6%	35.4%	1.4%	7.6%	100%	4.2
Paper, Print & Publishing	52.5%	32.0%	1.1%	14.4%	100%	3.9
Total	58.0%	34.7%	1.7%	5.6%	100%	916.8

Figure 6.1: Breakdown of 2001 BERD according to current/capital expenditure

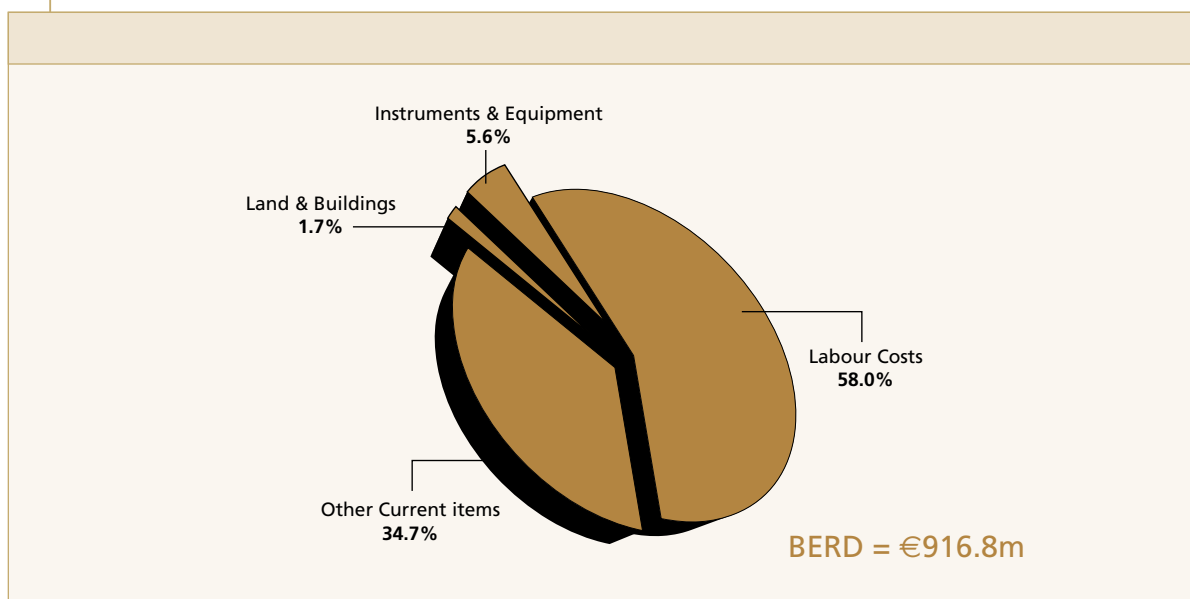


Table 6.2 also indicates sectoral variations in the level of capital orientation of BERD in Ireland. The highest levels of capital spend were recorded in the following key sectors: Pharmaceuticals (10.7%), Instruments (18.5%) and Food, Drink & Tobacco (12.4%).

In contrast, the following key sectors appear to have a much lower average level of capital orientation to their R&D expenditure: Electrical & Electronic equipment (5.0%) and Software & Computer related (4.4%).

6.4 Summary

Just over 90 per cent of funding for BERD in Ireland in 2001 was sourced from the companies' own internal finances. Government grants accounted for just under 3 per cent. Government grants were substantially more important for Irish (5.8 per cent) than for foreign (1.0 per cent) enterprises. 'Other Irish' and EU sources were also relatively more important for indigenous companies.

In terms of the nature of expenditure, current items accounted for as much as 93 per cent of total BERD. Labour costs were the single largest item (accounting for 58 per cent). Capital items such as land or buildings accounted for only 2 per cent and instruments or equipment for only 5 per cent.

The high level of expenditure accounted for by current expenditure (predominantly labour costs) could be a cause for concern. As mentioned previously, in circumstances of economic slowdown the current costs involved (especially labour costs) could be diverted to other areas of activity or shed completely.

7 Co-operative Research Ventures and Out-sourced R&D Activity

7.1 Introduction

This section considers the extent to which R&D active companies engaged in joint research projects throughout 2001 with other firms and with the higher education sector.

The section analyses the extent to which companies out-source R&D activity to a range of private research laboratories, institutes of higher education and government research facilities.

7.2 Co-operative Research Ventures

Table 7.1 outlines details on the percentages of R&D active companies in 2001 which engaged in joint research projects with other parties. The figures in the table provide details and a breakdown of the percentage of firms in selected industrial sectors which participated in collaborative research in 2001. At an aggregate level 15 per cent of R&D active companies engaged in joint research ventures with other firms inside Ireland compared to 23 per cent with firms located outside Ireland. In addition almost one-fifth of all R&D active companies were involved in research projects with the Irish higher education sector, whereas 9% were involved with third level institutes located outside Ireland.

Table 7.1: *Percentage of R&D active companies engaging in joint research projects with other parties located in Ireland and abroad, classified by main industrial sectors, 2001*

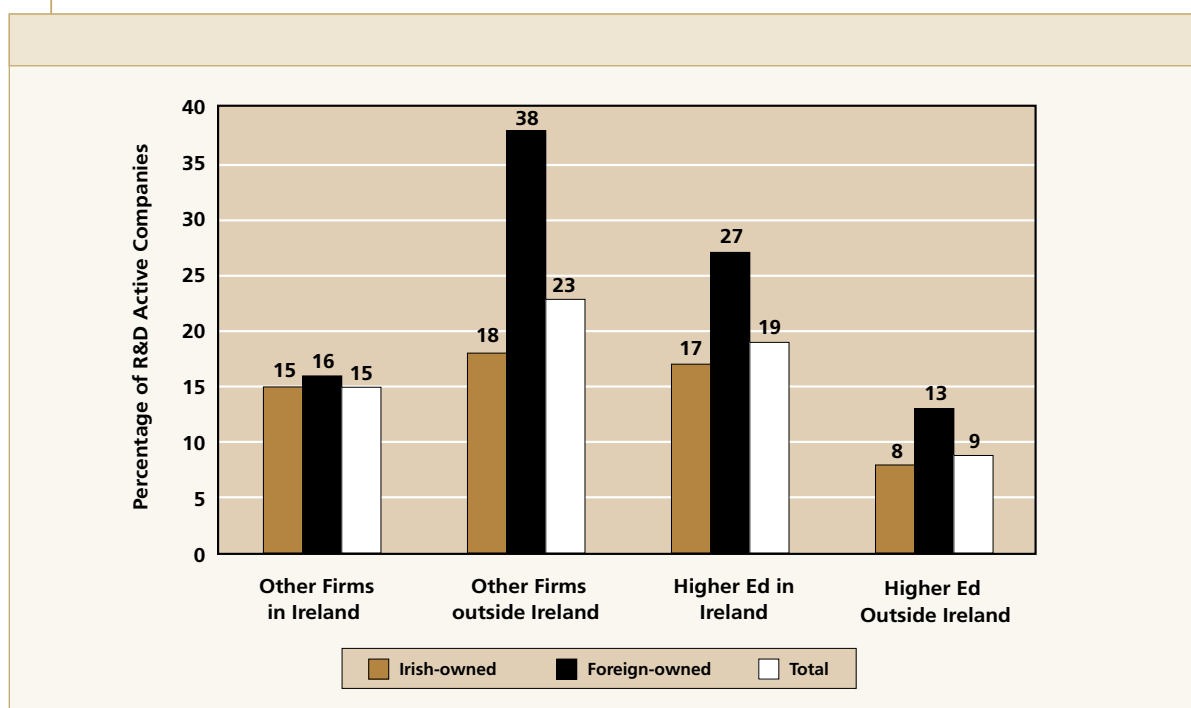
Sector	Outsourced to:			
	Other firms inside Ireland	Other firms outside Ireland	Higher Education inside Ireland	Higher Education outside Ireland
	(Percentage of R&D active companies)			
Electrical & Electronic equipment	12%	26%	28%	9%
Software & Computer related	17%	19%	12%	6%
Pharmaceuticals	9%	37%	35%	16%
Instruments	28%	38%	28%	18%
Food, Drink & Tobacco	17%	18%	26%	11%
Other Sectors	14%	23%	18%	9%
All Sectors	15%	23%	19%	9%
Irish Companies	15%	18%	17%	8%
Foreign Companies	16%	38%	27%	13%

In terms of industrial sectors, it is clear from the table that R&D active companies in the Instruments sector had the highest overall levels of collaborative activity. The Instruments sector saw 28% of all R&D active companies engage in joint research with other firms located in Ireland whereas an equal percentage of companies collaborated with the Irish third level sector. A high percentage of this sector, 38%, were also involved in research projects with other firms outside Ireland and 18% collaborated with third level institutions outside Ireland. Over a third of firms in the Pharmaceutical sector collaborated with the Irish higher education sector in 2001, and 37% of this sector collaborated with companies outside Ireland.

These reported percentages for 2001 are almost exactly the same as those reported in the 1993 BERD survey. The intervening period has not led to any significant increase in co-operative performance, particularly with the higher education sector, despite numerous policy initiatives aimed at raising such co-operation.

Figure 7.1 provides details on the extent of collaborative research classified according to ownership (foreign-owned or Irish-owned). It is noteworthy that the incidence of collaboration among foreign-owned companies is higher than for Irish-owned. Some element of the higher incidence of collaborative research among foreign-owned companies with firms outside Ireland may be linked to the overseas parent of the companies in question. The higher incidence of joint research among foreign-owned companies is also evident with regard to links with the third level sector (both inside and outside Ireland).

Table 7.1: *Percentage of R&D active companies which engaged in collaborative research with other institutions, 2001*



7.3 Outsourcing of R&D Activity

Table 7.2 summarises the level of outsourced R&D activity in 2001. At an aggregate level the total value of outsourced R&D in 2001 came to €110m, of which €79.2m was outsourced by foreign-owned firms and €30.8m was outsourced by indigenous firms. The Electrical & Electronic equipment sector outsourced €53.2m, almost half of the total expenditure on outsourced R&D.

Table 7.2: Amount of outsourced R&D activity classified by industrial sector, 2001.

Sector	Outsourced to:						Total %	Total Value €m
	Related Companies	Non-Related Companies	Govt. Research	Higher Education	Private R&D Lab	Other		
	(Percentage of R&D active companies)							
Electrical & Electronic equipment	86%	11%	0%	1%	2%	0%	100%	53.2
Chemicals	3%	0%	0%	96%	1%	0%	100%	16.8
Software & Computer related	73%	24%	0%	2%	0%	1%	100%	15.5
Pharmaceuticals	9%	64%	12%	10%	4%	0%	100%	8.6
Instruments	35%	37%	3%	21%	3%	1%	100%	4.7
Food, Drink & Tobacco	3%	17%	19%	30%	23%	8%	100%	2.6
Other Services	10%	47%	2%	30%	5%	8%	100%	2.5
Non-metallic Minerals	81%	10%	0%	9%	1%	0%	100%	1.3
Wood & Wood Products	2%	77%	0%	2%	18%	1%	100%	1.3
Machinery & Equipment	24%	47%	1%	14%	15%	0%	100%	1.1
Basic & Fabricated Metals	73%	20%	0%	2%	5%	0%	100%	1.0
Rubber & Plastics	0%	19%	12%	53%	15%	0%	100%	0.6
Paper, Print & Publishing	0%	32%	13%	28%	28%	0%	100%	0.3
Other Manufacturing	3%	39%	0%	0%	4%	54%	100%	0.3
Textiles/Clothing	0%	68%	2%	0%	30%	0%	100%	0.2
Transport Equipment	0%	0%	0%	67%	0%	33%	100%	0.0
Total Companies	56%	19%	2%	19%	3%	1%	100%	110
Irish Companies	7%	20%	5%	61%	5%	2%	100%	30.8
Foreign Companies	76%	18%	1%	3%	2%	0%	100%	79.2

Figure 7.2 provides a proportional breakdown of total expenditure on outsourced R&D (€110m) according to the six potential performers of outsourced R&D. The most important source which accounted for 56 per cent of expenditure was 'related companies'. A total of 19 per cent was outsourced to each of 'non-related companies' and the 'third-level education sector'.

Figure 7.2: Percentage of the value of the total outsourced R&D activity in 2001 to each of the 6 possible sources

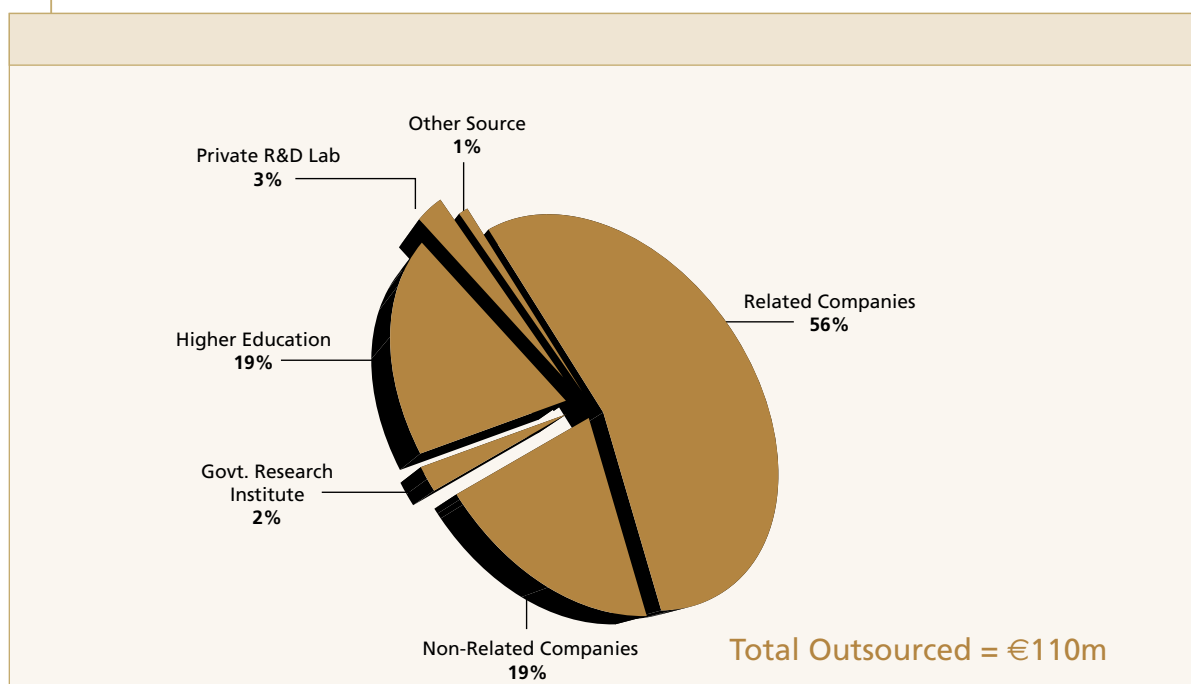


Table 7.3 provides details on the percentage breakdown of outsourced expenditure on R&D for each industrial sector. The percentage breakdown of total outsourced R&D indicates that 77 per cent of this expenditure was concentrated in three key sectors Electrical & Electronic equipment (48%); Chemicals (15%) and Software & Computer related (14%).

A total of €110m worth of R&D activity was outsourced in 2001. This was *in addition* to the in-house activity reported. Over 70 per cent of this was commissioned by overseas companies operating in Ireland. From Table 7.3 foreign-owned companies represent €79m of the expenditure on outsourced R&D. A large proportion, approximately three-quarters, of this activity is placed with 'Related companies' – presumably parent companies located overseas (refer to Table 7.2). Indigenous companies accounted for €30.8m (representing 28% of the total outsourced value). Out-sourcing among Irish-owned companies is generally placed within the country – over 81 per cent of the value of total outsourced R&D from Irish companies was located within Ireland. Indigenous companies which engaged in outsourcing tended to collaborate with third level institutes, accounting for just over 60 per cent of the total value of outsourced R&D among indigenous companies.

Table 7.3: Amount of outsourced R&D activity classified by sector, 2001

Sector	Amount outsourced:					
	Total Outsourced		Within Republic of Ireland		Outside Republic of Ireland	
	Value €m	% Total	Value €m	%	Value €m	%
Electrical & Electronic equipment	53.2	48%	6.2	18%	47.1	62%
Chemicals	16.8	15%	16.1	47%	0.7	1%
Software & Computer related	15.5	14%	2.1	6%	13.4	18%
Pharmaceuticals	8.6	8%	1.7	5%	6.9	9%
Instruments	4.7	4%	1.4	4%	3.3	4%
Food, Drink & Tobacco	2.6	2%	1.7	5%	0.9	1%
Other Services	2.5	2%	1.9	6%	0.6	1%
Non-metallic Minerals	1.3	1%	0.6	2%	0.7	1%
Wood & Wood Products	1.3	1%	1.0	3%	0.3	0%
Machinery & Equipment	1.1	1%	0.7	2%	0.4	1%
Basic & Fabricated Metals	1.0	1%	0.2	1%	0.7	1%
Rubber & Plastics	0.6	1%	0.4	1%	0.2	0%
Paper, Print & Publishing	0.3	0%	0.2	1%	0.1	0%
Other Manufacturing	0.3	0%	0.0	0%	0.3	0%
Textiles/Clothing	0.2	0%	0.1	0%	0.1	0%
Transport Equipment	0.0	0%	0.0	0%	0.0	0%
Total	110.0	100%	34.3	100%	75.7	100%
Irish Companies	30.8	28%	25.0	73%	5.8	8%
Foreign Companies	79.2	72%	9.3	27%	69.9	92%

7.4 Summary

Relatively substantial minorities of firms (15 to 23 per cent) engaged in collaborative research with other firms (both inside and outside Ireland) as well as with higher education institutions located in Ireland. Slightly lower percentages (9 per cent) of firms participated in joint research programmes with higher education institutes outside Ireland. In general, a higher proportion of foreign and Irish companies engaged in this type of activity.

A total of €110m worth of R&D activity was outsourced in 2001. This was in addition to the in-house activity. Over 70 per cent of this was commissioned by overseas companies operating in Ireland. In general, indigenous companies which engaged in outsourcing did so with third level education institutes (accounting for just over 60 per cent of the total value of outsourced R&D among indigenous companies). In contrast, foreign-owned companies located in Ireland generally placed such outsourcing with their overseas parent (accounting for 76 per cent of the value of outsourced R&D among foreign companies in Ireland). The reported percentages for 2001 are almost exactly the same as those reported in the 1993 BERD survey. The intervening period has not led to any significant increase in co-operative performance, particularly with the higher education sector, despite numerous policy initiatives aimed at raising such co-operation.

8 Type OF R&D Activity and Aims of R&D

8.1 Introduction

This section considers aspects such as the nature, type and aims of Research and Development activity in Ireland. Details are presented on the nature of R&D activity in terms of basic research, applied research and experimental development. Secondly, a breakdown of BERD classified according to nine main product fields is provided. Thirdly, an analysis of R&D expenditure in the area of biotechnology and related fields is given.

8.2 Nature of R&D Activity

The classifications used in the survey are based on standard OECD definitions (Frascati Manual, OECD, 2002). The definitions are as follows:

Basic Research: Experimental or theoretical work undertaken primarily to acquire new knowledge without any particular application or end-use in view.

Applied Research: Original investigation undertaken to acquire new knowledge primarily directed towards a specific practical aim or objective.

Experimental Development: Systematic work drawing on existing knowledge gained from research and practical experience that is directed to producing new materials, products and devices, to installing new processes, systems and services, or to improving substantially those already produced or installed.

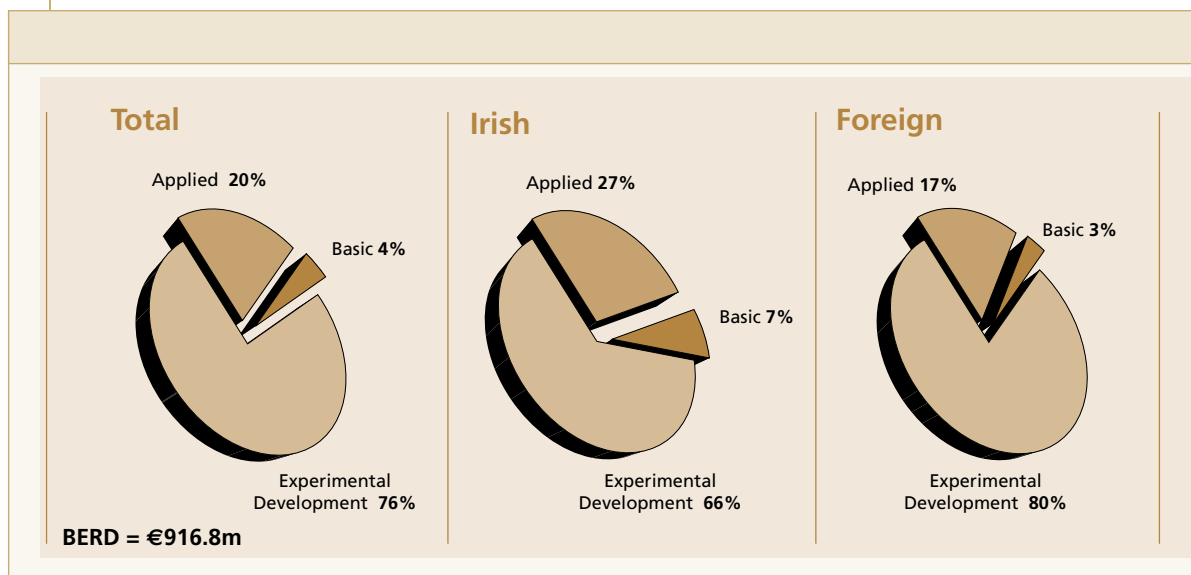
The results, presented in Table 8.1, indicate that three-quarters of BERD in Ireland is classified as being experimental development in nature – i.e. building on existing knowledge to develop and further the design of materials and processes. This is particularly true in the Electrical & Electronic equipment sector where 84 per cent of expenditure is related to experimental development. Applied research accounts for a further 20.5% of expenditure with basic research representing only 4.4% of total R&D expenditure.

Table 8.1: *Breakdown of the nature of R&D activity in Ireland, according to Industrial Sector, 2001*

Sector	Basic %	Applied %	Experimental Development %	Total %	Value €m	% of Value
Electrical & Electronic equipment	1.6%	14.3%	84.1%	100%	343.9	37.5%
Software & Computer related	5.3%	23.1%	71.7%	100%	252.3	27.5%
Pharmaceuticals	3.2%	26.5%	70.3%	100%	70.7	7.7%
Instruments	5.7%	24.3%	70.0%	100%	59.3	6.5%
Food, Drink & Tobacco	6.5%	26.3%	67.3%	100%	50.0	5.5%
Other Sectors	9.1%	24.6%	66.3%	100%	140.5	15.3%
Total	4.4%	20.5%	75.1%	100%	916.8	100%

Figure 8.1 outlines the breakdown across the three main categories of R&D expenditure according to company ownership (foreign-owned or indigenous). Experimental development accounts for a larger proportion of BERD among foreign-owned companies at 80% than Irish-owned companies (66%).

Figure 8.1: *Nature of R&D performed in Business Sector according to ownership, 2001*

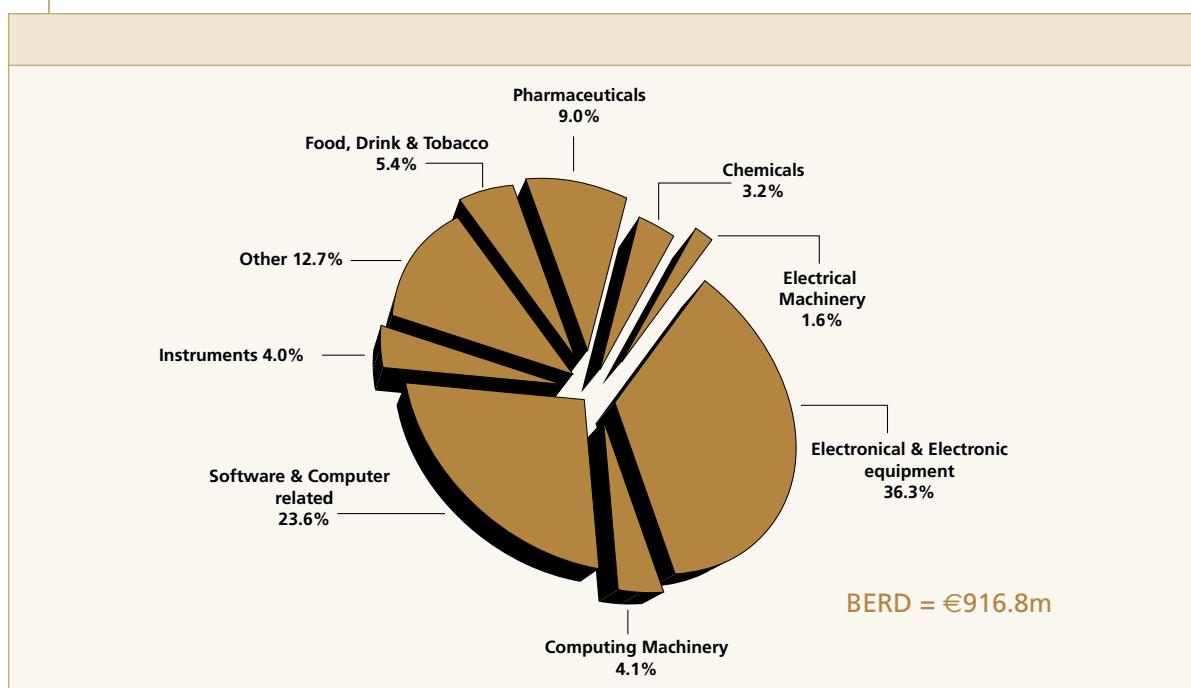


8.3 Main Aims of BERD in Ireland

8.3.1 Main Product Fields in the survey

Of the nine product fields listed in Figure 8.2, two main product areas dominate, namely, electronics which accounted for 37% of BERD in 2001 and software & computer related which accounted for 23% of BERD.

Table 8.2: *Main Product fields of BERD activity in Ireland, 2001*



8.3.2 Aims of R&D Activity

R&D expenditure was classified according to its broad aims or objectives in terms of product and process development. Table 8.3 shows that in aggregate terms, new product development accounted for over half (54%) of all BERD. This is followed by R&D aimed at improving existing products which accounted for 28.9%. Nine per cent of R&D expenditure funded developing new processes and a further 7% was spent on improving existing processes.

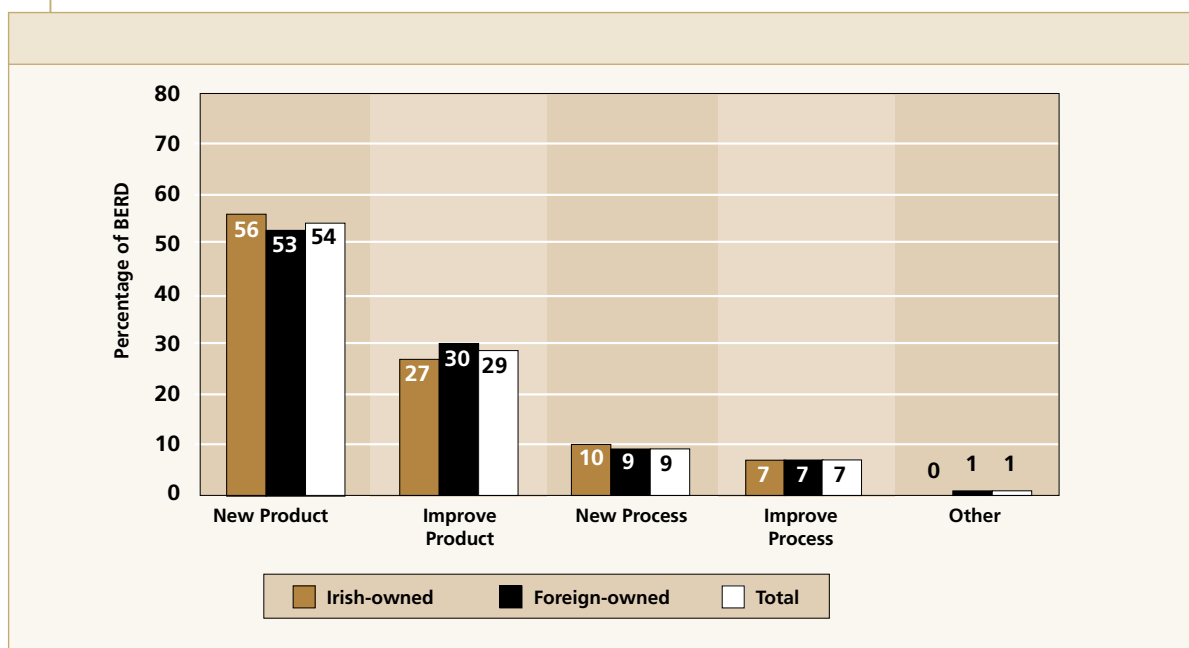
It is clear from Table 8.3 that new product development is of substantially greater relative importance for the more modern high-tech sectors such as Software & Computer related (60 per cent), Electrical & Electronic equipment (58 per cent) and Instruments (54 per cent). In the more traditional Food, Drink & Tobacco sector developing new products accounted for 39% of R&D expenditure. It is also apparent from the table that *process* development or improvements are of equal importance to *product* development or improvements in the Pharmaceuticals sector.

Table 8.3: *Breakdown of the aims of R&D activity in Ireland in 2001 according to broad industrial sector*

Aim of R&D:							
Sector	New Product	Improved Product	New Process	Improved Process	Other	Total	Value €m
Electrical & Electronic equipment	58.1	35.7	5.1	1.0	0.0	100%	343.9
Software & Computer related	60.4	31.3	4.2	4.2	0.0	100%	252.3
Pharmaceuticals	39.2	7.2	22.5	31.0	0.2	100%	70.7
Instruments	53.9	23.4	15.2	7.2	0.3	100%	59.3
Food, Drink & Tobacco	38.6	23.9	20.9	16.6	0.0	100%	50.0
Other Sectors	47.7	22.7	14.7	12.0	2.9	100%	140.5
Total	54.4%	28.9%	9.2%	7.1%	0.5%	100%	916.8

Figure 8.3 provides summary details on the breakdown of BERD in 2001 according to main aims and ownership. The figures indicate that there are, in fact, only relatively minor differences in terms of the main aims of R&D activity between Irish-owned and foreign-owned companies operating in Ireland.

Table 8.3: *Percentage breakdown of BERD 2001 according to main aims*



8.3.3 R&D Expenditure on Biotechnology

Table 8.4 presents details of expenditure on biotechnology R&D in 2001 as reported by companies. Expenditure on biotechnology R&D in 2001 reached €13m or a value of 1.4% of BERD. 68% of all expenditure on biotechnology among R&D active companies was accounted for by the Food, Drink & Tobacco sector with a further 25% arising in Pharmaceuticals. Food, Drink & Tobacco spent 18% of its total R&D budget on biotechnology related R&D and Pharmaceuticals devoted approximately 5% of its R&D resources to biotechnology related R&D.

Table 8.4: *Breakdown of R&D Expenditure on Biotechnology in 2001 classified by detailed sector*

	Total R&D Expenditure €m	Expenditure on Biotechnology €m	% of Sectoral Expenditure on Biotechnology	% of Total Biotechnology Expenditure
Software & Computer related	252.3	0.171	0.1%	1.3%
Pharmaceuticals	70.7	3.316	4.7%	25.5%
Instruments	59.3	0.353	0.6%	2.7%
Food, Drink & Tobacco	50.0	8.902	17.8%	68.4%
Other Services	37.9	0.118	0.3%	0.9%
Chemicals	19.6	0.148	0.8%	1.1%

8.4 Summary

Three-quarters of R&D activity is in experimental development. The predominance of this experimental work is higher among foreign than Irish companies. In terms of main product fields, Software & Computer related and Electrical & Electronic equipment jointly accounted for a total 65 per cent of BERD in Ireland.

Overall, it would appear that product development and improvement is of greater relative importance to R&D activity in Ireland than process developments or improvements. The former accounted for 83 per cent of expenditure, the latter for 17 per cent.

Finally, expenditure on R&D related to aspects of biotechnology amounted to €13.0m and was strongly concentrated in the Food, Drink & Tobacco sector (68 per cent) as well as Pharmaceuticals (25 per cent).

9 Patents

9.1 Introduction

This section briefly considers the number of patents applied for as well as the number issued to companies who were R&D active in 2001. Respondents were asked to record whether or not applications and awards were made in:

- ▶ the Republic of Ireland;
- ▶ Rest of Europe;
- ▶ USA;
- ▶ elsewhere.

9.2 Patents Applied for and Granted in 2001

9.2.1 Patent Applications

Table 9.1 summarises the number of patents applied for by and granted to R&D active companies in 2001. A total of 1,698 patents were applied for with 764 having been granted in that year. In terms of applications a total of exactly one-third were made by companies in the Software & Computer related sector (representing 566 applications). The next most important sectors were Electrical & Electronic equipment (accounting of 16 per cent of applications) and Instruments (13 per cent). Approximately one-third of patent applications were made in the Republic of Ireland with a further one-third being made in the US. Just under one-quarter were made in other European countries outside Ireland while the remaining 12 per cent were made elsewhere.

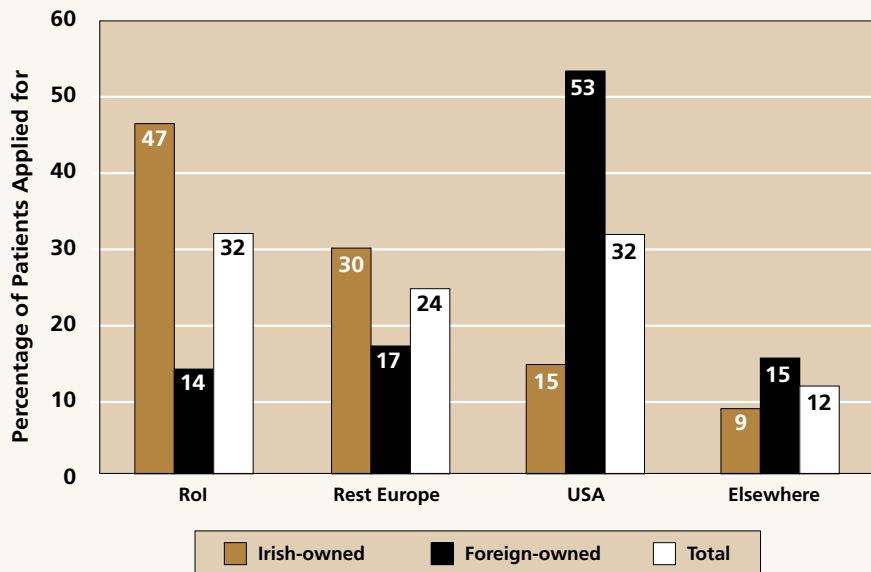
Table 9.1: *Distribution of patents applied for by companies which undertook in-house R&D activity in 2001 classified by industrial sector.*

Sector	All Companies*						
	Rol	Rest Europe	USA	Elsewhere	Total	No.	%
Electrical & Electronic equipment	30	29	29	13	100	277	16
Software & Computer related	31	21	47	1	100	566	33
Pharmaceuticals	9	22	28	40	100	152	9
Instruments	27	23	36	14	100	214	13
Food, Drink & Tobacco	41	40	5	14	100	58	3
Other Services	49	20	25	6	100	120	7
Machinery & Equipment	38	33	18	11	100	98	6
Chemicals	12	12	14	63	100	53	3
Rubber & Plastics	36	31	18	16	100	30	2
Non-metallic Minerals	75	25	0	0	100	12	1
Basic & Fabricated Metals	55	25	14	6	100	40	2
Wood & Wood Products	67	33	0	0	100	12	1
Transport Equipment	81	0	0	19	100	8	0
Textiles/Clothing	100	0	0	0	100	6	0
Other Manufacturing	47	48	5	0	100	41	2
Paper, Print & Publishing	84	16	0	0	100	11	1
Total	32%	24%	32%	12%	100%	1,698	100%

**Percentages rounded to nearest whole number*

In some relatively small sectors, such as Textiles/Clothing, applications were made exclusively in the Republic of Ireland. In other sectors, notably Chemicals and Pharmaceuticals, the role of non-European centres for patent application is clear. For example, in the Chemical sector 63 per cent of the 53 patent applications were made in the 'Rest of the World' with a further 13 per cent having been made in the US. Comparable figures for the Pharmaceuticals sector are 40 per cent and 28 per cent, respectively.

Table 9.1: *Patents Applied for in 2001 by R&D Active Companies classified according to country of application*



The figures in the Table 9.2 and Figure 9.1 provide details on the breakdown of patent applications classified by nationality of the company. From these one can see that 56 per cent representing 948 applications were submitted by Irish-owned companies whilst the remaining 750 applications were made by foreign-owned companies in Ireland. From Table 9.1 and also Figure 9.1 the most striking difference in terms of ownership is the much higher percentage of patents applied for in the US by foreign-owned companies. The US accounts for 53 per cent of all applications by foreign companies in Ireland. The comparable figure among Irish companies is 15 per cent. In contrast, patent applications among indigenous companies are characterised to a greater degree as originating in Ireland (47 per cent). The comparable figure among foreign companies is 13 per cent.

Table 9.2: *Distribution of patents applied for by companies which undertook in-house R&D activity in 2001 classified by industrial sector and ownership.*

	Rol	Rest Europe	USA	Elsewhere	Total	No.	%
Sector: Irish-owned							
Electrical & Electronic equipment	49	32	9	10	100	93	10%
Software & Computer related	44	32	23	1	100	342	36%
Pharmaceuticals	27	24	12	37	100	47	5%
Instruments	40	25	21	14	100	107	11%
Food, Drink & Tobacco	45	37	5	13	100	54	6%
Other Services	64	25	3	8	100	88	9%
Machinery & Equipment	40	33	12	14	100	65	7%
Chemicals	10	10	10	71	100	11	1%
Rubber & Plastics	40	27	13	20	100	23	2%
Non-metallic Minerals	75	25	0	0	100	12	1%
Basic & Fabricated Metals	54	23	16	7	100	35	4%
Wood & Wood Products	67	33	0	0	100	12	1%
Transport Equipment	100	0	0	0	100	5	1%
Textiles/Clothing	100	0	0	0	100	6	1%
Other Manufacturing	52	48	0	0	100	37	4%
Paper, Print & Publishing	84	16	0	0	100	11	1%
Total	47%	30%	15%	9%	100%	948	100%
Sector: Foreign-owned							
Electrical & Electronic equipment	20	27	39	14	100	183	24%
Software & Computer related	11	4	85	0	100	224	30%
Pharmaceuticals	1	21	36	42	100	105	14%
Instruments	15	20	51	14	100	108	14%
Food, Drink & Tobacco	0	75	0	25	100	5	1%
Other Services	8	8	83	0	100	32	4%
Machinery & Equipment	34	33	29	4	100	33	4%
Chemicals	13	13	15	60	100	41	6%
Rubber & Plastics	22	45	33	0	100	7	1%
Non-metallic Minerals	0	0	0	0	0	0	0%
Basic & Fabricated Metals	60	40	0	0	100	5	1%
Wood & Wood Products	0	0	0	0	0	0	0%
Transport Equipment	50	0	0	50	100	3	0%
Textiles/Clothing	0	0	0	0	0	0	0%
Other Manufacturing	0	50	50	0	100	4	1%
Paper, Print & Publishing	0	0	0	0	0	0	0%
Total	14%	17%	53%	15%	100%	750	100%

*Percentages rounded to nearest whole number

9.2.2 Patents Granted

Table 9.2 provides details on the total number of patents granted to R&D active companies in 2001. A total of 794 were granted in that year. The lead time between application and granting clearly makes direct comparison of the figures in Tables 9.2 and 9.3 difficult. For example the 794 patents granted in 2001 may not be related to the 1,698 applications made in that year. The figures on patents applied for and granted in that year are assumed to be representative of the usual level of flows in respect of each and it would appear that in the order of 47 per cent of applications are ultimately granted.

The Electrical & Electronic equipment sector accounts for the highest percentage of patents granted in 2001 at 22 per cent (174 patents), followed by Software & Computer related at 16 per cent (130 patents).

In aggregate terms the distribution of source country of patents granted is broadly similar to that of applications. Approximately one-third of patents are granted in Ireland, 28 per cent in the US, one quarter in the rest of Europe and the remaining 15 per cent in the rest of the World (refer to Table 9.3 and Figure 9.2).

Table 9.3: *Distribution of patents granted to R&D active companies in Ireland in 2001 classified according to industrial sector.*

Sector	All Companies*						
	RoI	Rest Europe	USA	Elsewhere	Total	No.	%
Electrical & Electronic equipment	34	26	26	15	100	174	22
Software & Computer related	25	16	59	0	100	130	16
Pharmaceuticals	6	19	40	35	100	75	9
Instruments	22	30	36	12	100	51	6
Food, Drink & Tobacco	46	35	5	13	100	53	7
Other Services	45	19	27	9	100	77	10
Machinery & Equipment	57	21	12	11	100	44	6
Chemicals	5	22	16	56	100	44	6
Rubber & Plastics	24	35	17	24	100	13	2
Non-metallic Minerals	50	50	0	0	100	3	0
Basic & Fabricated Metals	65	17	9	9	100	27	3
Wood & Wood Products	100	0	0	0	100	9	1
Transport Equipment	35	20	20	24	100	38	5
Textiles/Clothing	100	0	0	0	100	6	1
Other Manufacturing	49	46	5	0	100	39	5
Paper, Print & Publishing	84	16	0	0	100	11	1
Total	34%	23%	28%	15%	100%	794	100%

*Percentages rounded to nearest whole number

Table 9.4 provides details on the breakdown of patents granted according to ownership of the firm. This shows that exactly one half of the total number of patents granted were to foreign companies and one-half to Irish-owned companies.

Table 9.4: *Distribution of patents granted to R&D active companies in Ireland in 2001 classified by industrial sector and ownership.*

	RoI	Rest Europe	USA	Elsewhere	Total	No.	%
Sector: Irish-owned Companies*							
Electrical & Electronic equipment	55	22	10	13	100	53	13
Software & computer related	41	29	29	0	100	61	15
Pharmaceuticals	17	17	17	50	100	26	7
Instruments	43	29	29	0	100	11	3
Food, Drink & Tobacco	47	34	5	14	100	52	13
Other Services	59	23	5	13	100	54	14
Machinery & Equipment	61	17	9	13	100	36	9
Chemicals	23	55	23	0	100	5	1
Rubber & Plastics	40	20	0	40	100	8	2
Non-metallic Minerals	50	50	0	0	100	3	1
Basic & Fabricated Metals	66	11	11	11	100	22	6
Wood & Wood Products	100	0	0	0	100	9	2
Transport Equipment	100	0	0	0	100	4	1
Textiles/Clothing	100	0	0	0	100	6	2
Other Manufacturing	54	46	0	0	100	36	9
Paper, Print & Publishing	84	16	0	0	100	11	3
Total	53%	25%	11%	11%	100%	397	100%
Sector: Foreign-owned Companies*							
Electrical & Electronic equipment	25	27	32	15	100	121	30
Software & Computer related	11	4	85	0	100	69	17
Pharmaceuticals	0	21	52	27	100	48	12
Instruments	16	31	38	15	100	40	10
Food, Drink & Tobacco	0	100	0	0	100	1	0
Other Services	12	12	77	0	100	23	6
Machinery & Equipment	39	36	24	0	100	8	2
Chemicals	3	18	15	64	100	39	10
Rubber & Plastics	0	58	42	0	100	5	1
Non-metallic Minerals	0	0	0	0	0	0	0
Basic & Fabricated Metals	60	40	0	0	100	5	1
Wood & Wood Products	0	0	0	0	0	0	0
Transport Equipment	27	23	23	27	100	34	9
Textiles/Clothing	0	0	0	0	0	0	0
Other Manufacturing	0	50	50	0	100	4	1
Paper, Print & Publishing	0	0	0	0	0	0	0
Total	16%	22%	44%	18%	100%	397	100%

*Percentages rounded to nearest whole number

9.3 Summary

A total of 1,698 patents were applied for by R&D active firms in 2001. Just under 56 per cent of these were applied for by Irish owned companies. One-third of applications were made in the Republic of Ireland, one-third in the US, one-quarter in the rest of Europe and the remaining 12 per cent were made in other countries. The Software & Computer related sector (accounting for 33 per cent or 566 of patent applications), Electrical & Electronic equipment (accounting for 16 per cent, 277 patent applications) and Instruments sector (accounting for 13 per cent, 214 patent applications) were relatively most important in terms of applications made.

794 patents were granted to companies which were R&D active in 2001. Exactly one-half of these were granted to Irish and one-half to foreign companies. The Republic of Ireland was the most important source country for patents granted accounting for one-third (270 patents) of patents granted. A further 28 per cent (222 patents) were granted from the US, 23 per cent (183 patents) from the rest of Europe and the remaining 15 per cent (119 patents) from the rest of the World. The most important sectors to have patents granted were Electrical & Electronic equipment (22 per cent, 174 patents), Software & Computer related (16 per cent, 130 patents) and Other Services (10 per cent, 77 patents).

10 Innovation Indicators

10.1 Introduction

Technological innovation is an essential component of economic growth. In order for innovation to occur, a combination of favourable circumstances is necessary. Economists however have traditionally considered the accumulation of conventional inputs such as labour and capital to be the primary force behind economic growth. Robert Solow won the 1987 Nobel Prize for economics for formulating a growth theory in 1956 that identified the importance of technology but his ideas have only slowly become a significant part of economists' thinking. Now, however, many macroeconomists place technological progress at the centre of the growth process. For growth to occur it is necessary to establish and maintain favourable conditions for technological innovation. In other words, to build the economy, it is necessary to address the more complicated issue of creating a culture in which the introduction of new technologies can thrive.

Forfás continues in its effort to capture a broader picture of the innovative process. R&D is only one element of this innovative process. This section presents key findings from an analysis of the Irish data, as captured in the recent Community Innovation Survey (CIS) and earlier CIS surveys undertaken by Forfás. The latest innovation survey was based on a sample of 3,500 companies in the country with 10 or more employees operating in the manufacturing or services sectors

10.2 Key Innovation Indicators

Introduction of new/improved products

Table 10.1 gives details of the key 'innovation' indicators for the 1992 to 2000 period. From the table it is evident that Ireland, on par with the EU average, saw half of all firms surveyed introduce new or improved **products** during the 1998 to 2000 period. This represents a decline from the 62% of firms introducing new or improved products reported for the 1994 to 1996 period. The higher figure for the 1994-1996 probably reflects the 20+ employment cut-off for that survey, as larger firms appear to be more innovative.

Introduction of new/improved processes

Forty percent of firms had introduced or developed at least one new or improved **process** in the 1998 to 2000 period. This is lower than the EU average where the latest available data shows that 53% of firms introduced new or improved processes. The current Irish level is lower than the levels of 52% and 58% reported over the 1992 to 1996 period.

It is important to note that these products and processes are not necessarily new to the market. They are changed products and processes from the point of view of the firm itself. While it may be argued that this is a crude measure of "innovativeness", it at least allows us to separate the companies with a complete absence of innovation from those who have developed and introduced changes in their products and processes whether or not those changes have come from inside or outside the firm.

Share of annual turnover

In terms of annual turnover of a company the growing importance of innovative products (new or improved) is quite striking. 42% of the survey population's turnover in 2000 was due to the introduction of new/improved products. The proportion of turnover contributed to by new/improved products has risen significantly since the early 1990's and Ireland lies significantly above the EU average (31%).

Table 10.1: *Main Innovation Indicators – 1992-2000*

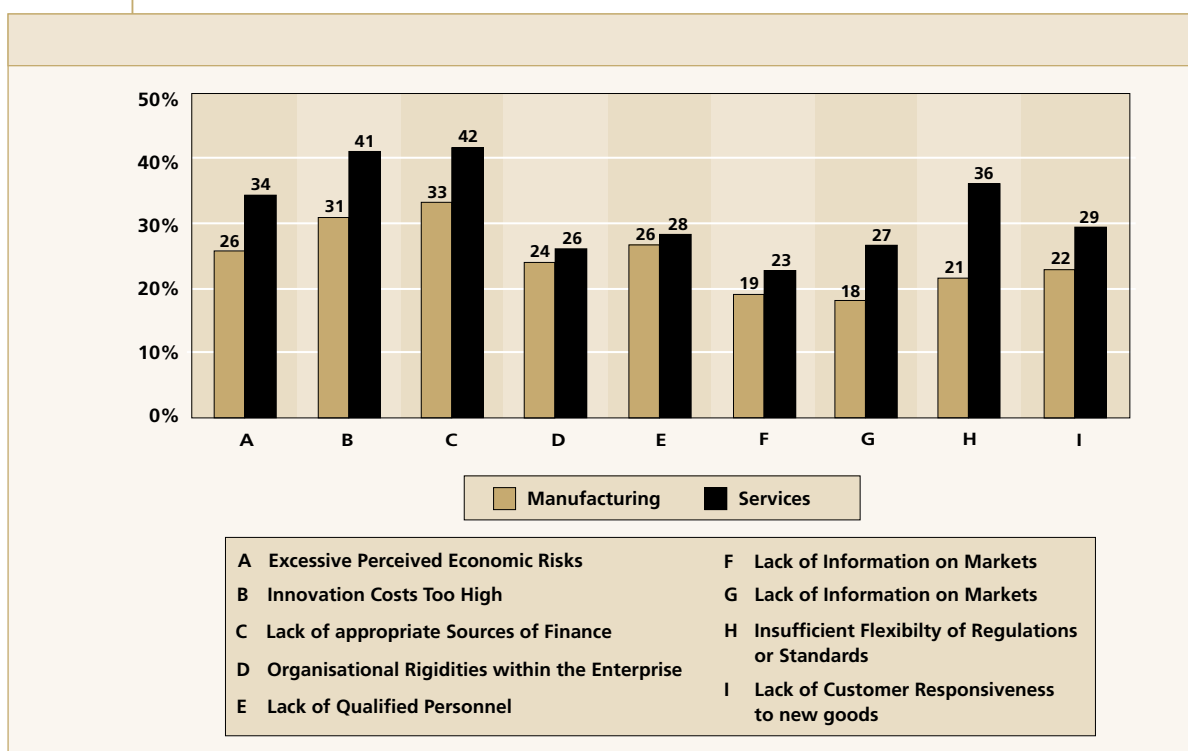
1992-1994	1992-1994 10+ employees	1994-1996 12+ employees	1998-2000 10+ employees	EU Average 1994-1996
Share of firms introducing new or improved products during the 2 year period	50%	62%	49%	48%
Share of firms introducing new or improved processes during the 2 year period	52%	58%	40%	53%
Share of Annual turnover from new or improved products	18% (1992)	32% (1996)	42% (2000)	31%

10.3 Barriers to Innovation

Figure 10.1 indicates the importance of different barriers to innovation from the 1998-2000 innovation survey.

Lack of financing and relatively high innovation costs are ranked as the greatest barriers to innovation in both manufacturing and service sectors. Complying with regulations and standards was also perceived as a significant barrier to innovation in the service sector. Excessive perceived economic risks ranked highly in both sectors as a factor hampering innovation between 1998 and 2000.

Figure 10.1: *Factors hampering innovation – frequency, 1998-2000*



In terms of innovation collaboration or networking, the most frequently cited partners were suppliers (17%), customers (12%), consultants (11%) and higher education institutes (11%). Funding still remains the most cited barrier to firms undertaking this type of innovation. Lack of qualified personnel is also a significant factor. In general, these questions and responses are too vague to offer much guidance for policy advice. They do, however, provide a starting-point for further research which is needed to develop innovation support strategies for enterprises.

Appendix 1: Detailed Tables

Table A1.1: *Business expenditure on R&D as a percentage of GDP*

	1993		1995		1997		1999		2001	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank	Value	Rank
Australia	0.69	17	0.86	16	0.75	18	0.65	18	0.72	18
Belgium	1.23	10	1.23	10	1.34	9	1.40	8	1.45	9
Canada	0.90	14	1.01	13	1.01	14	1.02	15	1.08	14
Czech Republic	0.88	16	0.66	17	0.73	19	0.78	17	0.79	17
Denmark	1.02	11	1.05	11	1.19	10	1.32	10	1.32	11
Finland	1.27	9	1.45	7	1.79	6	2.19	2	2.39	2
France	1.48	7	1.41	8	1.39	8	1.38	9	1.37	10
Germany	1.58	6	1.50	6	1.54	7	1.70	7	1.80	7
Greece	0.13	25	0.14	25	0.13	26	0.19	25	0.19	25
Hungary	0.32	22	0.32	22	0.30	23	0.28	24	0.36	22
Iceland	0.42	21	0.49	20	0.76	17	1.10	13	1.77	8
Ireland (GNP)	0.89	15	1.01	13	1.04	13	1.03	14	0.95	15
Italy	0.60	18	0.53	18	0.52	20	0.51	19	0.56	19
Japan	1.90	2	1.94	2	2.04	2	2.08	3	2.11	3
Korea	1.84	4	1.84	4	1.95	3	1.76	6	1.96	5
Netherlands	0.99	12	1.04	12	1.11	12	1.14	12	1.13	13
New Zealand	0.31	24	0.26	24	0.31	22	0.31	22	0.31	23
Norway	0.93	13	0.97	15	0.93	15	0.92	16	0.92	16
Poland	0.32	22	0.27	23	0.28	24	0.31	22	0.24	24
Portugal	0.12	26	0.12	26	0.14	25	0.17	26	0.17	26
Slovak Republic	0.51	19	0.53	18	0.83	16	0.42	21	0.44	21
Spain	0.44	20	0.39	21	0.40	21	0.46	20	0.52	20
Sweden	2.28	1	2.57	1	2.75	1	2.84	1	2.84	1
Switzerland	1.86	3	1.86	3	1.93	4	1.95	5	1.95	6
United Kingdom	1.42	8	1.30	9	1.18	11	1.25	11	1.21	12
United States	1.78	5	1.80	5	1.91	5	1.98	4	2.04	4
OECD Average	1.44		1.45		1.48		1.52		1.56	
EU Average	1.18		1.12		1.13		1.19		1.21	

Source: *Forfás R&D in the Business Sector 1999*

Source: *MSTI OECD 2002 Volume 2, nearest year used if data not available*

Table A1.2: *Business Sector R&D Personnel per 1000 industrial employment*

	1995		1997		1999		2001	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank
Australia	4.3	14	4.0	15	4.0	15	4.1	15
Belgium	11.3	4	11.7	4	12.6	4	13.4	4
Canada	8.1	9	8.1	10	7.2	11	7.2	10
Denmark	11.0	5	11.7	4	12.0	5	12.0	5
Finland	15.0	2	15.5	2	18.3	1	18.9	1
France	10.7	6	10.9	6	10.9	7	11.0	7
Germany	10.3	7	10.7	7	11.2	6	11.2	6
Greece	1.0	21	1.1	21	1.5	21	1.5	21
Hungary	2.3	19	2.5	19	2.1	19	2.3	19
Ireland	5.9*	12	6.7	12	6.8	12	6.9	12
Italy	3.8	15	3.8	16	3.6	16	3.8	17
Japan	13.2	3	13.1	3	13.9	3	13.5	3
Korea	5.0	13	5.1	13	5.0	13	5.0	13
Mexico	0.2	23	0.2	24	0.2	24	0.2	24
Netherlands	7.9	10	8.2	9	8.2	9	8.7	9
New Zealand	3.8	15	3.8	16	4.1	14	4.1	15
Norway	9.3	8	9.3	8	9.2	8	9.2	8
Poland	1.9	20	1.8	20	1.6	20	1.4	21
Portugal	0.6	22	0.6	22	0.9	22	0.9	22
Slovak Republic	3.2	17	4.5	14	3.5	17	3.0	18
Spain	3.0	18	2.9	18	3.5	17	4.6	14
Sweden	18.1	1	18.1	1	17.5	2	17.5	2
Turkey	0.2	23	0.3	23	0.3	23	0.3	23
United Kingdom	7.3	11	6.9	11	7.5	10	7.1	11
EU Average	7.7		7.8		8.1		8.1	

Source: MSTI OECD 2002 Volume 2, nearest year used if data not available.

* Ireland used 1996 industrial employment data as denominator

Table A1.3: Business Sector Researchers per 1000 industrial employment

	1995		1997		1999		2001	
	Value	Rank	Value	Rank	Value	Rank	Value	Rank
Australia	2.5	14	2.3	15	2.4	16	2.3	16
Belgium	5.5	5	5.7	6	6.7	6	7.3	5
Canada	4.9	6	5.1	7	4.6	10	4.6	10
Denmark	4.2	9	4.4	10	4.9	8	4.9	9
Finland	9.6	1	11.4	1	12.3	1
France	4.5	8	4.7	9	4.8	9	5.0	8
Germany	4.7	7	5.0	8	5.5	7	5.5	7
Greece	0.5	21	0.6	22	0.7	22	0.7	22
Hungary	1.0	19	1.1	20	1.2	20	1.4	19
Ireland	3.5*	12	4.2	11	4.3	12	4.5	11
Italy	1.7	16	1.7	18	1.6	17	1.6	18
Japan	9.0	2	9.0	3	10.0	3	9.8	3
Korea	3.7	11	3.9	13	3.9	13	4.2	12
Mexico	0.1	23	0.1	25	0.1	25	0.1	25
Netherlands	2.8	13	3.3	14	3.5	14	3.5	14
New Zealand	2.2	15	2.2	16	2.7	15	2.7	15
Norway	6.7	4	6.7	5	6.8	5	6.8	6
Poland	0.8	20	0.9	21	0.8	21	0.8	21
Portugal	0.3	22	0.3	23	0.5	23	0.5	23
Slovak Republic	1.4	17	2.1	17	1.6	17	1.4	19
Spain	1.1	18	1.2	19	1.4	19	1.8	17
Sweden	8.6	3	8.6	4	9.0	4	9.0	4
Turkey	0.1	23	0.2	24	0.2	24	0.2	24
United Kingdom	4.2	9	4.2	11	4.5	11	4.2	12
United States	9.2	1	9.6	1	10.1	2	10.2	2
OECD Average	5.2		5.3		5.7		5.7	
EU Average	3.6		3.7		4.0		4.1	

Source: MSTI OECD 2002 Volume 2, nearest year used if data not available.

* Ireland used 1996 industrial employment data as denominator

Appendix 2: Methodology

Methodology

A2.1: Survey Administration

The survey was conducted on a so-called mixed mode basis of postal questionnaires and telephone follow-up. This involved sending an introductory letter to all respondents in the sample. This was followed by sending a series of questionnaires to all respondents along with very intensive phone call follow-ups made by ESRI interviewers to encourage response. A total of 5 complete mailshots of all respondents was carried out between June and November 2002 with each of the mailshots followed by intensive phoning.

A2.2: The sample

The sample of firms which was used for the survey was derived from a number of sources. These included:

- ▶ a Forfás list of priority companies which were identified as having a high potential of being R&D active.
- ▶ a Forfás list of potentially R&D active companies.
- ▶ additional firms identified by Forfás as having recorded that they undertook R&D activity in recent Annual Business Surveys.
- ▶ a group of large firms selected from an ESRI database of firms from sectors which were assumed to have a high level of R&D activity.

A total valid target sample of 3,024 firms were approached. A response rate of just over 48 per cent was achieved from this sample (1,460 firms) in the main survey. This is very much in keeping with the expected response rate from a survey of firms in Ireland today. A total of 694 of the firms which completed the main questionnaire recorded having undertaken in-house R&D activity in the course of 2001. Response levels to the survey are as shown below:

Non Response	1323	44%
Completed	1460	48%
Refused	172	6%
Other	69	2%
Total	3024	100%

A2.3: Supplementary Short Questionnaire

In October 2002 an abbreviated questionnaire was sent to a group of 775 companies from the 1,323 who had not responded to the main survey. This group was selected on the basis of having the highest potential of having undertaken R&D activity. This abbreviated questionnaire recorded details only on whether or not in-house and outsourced R&D activity had been

completed; (where relevant) the level of in-house activity; number of employees; description of business activity; ownership and turnover. A total of 370 firms from this group recorded having undertaken R&D in 2001 on an in-house basis.

A2.4: Re-weighting the data

In common with all statistical surveys the data were re-weighted or statistically adjusted prior to analysis. The purpose of this is to ensure that they are fully representative of the entire population from which they have been selected. In carrying this out for the current survey the basic weighting metric was number of employees. Two main components were involved in the weighting process. First, an estimate was made of the probability of the non-respondents to the survey having actually carried out in-house R&D activity in 2001. The information on the completed questionnaires (both full or main questionnaires and also the abbreviated questionnaires) was used in this component of the weighting scheme. The probability or percentage of employees who were located in R&D active enterprises was derived. This probability was based on a 3-way classification of firms according to industrial sector; employee size category and ownership. This probability was then applied to non-respondent firms. A population frame was thus created from a combination of this indirect probability approach as well as the direct responses of respondents who completed either the main or abbreviated questionnaire.

When the population frame of R&D active companies was established, respondents to the main survey were then statistically adjusted or re-weighted to that population of companies who were engaged in R&D activity. This second component or aspect to the weighting was implemented using a standard ratio weighting approach based on sector; nationality and size of company. The weighting criteria or metric used was number of employees. This approach provides the best unbiased estimates of R&D activity among firms in Ireland in 2001.

Reports Published by Forfás 2002 / 2003

The Labour Market Participation of Over 55s in Ireland <i>Expert Group on Future Skills Needs</i>	January 2002
International Trade and Investment Report	February 2002
Biotechnology <i>Irish Council for Science, Technology & Innovation (ICSTI)</i>	February 2002
Enlargement of the European Union <i>Forfás Submission to the National Forum on Europe</i>	February 2002
Broadband Investment in Ireland	March 2002
Research & Development in the Business Sector 1999	May 2002
Comparative Consumer Prices in the Eurozone	June 2002
Forfás Annual Report 2001	July 2002
e-Business: Where we are and where do we go from here	August 2002
Measuring and Evaluating Research <i>Irish Council for Science, Technology & Innovation (ICSTI)</i>	August 2002
Legislating for Competitive Advantage in e-Business and Information & Communications Technologies	October 2002
A Strategy for the Digital Content Industry in Ireland	November 2002
Annual Competitiveness Report 2002 & The Competitiveness Challenge Report <i>National Competitiveness Council (NCC)</i>	November 2002
World Trade Organisation Negotiating Objectives for Irish Enterprise Policy	February 2003
National Survey of Vacancies in the Private Non-Agricultural Sector National Survey of Vacancies in the Public Sector <i>Expert Group on Future Skills Needs</i>	March 2003
Utilising Intellectual Property for Competitive Advantage <i>Irish Council for Science, Technology & Innovation (ICSTI)</i>	April 2003
Design & Development <i>Irish Council for Science, Technology & Innovation (ICSTI)</i>	April 2003
Baseline Assessment of the Public Research System in Ireland in the areas of Biotechnology and Information and Communication Technologies	April 2003

The Demand and Supply of Skills in the Food Processing Sector <i>Expert Group on Future Skills Needs</i>	April 2003
State Expenditure on Science and Technology, 2001 <i>Volume One: The Total Science & Technology Budget</i> <i>Volume Two: The Research & Development Element of the Science & Technology Budget</i>	May 2003
Statement on Inflation <i>National Competitiveness Council</i>	May 2003
Consumer Pricing Report 2003	May 2003
Embedding the PharmaChem Industry in Ireland <i>Irish Council for Science, Technology & Innovation</i>	May 2003
The Economic Appraisal System for Projects Seeking Support from the Industrial Development Agencies	May 2003
International Trade and Investment	June 2003
The Demand and Supply of Engineers and Engineering Technicians <i>Expert Group on Future Skills Needs</i>	July 2003
State Expenditure Priorities for 2004 <i>Irish Council for Science, Technology & Innovation</i>	July 2003
Annual Report, 2002	July 2003
A Comparison of Starting Salaries for Science and Engineering Graduates	September 2003

Functions of Forfás

Is é Forfás an bord náisiúnta um polasaí agus comhairle le haghaidh fiontraíochta, trádála, eolaíochta, teicneolaíochta agus nuála. Is é an comhlacht é a bhfuil comhactaí dlíthiúla an stáit maidir le cur-chun-cinn tionscail agus forbairt teicneolaíochta dílsithe ann. Is é an comhlacht é freisin trína dciomnaítear cumhachtaí ar Fhiontraíocht Éireann le tionscail dúchais a chur chus cinn agus ar ghníomhaireacht Forbartha Tionscail na hÉireann (GFT Éireann) le hinfheistíocht isteach sa tír a chur chun tosaigh. Is iad feighmeanna Fhorfás:

- ▶ comhairle a chur ar an Aire ó thaobh cúrsaí a bhaineann le forbairt tionscail sa Stát
- ▶ comhairle maidir le forbairt agus comhordú polasaithe a chur ar fáil d'Fhiontraíocht Éireann, d'GFT Éireann agus d'aon fhoras eile dá leithéid (a bunaíodh go reachtúil) a d'fhéadfadh an tAire a ainmniú trí ordú
- ▶ forbairt na tionsclaíochta, na heolaíochta, na nuála agus na teicneolaíochta, na margaíochta agus acmhainní daonna a spreagadh sa Stát
- ▶ bunú agus forbairt gnóthas tionsclaíoch ón iasacht a spreagadh sa Stát, agus
- ▶ Fiontraíocht Éireann agus GFT Éireann a chomhairliú agus a chomhordú ó thaobh a gcuid feidhmeanna.

Forfás is the national policy and advisory board for enterprise, trade, science, technology and innovation. It is the body in which the State's legal powers for industrial promotion and technology development have been vested. It is also the body through which powers are delegated to Enterprise Ireland for the promotion of indigenous industry and to IDA Ireland for the promotion of inward investment. The broad functions of Forfás are to:

- ▶ advise the Minister on matters relating to the development of industry in the State
- ▶ advise on the development and co-ordination of policy for Enterprise Ireland, IDA Ireland and such other bodies (established by or under statute) as the Minister may by order designate
- ▶ encourage the development of industry, science and technology, innovation, marketing and human resources in the State
- ▶ encourage the establishment and development in the State of industrial undertakings from outside the State, and
- ▶ advise and co-ordinate Enterprise Ireland and IDA Ireland in relation to their functions.

Board Members

Peter Cassells	<i>Chairman</i>
Martin Cronin	<i>Chief Executive, Forfás</i>
Sean Dorgan	<i>Chief Executive, IDA Ireland</i>
Dan Flinter	<i>Chief Executive, Enterprise Ireland</i>
Paul Haran	<i>Secretary General, Department of Enterprise, Trade & Employment</i>
Professor Michael Hillery	<i>Chair of Manufacturing Engineering University of Limerick</i>
Rody Molloy	<i>Director General, FÁS</i>
William Murphy	<i>Partner, Tynan Dillon and Company</i>
Feargal O'Rourke	<i>Partner, Taxation Pricewaterhouse Coopers</i>
Dr Don Thornhill	<i>Chairman, Higher Education Authority</i>
Toni Wall	<i>Managing Director, Wall-2-Wall Ltd</i>
Jane Williams	<i>Managing Director, The Sia Group Ltd</i>

