A Model to Predict the Supply and Demand for Researchers and Research Personnel in Line with Ireland's Strategy for Contributing to the European Research Area 3% Initiative

A Report Prepared for Forfás and
the Expert Group on Future Skills Needs

by

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1. Introduction

1.1 Background

The Heads of EU States agreed the European Research Area (ERA) project at the Lisbon Summit in 2000 as a contribution to making Europe the most competitive knowledge-based economy by 2010. At Barcelona in 2002, they set two targets:

- a target for Europe of achieving Gross Expenditure on Research and Development as a percentage of GDP of 3% by 2010; with
- two thirds (i.e. 2%) to come from the private sector.

The European Commission has asked Member States to produce "action plans" to demonstrate how they intend to progress the ERA agenda, including the 3% target.

In this context, the Tánaiste and Minister for Enterprise, Trade and Employment announced the establishment of a high level national Steering Group to:

- assess the implications of the key emerging ERA policy initiatives, and
- prepare action plans for progressing priority areas.

Three subgroups to the Steering Group were established, one of which, the Framework Conditions subgroup, considered the issue of increased demand for researchers that will arise in line with increased R&D expenditure. Since most R&D expenditure is on staff salaries, the ability of Ireland and the EU to close the R&D gap will depend ultimately on the availability of research personnel to perform the R&D. This paper provides details of the model used to project the demand and supply of researchers required to meet Ireland' target.

1.2 Objectives of the Study

The key objectives of the study were to:

- predict the supply of researchers and research personnel on an annual basis to 2010;
- predict the demand for researchers and research personnel to 2010, again on an annual basis; and
- provide a comparison of supply and demand.

The analysis was required to take account of:

- demographics; and
- flows of researchers and research personnel into and out of the system.

As this project progressed in parallel with other work by the ERA Steering Group, requirements emerged for the inflow/outflow model to be presented for three scenarios as follows:

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[13] GERD – Gross Expenditure on R&D.

- achieving a 2.5% GERD[3]/GNP spend on R&D;
- achieving a 2.8% GERD/GNP spend on R&D; and
- achieving the Barcelona target of 3% GERD/GNP[4].

1.3 Strategic Perspective

The questions posed in this study are narrow and specific: the focus is on the supply of graduates required for research work over what is effectively the short term future, a period over which past and existing trends provide a reasonable basis for estimating industry requirements. It is also a period over which graduate supply is already largely fixed by decisions and investments already made; it is only by around 2009 or 2010 that a decision made now could impact significantly on graduate numbers.

The specificity of the questions posed were dictated by the purpose for which the study was commissioned – establishing whether the supply of graduates is likely to be sufficient to allow ERA targets for research activity to be met by 2010. However, it should be noted that ***if the purpose had instead been to establish a view as to the optimum supply of graduates, it is likely that significantly higher numbers would have been found to be required, possibly with a different mix of academic disciplines, and certainly with a greater ratio of PhD to non-PhD graduates.***

The reasons for these differences are fourfold.

- The strategic purpose in producing graduates for research work is not just to satisfy projected demand. It is, just as importantly, to stimulate further demand. Decisions on graduate output made now are likely to significantly affect growth in research activity over the decade from 2010 to 2020. The greater the supply of PhD graduates, the greater the likely volume of inward research investment, the greater the likely volume of research-related start-ups, and the greater the likely volume of investment in research by indigenous companies.

  Similar principles have served Ireland well in the past, when apparent over-production of graduates in engineering and computing during the 1980s and early 1990s allowed rapid ICT industry growth through most of the 1990s. There is significant evidence from around the world of research activity following the availability of suitable graduates, often clustering around the institutions from which they graduated.

- It is possible to make reasonable estimates of the broad disciplinary mix of graduates required for research work, over a short period into the future, based on existing patterns of recruitment. However, beyond 2010 there are greater uncertainties. Some of these uncertainties relate to the future direction of Irish industry. Others relate to the fact that much is unknown, even within fairly broad disciplinary areas, about what areas of research will be “hot” several years into the future. Thus, for strategic reasons, it is important to avoid building a supply of research graduates so narrowly focused that it will only meet Ireland’s needs beyond 2010 in the unlikely event that uncertain projections turn out to be precisely correct. Responsiveness to changing circumstances and a degree of diversity in PhD output are required to mitigate this risk.

[4] The EU Barcelona target is expressed as a percentage of GDP. For most EU countries, there is little difference between GDP and GNP. However, reflecting patterns of inward and outward investment, Irish GNP is significantly less than Irish GNP. It is considered that GNP is a more appropriate basis for a target for Ireland.

- Because of the specific aims of this study, the model of demand for researchers used here takes a conservative view of the share of all researchers, and indeed of graduates entering non-research careers, that must be made up of PhD graduates. It seeks to answer the question: "how many PhD graduates are needed to allow Ireland to meet its ERA target?" rather than "what is the optimum number of PhD graduates?" However, we believe that substituting a PhD graduate for a non-PhD graduate will, on average, improve the quality and creativity of work done, whether in research or other fields of endeavour. Thus, the optimum share of researchers made up of PhD graduates is likely to be well above the level at which demand is projected in this model, even during the period to 2010, and even more so over the period to 2020.
- If the demand model was extended beyond 2010, assuming all other things unchanged, the results would show the demand for graduates for research work continuing to increase.

1.4 Existing Skills Research

In recent years, Ireland has invested significantly in skills research, primarily through the Expert Group on Future Skills Needs (EGFSN). This research has addressed the skills needs of many of the key industry sectors engaged in research, and which have the potential to engage in more research into the future. In many cases, the skills requirements for researchers that are the concern of this study are identical with, or are subsets of, skills requirements that have already been investigated recently by the Expert Group. The Expert Group has undertaken work relating to all of the main sectors engaged in research in the recent past, including (published in 2003) Information and Communications Technology[5], Biotechnology[6], Pharmaceuticals and Medical Devices[7].

It is desirable to take account of this other work for a number of reasons.

- It would be preferable to have a consistent view, to the extent that this is feasible given practical considerations and the requirements of policy.
- It is desirable to have a joined-up approach to skills policy and research policy where they overlap.

In recognition of these considerations, we have drawn upon outputs from previous research. Projections of supply and demand for engineers and computing graduates have been inserted into the analysis. Projections of incremental Biotechnology employment have also been inserted. Projections of employment for various industries have also been used, drawn from a number of EGFSN studies.

1.5 Importance of Focus on Sectors and Academic Disciplines in Analysis

1.5.1 Requirement for Research Graduates for Non-Research Roles

Graduates with the skills required to work as researchers are attractive to many employers that may not employ them as researchers, and even to employers that may not have a use for the specific skills and knowledge that they have acquired through their studies and research.

[5] Major unpublished report prepared for Forfás and the Expert Group on Future Skills Needs jointly by McIver Consulting and PA Consulting. The main skills highlights are published in the Fourth Report of the Expert Group.
[6] Report on Biotechnology skills published by Expert Group.
[7] Requirement for engineers in Pharmaceuticals and Medical Devices is addressed in Report on Demand and Supply for Engineers and Engineering Technicians, by the Expert Group.

A PhD graduate in any discipline, or indeed a Masters graduate or an honours primary degree graduate, possesses generic skills that make them likely to find high quality employment that makes a valuable economic contribution, regardless of whether there are opportunities to work in research.

An analysis of salary data on new graduates presented later in the report shows that starting salaries for graduates with PhDs are significantly higher than those for non-PhD graduates, indicating that the labour market places a premium on such qualifications.

It is important to the general health of the economy that there should be a flow of graduates with research-relevant qualifications into non-research jobs from across a wide range of disciplines. This includes a need for a flow of PhD and research Masters graduates in non-SET[8] disciplines where opportunities for careers in research are limited, but where there is a need for knowledge and expertise in the economy and in society. While the focus of the analysis behind this report is on SET disciplines, because it is from these disciplines that graduates are most likely to start research careers, this should not be seen as downplaying the requirement for graduates with research degrees in non-SET disciplines for non-research work[9].

1.5.2 Match Between Qualifications and Job Skills Requirements of Economic Sectors

For research work, and for jobs that may be capable of leveraging the specific skills and knowledge derived from postgraduate study, the quality of the match between the subject matter of the qualification and the requirements of the job is important. In some cases, employers may be satisfied with a fairly loose match. In others, they may seek quite a tight match, and may choose to recruit overseas, or even establish operations outside Ireland, in order to gain access to the skills they require. For this reason, a scattergun approach to research skills policy would be likely to retard the achievement of broader research policy objectives.

Researcher skills requirements vary very substantially between industry sectors. ICT industries will primarily require graduates in Computing and Electronic Engineering, with a smaller admixture of graduates in other engineering and scientific disciplines. Biotechnology industries will primarily require graduates from life sciences disciplines such as Biochemistry, Genetics, Microbiology and Pharmacology, again with an admixture of graduates from other disciplines. Thus, any analysis should take account of the current and likely future sectoral structure of Irish industry, and should draw conclusions about the required disciplinary mix of graduates based on this analysis. While there is a risk that industry will not develop as projected, it is less than the risk associated with ignoring the sectoral structure of the economy, and the link between that structure and skills requirements.

Such an approach is particularly important for Ireland for the following reasons.

- Business R&D is heavily skewed towards a small number of sectors, which also offer some of the main opportunities to increase R&D expenditure productively.
- While the general shape of public R&D funding policies fits well with the list of sectors that provide opportunities to increase business R&D expenditure, there has not, to date, been a formal effort to make the flow of research degree graduates resulting from such funding proportionate to the volume of skills demand in those sectors.

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[8] SET - Science, Engineering and Technology.

[9] Indications from interviews are that the current level of funding for academic research in the social sciences and humanities is about right, given the current level of interest in research funding from higher education institutions.

1.6 Terminology and Levels of Qualification

There is a tendency for discourse about research skills to be confused by a lack of clarity about what is meant by the terms “researcher” and “research skills”. Supply side discussions have tended to focus on research degrees (PhDs and research masters), while the available data on those employed as researchers categorises many people without research degrees as researchers. Forfás research and development surveys, which form one of the main sources of demand side data, and which are designed for consistency with similar surveys conducted elsewhere in the EU, cover many people working in development who, it can be argued, are not strictly speaking researchers.

Faced with this diversity of views as to what a “researcher” is, it is necessary for the current study to adopt a clear operational definition of what is meant by the term. As the purpose of this study is to explore the skills implications of meeting the Barcelona 3% target, and as compliance with the target will be judged in terms of the outputs of Forfás R&D surveys, the operational definition chosen is that a person who appears in Forfás research and development surveys as a researcher should be considered to be a researcher.

However, it is important to be conscious that there are other views as to what constitutes a “researcher”, and that many of those recorded as researchers in Forfás surveys might not be judged to be researchers by criteria that draw a precise distinction between research work and development work.

By the standard adopted for the current report, the overwhelming majority of researchers working in Ireland do not have PhD degrees, and most of these probably do not have research masters degrees either[10]. In the 2001 BERD survey, just 10% of business sector researchers were found to have PhDs. In the higher education sector, the number of researchers studying for PhDs and research Masters degrees appears to exceed the numbers that already have such degrees by a significant margin.

Thus, demand for “researchers” in this report refers to demand for both PhD and non-PhD researchers.

The report does deal directly with the supply of “researcher skills”. For most relevant disciplines and levels of qualification, the available supply of graduates feeds both researcher and non-researcher jobs. At primary degree level, non-researcher demand mostly exceeds researcher demand. Thus, in order to form a basis for comparisons between projections of supply and demand, the report complements the projections of demand for “researchers” with “whole economy” demand projections that take into account both researcher and non-researcher demand.

Projections of graduate supply and demand are made at two levels:

- ISCED 5A, which incorporates primary degrees, graduate diplomas and masters degrees; and
- ISCED 6, which covers PhD degrees.

Underlying the supply projections for ISCED 5A, are projections for ISCED 5B, which cover higher education undergraduate certificates and diplomas. While these projections are not presented in the report, they are used to drive the add-on degree component of ISCED 5A.

No distinction is made in the findings between primary degrees and masters degrees, whether research or taught, for two main reasons.

[10] In 2001, 73% of non-PhD researchers were employed in the ICT-dominated sectors of Electrical & Electronic Equipment and Software & Computer Related Services, in which a primary degree is by far the most common qualification for development work.

- It was intended that the study should produce internationally comparable projections, with distinctions in level of qualification being based on ISCED coding. Both primary and masters degrees are classified as ISCED 5A.
- Treating primary degrees and masters degrees as being at the same level simplified the analysis significantly, and contributed to overcoming shortcomings in the available data.

1.7 Disciplinary Definitions

Table 1.1 below describes the disciplinary classifications used for the study. These were designed to be reasonably consistent with the ISCED coding system, while responding to issues specific to higher education in Ireland.

The supply side analysis was conducted using these classifications to categorise courses for which data had been collected. The demand side analysis made use of an analysis of HEA First Destination data, with anonymised student data being categorised according to these classifications.

Table 1.1 Disciplinary Classifications Used in Study

ISCED Subject Code		Typical Course Titles / PhD Descriptions
522,523	Electrical/Electronic/Computer Engineering	Electrical, Electronic, Computer or Telecommunications Engineering; Electronics; Electronic Systems
521,525	Mechanical/Production/Industrial Engineering	Mechanical, Production, Industrial, Manufacturing or Quality Engineering; Computer Integrated Manufacturing
582	Civil/Environmental	Civil, Structural or Environmental Engineering; Construction (excluding Construction Economics)
520/580 n.e.c.	Other Engineering	Chemical, Process, Biomedical, Aeronautical Engineering
520/580	Unspecified Engineering	
543	Materials Science / Engineering	Materials Science; Materials Engineering; Advanced Materials
441 (part of)	Physics	Theoretical, Experimental or Applied Physics
441 (remainder)	Instrumentation	Physics (at an IoT); Instrumentation; Chemical Instrumentation
442	Chemistry	Chemistry; Industrial Chemistry; Pharmaceutical Science
421 (part of)	Biosciences - Core Biotech	Biotechnology; Biochemistry; Microbiology; Pharmacology (not Pharmacy); Genetics; Biomedical Science; Biology (where it was known the course has a Biotechnology slant)
421 (remainder)	Biosciences - Other	Zoology; Toxicology
421	Biosciences - Unspecified	
541	Food Science	Food Science
420 (part of)	Analytical Science	Analytical Science
721 (part of)	Medical Sciences	Physiology; Anatomy; Medical Laboratory Science; Nutrition; Health & Safety; Medicine (PhD only)
311	Psychology	Psychology
422	Environmental Science	Environmental Science
443 (part of)	Marine Science	Marine Science
461,462	Mathematics	Mathematics; Applied Mathematics; Statistics; Mathematical Science
481	Computer Science	Computing; Software Engineering; Computer Science; Computer Applications; Business Information Systems;
621	Agricultural Science	Agricultural Science; Horticulture; Forestry; Animal Science;
420 n.e.c.	Other Sciences	Geology; Earth Sciences
420/440	Unspecified Science	

To the extent that has been feasible, given the limitations of the data sources, courses and research students have been included in the analysis if they fall into the above categories, even if they are not within the responsibilities of an Engineering or Science faculty/school/college.

1.8 Data Sources and Data Issues

The report draws on a wide range of sources of data of which the following are the principal sources.

Graduate Supply

- Course level data on student numbers and graduate numbers in the HEA sector from HEA.
- Course level data on graduate numbers from HETAC.
- Course level data on student numbers in the technology sector from Department of Education & Science.
- Anonymised college acceptances data from CAO at the level of the individual applicant.
- Anonymised First Destination data from HEA at the level of the individual[11].
- Data and projections on graduate supply drawn from earlier EGFSN studies.
- Demographic projections drawn from an unpublished 2003 study of demographic trends by EGFSN.

Industry Projections

- Census 2002 employment data by detailed industry (CSO).
- Survey of Industrial Employment (CSO).
- Census of Industrial Production (CSO) employment data.
- Projections in earlier EGFSN studies, including ICT study (2003), Biotechnology Skills Study (2003) and Study of Demand and Supply of Engineers and Engineering Technicians. (2003)

Demand Projections

Outputs from supply analysis and industry projections were combined with data from the following.

- Forfás BERD survey 2001 (data on expenditure and employment).
- First Destination of Award Recipients in Higher Education survey 2001, anonymised database of responses (used to estimate graduate recruitment by industry in relevant disciplines for graduates of 2001).

[11] This database includes some data on subjects taken that is not included in other college returns.

2. Demand Projections

2.1 Introduction

The demand projections were built up from a combination of the following:

- The view of the future of the economy to 2010 set out in the Benchmark Forecast of ESRI's Medium Term Review (published 2003);
- More detailed industry, higher education research and government research perspectives on the future drawn from other work and studies, including the 2003 ICT clustering and skills study, the 2003 Report on Supply and Demand for Engineers and Engineering Technicians and various projection exercises undertaken in connection with the work of the ERA Steering Group;
- Data on the existing situation drawn from Forfás reports and research in relation to Business Expenditure on Research and Development (BERD), Higher Education Expenditure on Research and Development (HERD) and Government Expenditure on Research and Development (GOVERD);
- Qualitative understanding of government and higher education research activity drawn from interviews with a range of relevant agencies; and
- Analyses of existing relevant labour market behaviour, such as an examination of graduate recruitment patterns, as reflected by the HEA's First Destination of Award Recipients survey for graduates of 2000.

Demand projections were built up in the following stages:

- GNP Projections;
- Employment Projections by Industry;
- Projections of BERD Research Staff Numbers;
- Projections of BERD Researcher Demand;
- Projections of HERD and GOVERD Researcher Demand; and
- Projections of Whole Economy Demand in Relevant Disciplines.

Industry level projections were undertaken in terms of the list of industries set out in the Forfás BERD survey for 2001. While this is based on the same coding system (NACE Rev.1) as other relevant projections and sources of data, differences in choices as to how industries are grouped posed complications in comparing and integrating both historical data and projections drawn from different sources.

2.2 GNP Projections

GNP projections were prepared by applying projections of GNP growth rates drawn from the ESRI Medium Term Review to GNP data drawn from the CSO web site. These projections, which are at 2002 prices, are set out in Table 2.1.

Table 2.1 GNP Projections

	2002	2003	2004	2005	2006	2007	2008	2009	2010
ESRI MTR Benchmark Forecast GNP Growth	0.6%	2.4%	3.0%	4.7%	5.7%	5.6%	5.7%	5.1%	4.8%
GNP 2002 Prices €m	104,364	106,869	110,075	115,248	121,817	128,639	135,972	142,906	149,766
2.5% GNP 2002 Prices €m	2,609	2,672	2,752	2,881	3,045	3,216	3,399	3,573	3,744
2.8% GNP 2002 Prices €m	2,922	2,992	3,082	3,227	3,411	3,602	3,807	4,001	4,193
3.0% GNP 2002 Prices €m	3,131	3,206	3,302	3,457	3,655	3,859	4,079	4,287	4,493

2.3 Employment Projections by Industry

The approach taken to constructing projections of employment for each industry is outlined in Figure 2.2. The need to combine and reconcile different sources arose mainly from differences in the ways in which industries are grouped in different analyses.

Data from Census 2002, from the Forfás/EGFSN ICT Clustering and Skills Study (2003) and from the CSO’s Census of Industrial Production were fitted to the industry sector classifications used in Forfás BERD surveys (such as that of 2001). This led to the creation of the industry employment profile of the economy that can be seen in the 2002 column of Table 2.3.

Employment growth rate projections from the ESRI Medium Term Review (MTR) formed the basis for employment growth rates in the model. However, industries in the MTR are grouped differently to those in Forfás BERD surveys, giving a low degree of resolution on many of the industries that are most heavily involved in research and development. It was necessary to make use of other existing industry employment growth projections to bridge this gap.

When applied to the industry employment profile of the economy for 2002, these growth rates led to the projected employment profiles of the economy that can be seen in the columns of Table 2.2 for 2003 to 2010.

Figure 2.2 Construction of Industry Employment Projections

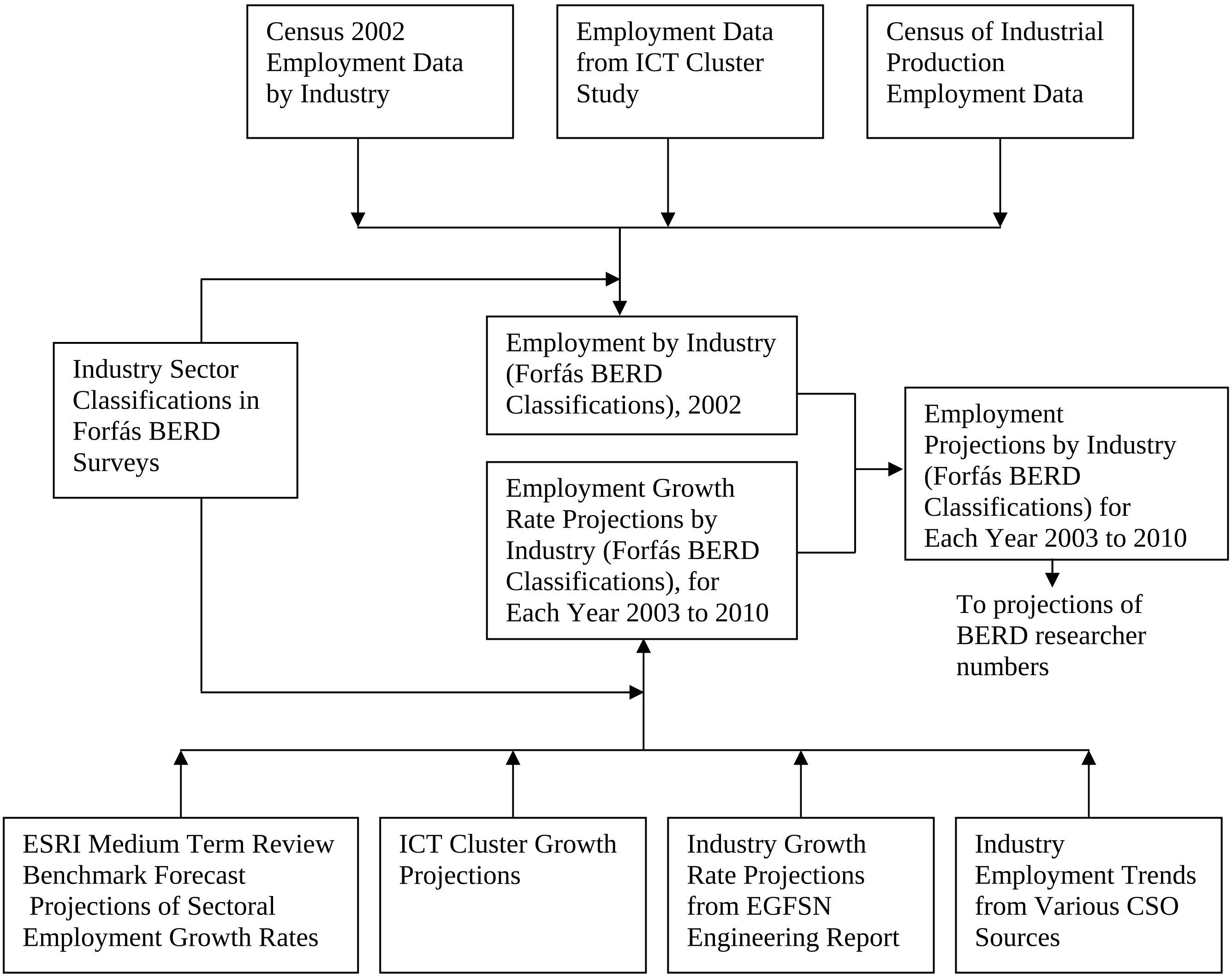

Table 2.3 Sectoral Employment Projections to 2010

		2002	2003	2004	2005	2006	2007	2008	2009	2010
30,31,32	Electrical & Electronic Equipment – ICT Study*	28,151	26,225	25,817	25,485	25,825	25,043	24,927	24,878	24,895
30,31,32 Continued	Electrical & Electronic Equipment – Residue*	10,916	9,825	8,842	8,400	7,980	7,581	7,202	6,842	6,500
72	Software & Computer-Related Services - ICT Study*	27,168	26,819	29,652	32,813	36,343	40,287	44,698	49,633	55,158
72 Continued	Software & Computer-Related Services – Residue*	9,037	9,489	9,964	10,462	10,985	11,534	12,111	12,716	13,352
244	Pharmaceuticals	19,685	20,276	21,493	22,782	24,149	25,598	27,134	28,762	30,488
331	Medical Devices	15,091	15,544	16,476	17,465	18,513	19,624	20,801	22,049	23,372
339	Other Instruments	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696	3,696
15,16	Food, Drink, Tobacco	45,035	44,630	45,166	45,120	45,120	45,120	45,120	45,120	45,120
65-67	Banking & Financial Services	75,508	75,508	77,018	78,559	80,130	81,732	83,367	85,034	86,735
50-52,55,70,71,73, 74,90-93,95	Other Services	617,077	634,645	655,270	662,273	692,892	720,174	752,095	768,969	787,989
29	Machinery & Equipment	14,316	14,316	14,316	14,316	14,316	14,316	14,316	14,316	14,316
249	Chemicals	7,598	7,598	7,598	7,598	7,598	7,598	7,598	7,598	7,598
25	Rubber & Plastics	8,195	7,867	7,552	7,250	6,960	6,682	6,415	6,158	5,912
26	Non-Metallic Minerals	14,143	14,143	14,143	14,143	14,143	14,143	14,143	14,143	14,143
27,28	Basic & Fabricated Metals	22,145	21,702	21,268	20,843	20,426	20,017	19,617	19,225	18,840
20	Wood & Wood Products	6,416	6,358	6,549	6,745	6,948	7,156	7,371	7,592	7,820
34,35	Transport Equipment	10,877	10,551	10,551	10,551	10,551	10,551	10,551	10,551	10,551
17,18	Textiles/Clothing	11,321	9,962	8,767	7,715	6,789	5,974	5,258	4,627	4,071
19,23,36,37	Other Manufacturing	17,474	17,317	17,317	17,317	17,317	17,317	17,317	17,317	17,317
21,22	Paper, Print & Publishing	25,176	24,949	24,949	24,949	24,949	24,949	24,949	24,949	24,949
01,02,05,10-14,40,41,45	Other Business (Not Covered in BERD Report)	282,015	283,729	281,157	278,393	272,031	267,591	264,006	260,502	255,570
75,99,80,85	Other Non-Business	370,480	401,434	405,554	411,787	428,258	445,389	463,204	481,732	501,002
	Total	1,641,521	1,686,584	1,713,114	1,728,661	1,775,919	1,822,073	1,875,895	1,916,409	1,959,393

* The major part of each of these sectors was addressed by the Forfás/EGFSN ICT Clusters and Skills Study (2003), which included employment projections to 2010. The “ICT Study” projections above are based on aggregating subsectoral projections from this study together. There are some businesses in each of these sectors which were not included within the ICT study (in areas such as electrical equipment and computer repair). These are covered by the “Residue” projections.

Key features of the employment projections include relatively strong growth in the research-intensive areas of Software & Computer-Related Services, Pharmaceuticals and Medical Devices. If this is achieved, it will tend to increase the volume of research undertaken in Ireland, even if these industries fail to become more research-intensive.

Employment growth in Electrical and Electronic Equipment is projected to stall, reflecting a combination of a continuing fall in lower value added assembly work, balanced by an increase in the volume of higher value added activities including research and development.

2.4 Projections of BERD Research Staff Numbers

Figure 2.4 summarises how projections of research staff numbers for each industry were constructed. Research staff numbers for 2001 were taken from the Forfás BERD survey of that year. They were projected forward into the future, up to 2010, based on changes in industry employment, and on assumptions as to changes in the R&D-intensivity of employment in each sector.

These assumptions were driven by the spend on BERD targeted by each scenario, with the allocation of changes in that spend between industries being driven by a combination of strategic and policy considerations. The objective was to ensure that each scenario would be plausible in industry terms as well as meeting the BERD target.

The spending implications of each employment scenario were calculated by taking account of the spend per member of research staff in 2001 in each industry and projected changes (taken from the MTR Benchmark forecast) in real take-home pay per employee across the economy. The calculation makes the assumptions that pay of research staff in the enterprise sector will rise in line with that for other occupations, and that the share of spending on research in each industry devoted to labour costs will remain constant. (However, the average share of research spending devoted to labour costs falls across the economy, as industries engaged in Biotechnology research increase their activity.

Figures 2.5 to 2.7 present research staff employment projections at industry level for each of the three scenarios.

In addition to the industries for which employment projections had been made, two additional industry categories were included in each of these, reflecting a projected discontinuous increase in activity in Biotechnology and Nanotechnology research that was in addition to existing trends.

The projections in the “Incremental Biotechnology” category were based on an interpretation of the findings of the 2003 EGFSN report on Biotechnology skills.

The projections in the “Incremental Nanotechnology” category were based on an interpretation of work done by Forfás on the topic of nanotechnology.

Figure 2.4 Construction of Projections of Research Staff Numbers

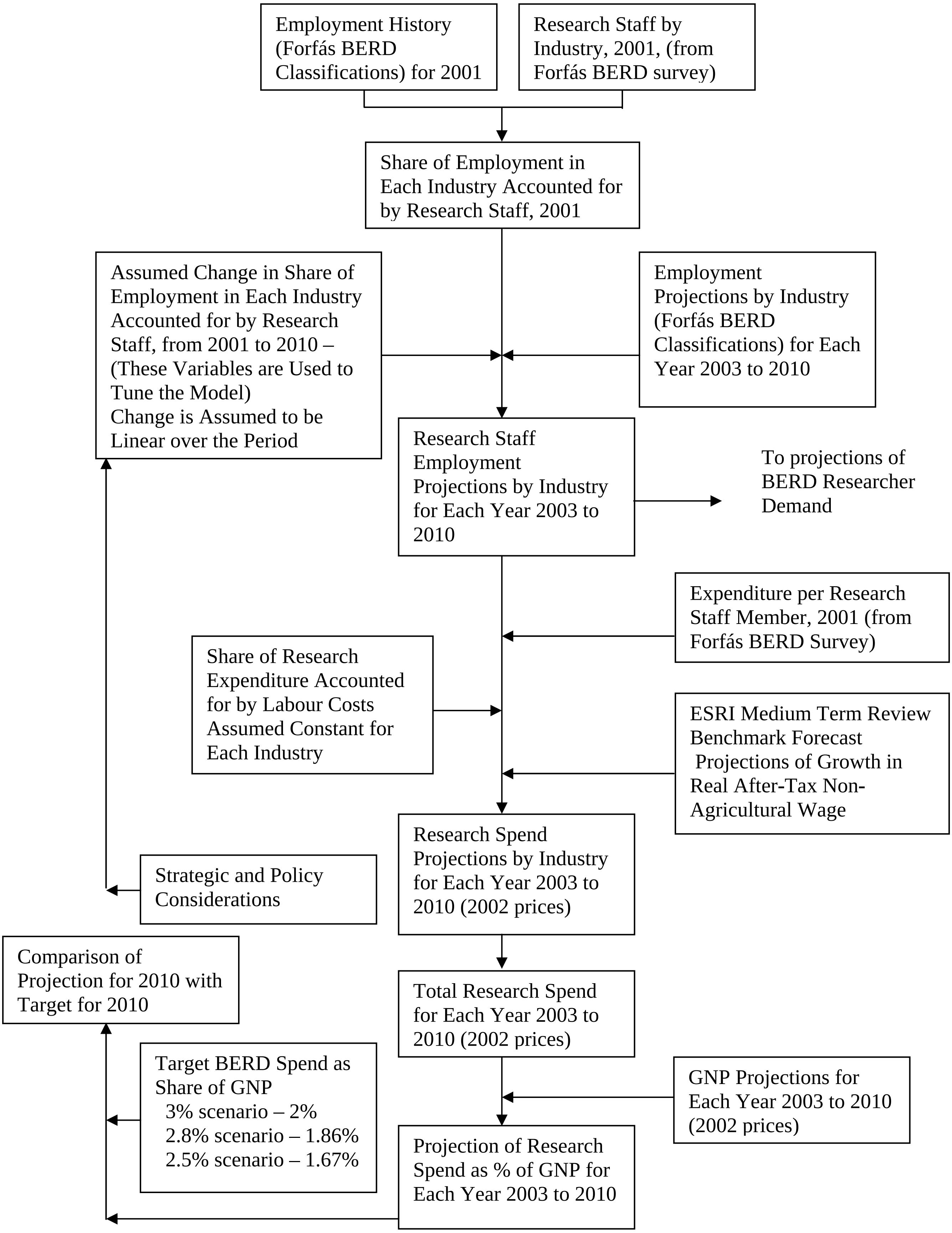

Table 2.5 Projections of BERD Research Staff Numbers by Industry, 3% Scenario

	2004	2005	2006	2007	2008	2009	2010
Electrical & Electronic Equipment	2,889	3,126	3,445	3,610	3,861	4,120	4,390
Incremental Nanotech	80	120	160	200	240	280	320
Software & Computer-Related	3,319	3,930	4,637	5,455	6,402	7,497	8,763
Pharmaceuticals	686	774	871	977	1,092	1,217	1,354
Incremental Biotech (based on EGFSN Biotech report)	360	540	720	900	1,080	1,260	1,440
Instruments	624	697	776	862	955	1,056	1,164
Food, Drink, Tobacco	652	694	737	779	822	864	907
Other Services	463	484	505	527	549	572	596
Machinery & Equipment	302	309	316	323	330	338	345
Chemicals	192	197	201	206	210	215	220
Rubber & Plastics	129	127	125	123	120	118	116
Non-Metallic Minerals	136	139	143	146	149	152	156
Basic & Fabricated Metals	121	121	122	122	122	122	123
Wood & Wood Products	68	71	75	79	83	88	92
Transport Equipment	101	103	106	108	110	113	115
Textiles/Clothing	41	37	33	30	27	24	22
Other Manufacturing	77	79	81	83	84	86	88
Paper, Print & Publishing	70	72	74	75	77	79	80
Total	10,311	11,621	13,126	14,604	16,315	18,202	20,290

Table 2.6 Projections of BERD Research Staff Numbers by Industry, 2.8% Scenario

	2004	2005	2006	2007	2008	2009	2010
Electrical & Electronic Equipment	2,860	3,083	3,387	3,539	3,776	4,022	4,278
Incremental Nanotech	70	105	140	175	210	245	280
Software & Computer-Related	3,212	3,752	4,374	5,092	5,918	6,870	7,967
Pharmaceuticals	665	741	824	914	1,013	1,119	1,235
Incremental Biotech (based on EGFSN Biotech report)	337	506	674	843	1,011	1,180	1,349
Instruments	605	667	735	807	886	971	1,063
Food, Drink, Tobacco	624	652	680	708	737	765	793
Other Services	463	484	505	527	549	572	596
Machinery & Equipment	302	309	316	323	330	338	345
Chemicals	192	197	201	206	210	215	220
Rubber & Plastics	129	127	125	123	120	118	116
Non-Metallic Minerals	136	139	143	146	149	152	156
Basic & Fabricated Metals	121	121	122	122	122	122	123
Wood & Wood Products	68	71	75	79	83	88	92
Transport Equipment	101	103	106	108	110	113	115
Textiles/Clothing	41	37	33	30	27	24	22
Other Manufacturing	77	79	81	83	84	86	88
Paper, Print & Publishing	70	72	74	75	77	79	80
Total	10,073	11,245	12,594	13,899	15,414	17,079	18,916

Table 2.7 Projections of BERD Research Staff Numbers by Industry, 2.5% Scenario

	2004	2005	2006	2007	2008	2009	2010
Electrical & Electronic Equipment	2,773	2,953	3,211	3,327	3,523	3,727	3,940
Incremental Nanotech	60	90	120	150	180	210	240
Software & Computer-Related	3,069	3,515	4,024	4,607	5,272	6,034	6,905
Pharmaceuticals	641	703	771	843	922	1,008	1,100
Incremental Biotech (based on EGFSN Biotech report)	314	471	629	786	943	1,100	1,257
Instruments	579	627	678	733	792	856	924
Food, Drink, Tobacco	605	624	643	662	681	701	720
Other Services	458	475	493	512	531	551	571
Machinery & Equipment	298	303	309	314	320	325	330
Chemicals	190	193	197	200	204	207	210
Rubber & Plastics	128	125	122	119	116	114	111
Non-Metallic Minerals	134	137	139	142	144	147	149
Basic & Fabricated Metals	120	119	119	119	118	118	117
Wood & Wood Products	67	70	73	77	81	84	88
Transport Equipment	100	101	103	105	107	109	110
Textiles/Clothing	40	36	32	29	26	23	21
Other Manufacturing	76	78	79	80	82	83	84
Paper, Print & Publishing	69	71	72	73	74	76	77
Total	9,722	10,693	11,815	12,878	14,116	15,470	16,956

2.5 Projections of BERD Researcher Demand

Figure 2.8 outlines the approach taken to constructing projections of demand for researchers by business, starting from projections of research staff employment by industry over the period 2003 to 2010.

The first stage was to convert projections of research staff employment into projections of researcher employment at PhD level and at non-PhD level. For practical purposes, non-PhD level is equivalent to a combination of masters (research and taught), primary degree and graduate diploma level. Thus, in ISCED terms, PhD level is equivalent to ISCED Level 6, and non-PhD Level is equivalent to ISCED Level 5A.

The Forfás BERD survey divides research staff into four groups:

- PhD Researchers
- Non-PhD Researchers
- Technicians
- Support Staff

Overall projections of research staff employment were divided among these four categories for each industry in proportion to the share of research staff employment accounted for by each in 2001, for all except "Incremental Biotechnology" and "Incremental Nanotechnology". Projections of technician and support staff numbers were not taken any further, as the main focus of the study was on supply and demand at levels from primary degree upwards, and in SET disciplines.

The divide for “Incremental Biotechnology” was based on the projections in the EGFSN report on Biotechnology skills. The divide for “Incremental Nanotechnology” was based on an interpretation of work done by Forfás on the topic of nanotechnology.

Projections of demand for PhD and non-PhD researchers in each industry were derived by assuming that any net increase in employment would lead to a corresponding increase in demand, and that one in ten researchers would have to be replaced in each year. The one-in-ten estimate is based on the knowledge that many of those internationally who start their careers as researchers move into non-research roles after a number of years. No hard information is available as to the average length of research careers in Ireland, but the one-in-ten estimate is seen by the consultants as being close to the middle of the range of plausible possibilities.

The analysis moved from providing separate annual projections to providing an average over the period 2004 to 2010, along with a projection for 2010. This was done partly to limit the complexity of adding another dimension to the model – that of academic discipline – and partly because detailed annual projections are of limited usefulness.

For each industry, the projections of PhD researcher and non-PhD researcher demand were then disaggregated by discipline, based on ratios derived in part from an examination of recruitment patterns by each relevant industry from graduates in SET disciplines, and in part from a qualitative and strategic understanding of the skills requirements of research in each industry.

Up to this point, the analysis assumed that the ratio of PhD to non-PhD researchers would remain as it was in 2001. In fact, it is very likely that the ratio among new recruits for research work favours PhDs, and that it would favour them more if a sufficient supply were available. This is true across all disciplines, but is particularly the case in science disciplines where there is a tendency internationally for the PhD to be seen as the standard professional qualification. Inward investment to establish biotechnology and pharmaceutical research centres will have a requirement for PhD graduates that exceeds that of existing research operations in these areas.

The outputs from these steps are set out in Table 2.9 for each of the three scenarios, and for both 2010 and the average over the period 2004 to 2010.

Figure 2.8 Construction of Projections of BERD Researcher Demand by Discipline and Level

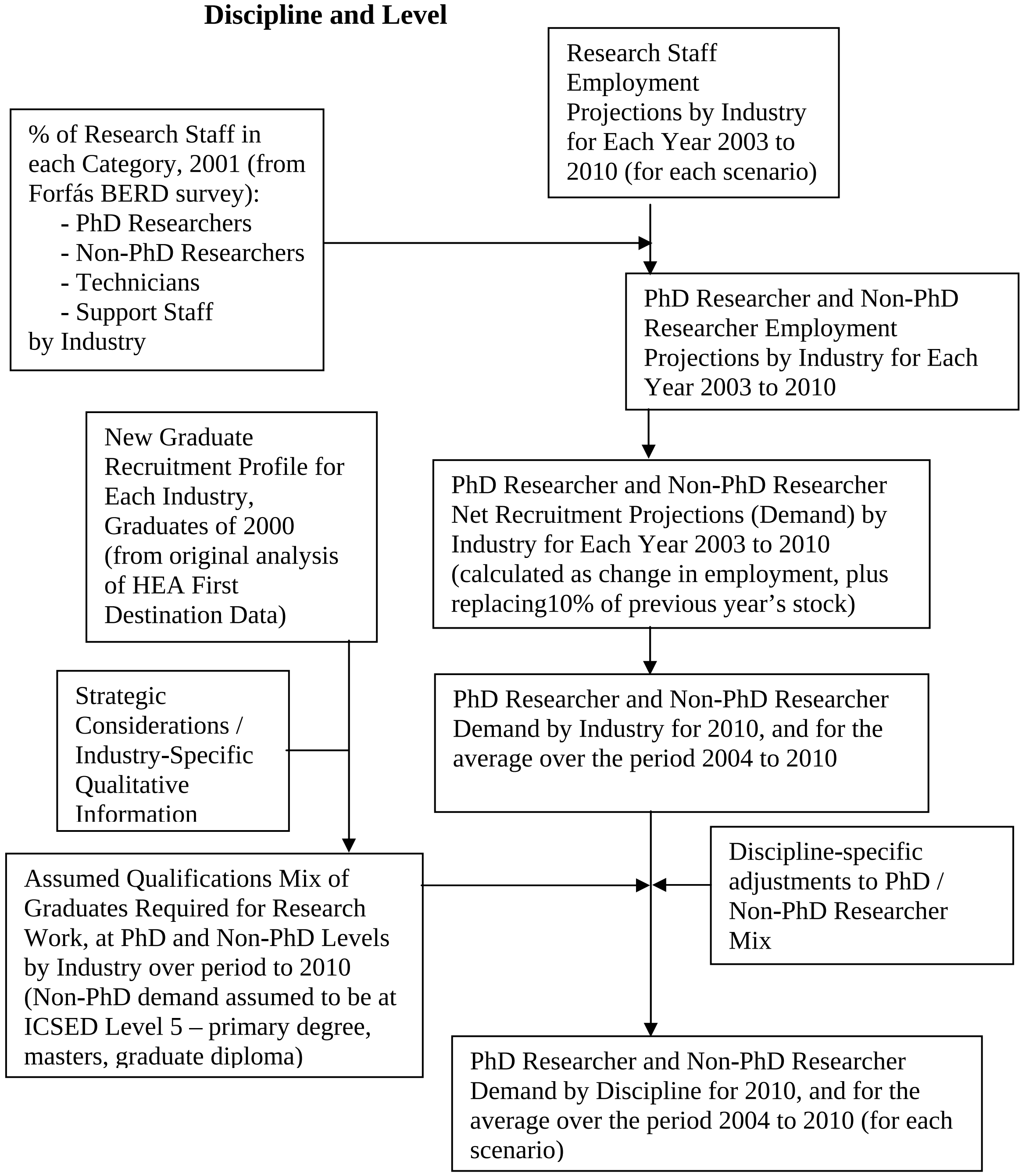

Table 2.9 Projections of BERD Researchers Demand, 2010 and Average 2004-2010

2010	PhD Level Researchers			Non-PhD Level Researchers		
	3% Scenario	2.8% Scenario	2.5% Scenario	3% Scenario	2.8% Scenario	2.5% Scenario
Electronic Eng	62	57	49	283	261	225
Mech/Prod Eng	36	34	30	108	102	90
Civil/Env Eng	0	0	0	0	0	0
Other Eng	4	4	3	40	36	31
Materials	21	20	17	78	73	65
Physics	22	21	18	45	43	37
Instrumentation	0	0	0	0	0	0
Chemistry	62	57	49	114	104	91
Core Biosciences	166	157	149	94	90	85
Other Biosciences	6	5	4	13	11	9
Food Science	7	6	5	25	20	17
Medical Sciences	26	24	23	21	20	18
Psychology	7	6	5	13	12	11
Environmental Science	0	0	0	0	0	0
Marine Science	0	0	0	0	0	0
Maths	12	12	11	22	21	19
Computing	216	194	163	1,134	1,016	854
Ag Science	5	4	4	11	9	7
Other Sciences	0	0	0	0	0	0
Total	652	601	530	2,001	1,818	1,559

Mean 2004 to 2010	PhD Level Researchers			Non-PhD Level Researchers		
	3% Scenario	2.8% Scenario	2.5% Scenario	3% Scenario	2.8% Scenario	2.5% Scenario
Electronic Eng	47	44	39	215	202	178
Mech/Prod Eng	31	30	27	92	89	81
Civil/Env Eng	0	0	0	0	0	0
Other Eng	3	3	3	29	27	24
Materials	18	17	15	65	63	58
Physics	18	18	16	37	35	32
Instrumentation	0	0	0	0	0	0
Chemistry	50	47	42	92	87	77
Core Biosciences	149	145	139	85	82	79
Other Biosciences	5	5	4	12	10	8
Food Science	7	6	5	22	18	16
Medical Sciences	23	23	21	19	18	17
Psychology	5	5	4	10	10	9
Environmental Science	0	0	0	0	0	0
Marine Science	0	0	0	0	0	0
Maths	11	10	10	18	18	16
Computing	151	138	119	792	721	621
Ag Science	5	4	3	10	9	7
Other Sciences	0	0	0	0	0	0
Total	523	495	447	1,498	1,389	1,223

2.6 Projections Relating to HERD and GOVERD Researchers

Higher education research is research carried out in higher education institutions, which is primarily funded by various state funding programmes. Major programmes include those operated by Science Foundation Ireland, the HEA (PRTLI), IRCSET[12], IRCHSS[13] and Enterprise Ireland. Various other agencies, including inter alia the Health Research Council, Teagasc and the Marine Institute also fund significant volumes of research in the higher education system. Expenditure on higher education research is referred to as HERD.

Government research is research carried out by government agencies, such as Teagasc, the Environmental Protection Agency and the Marine Institute. Some research is also carried out directly by government departments. Expenditure on government research is referred to as GOVERD.

The approach taken to constructing HERD and GOVERD projections (outlined in Figure 2.11) began with spending projections, taking existing projections to 2006 already collated by Forfás on behalf of the ERA Steering Committee, and extending them to 2010 on the basis of the expenditure implied by each scenario. These projections were used as the basis for projections of the number of HERD and GOVERD researchers by taking account of 2002 Forfás data on HERD and GOVERD numbers, trends in pay costs, and an assumed real escalation in cost of research per researcher. These projections are summarised in Table 2.10.

Table 2.10 Projections of HERD and GOVERD Researcher Numbers

	2004	2005	2006	2007	2008	2009	2010
GOVERD – 3% Scenario	560	560	560	657	744	824	897
HERD – 3% Scenario	4,410	4,897	5,306	6,050	6,690	7,246	7,733
GOVERD – 2.8% Scenario	560	560	560	641	715	782	844
HERD – 2.8% Scenario	4,410	4,897	5,306	5,908	6,425	6,875	7,269
GOVERD – 2.5% Scenario	560	560	560	613	661	705	745
HERD – 2.5% Scenario	4,410	4,897	5,306	5,647	5,940	6,195	6,419

HERD projections were taken no further, for reasons which are explained in the section of this report addressing "whole economy" demand[14].

Projections of GOVERD researcher numbers were disaggregated between PhD researcher level and non-PhD researcher level, and were converted to demand projections by assuming that any net increase in employment would lead to a corresponding increase in demand, and that 7%[15] of researchers would have to be replaced in each year. These demand projections were further disaggregated between academic disciplines on the basis of a combination of qualitative information and the profile of recruitment of graduates of 2000 by government bodies, as revealed by an analysis of data from the HEA's annual First Destination of Award Recipients survey. The resulting demand projections are summarised in Table 2.12.

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[12] Irish Research Council for Science Engineering and Technology

[13] Irish Research Council for the Humanities and Social Sciences

[14] Briefly, those undertaking HERD research at student level appear as research students in the supply side analysis. It is necessary to avoid double counting them. As the overall flow of PhD graduates into post-doctoral HERD research appears to be moving rapidly towards being balanced by a corresponding flow out the other end of postdoctoral programmes, it is simplest, and broadly reasonable, to treat postdoctoral programmes as presenting no net demand.

[15] The choice of 7% is subjective, but reflects the likelihood that research careers in government service are likely to be longer than in business, tempered by the fact that the age profile of existing government researchers appears to be higher than in industry.

Figure 2.11 Construction of Projections of HERD and GOVERD Researcher Numbers, and of GOVERD Demand by Discipline and Level

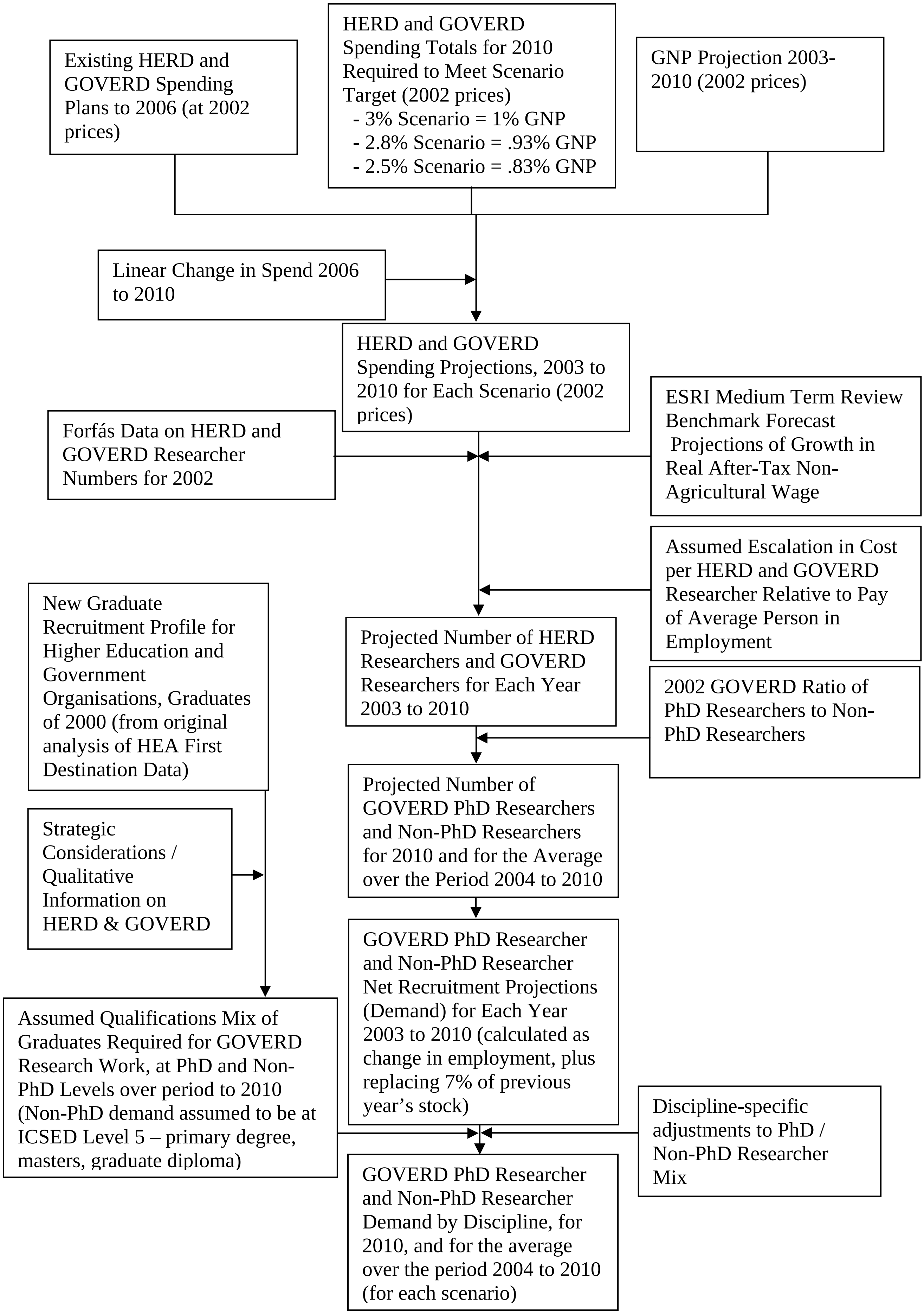

Table 2.12 Projections of GOVERD Researcher Demand

2010	PhD Level Researchers			Non-PhD Level Researchers		
	3% Scenario	2.8% Scenario	2.5% Scenario	3% Scenario	2.8% Scenario	2.5% Scenario
Electronic Eng	3	3	3	2	1	1
Mech/Prod Eng	6	5	5	3	2	2
Civil/Env Eng	3	3	3	2	1	1
Other Eng	3	2	1	1	1	1
Materials	0	0	0	0	0	0
Physics	1	1	1	1	1	1
Instrumentation	0	0	0	0	0	0
Chemistry	1	1	1	1	1	1
Core Biosciences	9	8	7	4	4	4
Other Biosciences	9	8	7	4	4	4
Food Science	9	8	7	4	4	4
Medical Sciences	5	4	4	6	6	5
Psychology	6	5	5	3	2	2
Environmental Science	3	2	2	4	3	3
Marine Science	3	3	3	2	1	1
Maths	3	2	1	1	1	1
Computing	7	6	5	3	3	3
Ag Science	9	8	7	4	4	4
Other Sciences	5	4	4	2	2	2
Non-SET Disciplines	27	24	22	11	9	8
Total	112	97	88	58	50	48

Mean 2004 to 2010	PhD Level Researchers			Non-PhD Level Researchers		
	3% Scenario	2.8% Scenario	2.5% Scenario	3% Scenario	2.8% Scenario	2.5% Scenario
Electronic Eng	3	3	2	1	1	1
Mech/Prod Eng	4	4	3	2	2	2
Civil/Env Eng	3	3	2	1	1	1
Other Eng	1	1	1	1	1	1
Materials	0	0	0	0	0	0
Physics	1	1	1	1	1	0
Instrumentation	0	0	0	0	0	0
Chemistry	1	1	1	1	1	0
Core Biosciences	6	6	5	3	3	3
Other Biosciences	6	6	5	3	3	3
Food Science	6	6	5	3	3	3
Medical Sciences	3	3	2	5	5	4
Psychology	4	4	3	2	2	2
Environmental Science	2	2	2	2	2	2
Marine Science	3	3	2	1	1	1
Maths	1	1	1	1	1	1
Computing	5	5	4	2	2	2
Ag Science	6	6	5	3	3	3
Other Sciences	3	3	3	2	1	1
Non-SET Disciplines	20	18	17	7	7	6
Total	78	76	65	41	40	35

2.7 Projections of Whole Economy Demand in Relevant Disciplines

There is a very substantial level of demand for graduates in SET disciplines to undertake non-research work, and indeed a small proportion of all such graduates take up positions in research and development. Thus, in order to make a meaningful comparison between the supply of graduates and demand for those graduates, it is necessary to take account of non-research demand for graduates as well as research-related demand.

For purposes of these projections, whole economy demand is made up of four components:

- BERD demand;
- GOVERD demand;
- Non-research demand; and
- A small part of higher education demand associated with recruitment of graduates into permanent teaching positions.

The majority of those undertaking HERD research have to be discounted from the demand analysis. Those undertaking research at student level appear as research students in the supply side analysis, and it is necessary to avoid double counting them.

As the overall flow of PhD graduates into post-doctoral HERD research appears to be moving rapidly towards being balanced by a corresponding flow out the other end of postdoctoral programmes, it is simplest, and broadly reasonable, to treat postdoctoral programmes as presenting no net demand. Given limitations on the data available, any more detailed approach would be liable to introduce more errors than it eliminated.

Two divergent approaches were taken to projecting whole economy demand.

- For all disciplines at ISCED Level 6 (PhD), and for all disciplines other than Computing and Engineering at ISCED Level 5A (primary degree, masters, graduate diploma) total projected BERD and GOVERD demand in a supplementary "no change in research spend" scenario was compared with actual recruitment of graduates of 2000 to form a basis for understanding how large a part of the demand for graduates of 2000 was accounted for by BERD and GOVERD research. The residue was assumed to reflect approximately a combination of non-research demand and the residue of higher education demand associated with permanent teaching posts. It was assumed that this demand would continue at a constant rate over the period to 2010.
- The demand projections in the Forfás/EGFSN ICT Clusters and Skills Report (2003) were whole economy projections which covered all of Computing and Engineering both at ISCED Level 5A and at Level 6. Level 5A projections in these disciplines for the current report were calculated for each scenario by subtracting whole economy PhD (Level 6) demand from these existing projections.

The resulting "whole economy" projections are presented in Tables 2.13 and 2.14

Table 2.13 Projections of Whole Economy Demand, 2010

2010	PhD Level Graduates			Non-PhD Level Graduates		
	3% Scenario	2.8% Scenario	2.5% Scenario	3% Scenario	2.8% Scenario	2.5% Scenario
Electronic Eng	65	60	52			
Mech/Production Eng	42	39	35			
Civil/Environmental Eng	12	12	12			
Other Engineering	7	6	4			
Unspecified Engineering	25	25	25	1,548	1,550	1,559
Materials	21	20	17	78	73	65
Physics	29	28	25	94	92	86
Instrumentation	0	0	0	48	48	48
Chemistry	66	61	53	464	454	441
Biosciences - Core Biotech	175	165	156	403	399	394
Biosciences - Other	19	17	15	46	44	42
Biosciences - Unspecified	0	0	0	50	50	50
Food Science	16	14	12	67	62	59
Analytical Science	0	0	0	19	19	19
Medical Sciences	87	84	83	74	73	70
Psychology	23	21	20	142	140	139
Environmental Science	3	2	2	157	156	156
Marine Science	3	3	3	27	26	26
Mathematics	15	14	12	61	60	61
Computer Science	223	200	168	3,412	3,427	3,450
Agricultural Science	21	19	18	95	93	91
Other Sciences	10	9	9	157	157	157
Total	862	799	721	6,942	6,923	6,913

Table 2.14 Projections of Whole Economy Demand, Mean 2004-2010

Mean 2004 to 2010	PhD Level Graduates			Non-PhD Level Graduates		
	3% Scenario	2.8% Scenario	2.5% Scenario	3% Scenario	2.8% Scenario	2.5% Scenario
Electronic Eng	50	47	41			
Mech/Production Eng	35	34	30			
Civil/Environmental Eng	11	11	10			
Other Engineering	4	4	4			
Unspecified Engineering	22	22	22	1,397	1,400	1,405
Materials	18	17	15	65	63	58
Physics	26	26	24	87	85	81
Instrumentation	2	2	2	48	48	48
Chemistry	57	54	49	355	350	339
Biosciences - Core Biotech	155	151	144	357	354	351
Biosciences - Other	16	16	14	28	28	29
Biosciences - Unspecified	7	7	7	35	35	35
Food Science	13	12	10	97	93	91
Analytical Science	0	0	0	18	18	18
Medical Sciences	76	76	73	57	56	54
Psychology	19	19	17	126	126	125
Environmental Science	2	2	2	146	146	146
Marine Science	3	3	2	22	22	22
Mathematics	12	11	11	63	63	62
Computer Science	156	143	123	2,591	2,600	2,614
Agricultural Science	19	18	16	93	92	90
Other Sciences	10	10	10	149	148	148
Total	713	685	626	5,734	5,727	5,716

2.8 Required Population of Researchers

Table 2.15 summarises projections for the populations of researchers required to achieve the 2.5% target[16].

Table 2.15 Projections for Population of Researchers Needed to Achieve the 2.5% Target, 2003-2010

Researchers relating to / Year	**2003**	**2004**	**2006**	**2008**	**2010**
Business Expenditure on R&D	5,838	6,575	8,241	10,038	11,079
Government Expenditure on R&D	560	560	560	703	807
Higher Education Expenditure on R&D	3,816	4,410	5,306	5,940	6,419
Total	**10,214**	**11,545**	**14,107**	**16,681**	**18,304**

[16] Note that projections of demand for researchers amount to more than the differences between the population projections for successive years. The factor driving this is that significant turnover in the researcher population is projected.

3. Supply Projections

3.1 Introduction

This chapter describes the preparation of the projections of graduate numbers, and their conversion into projections of graduate supply. It also presents a summary of the graduate supply projections.

3.2 Collation of Data

Data on student and graduate numbers in relevant disciplines were collated at the level of the individual course and at the greatest level of resolution available for research students. Data sources used were Department of Education & Science (Institutes of Technology student numbers), HEA (university sector student and graduate numbers), HETAC (graduate numbers, primarily in the Institutes of Technology sector) and CAO (data on acceptances of places on courses).

These sources were supplemented by data from the HEA's First Destination of Award Recipients database, which in some cases provided more detailed information on academic disciplines pursued by graduates than were available through regular college returns.

3.3 Grouping Data by Level of Qualification and Discipline

Data on courses and on research students were aggregated by discipline, grouped into the following levels of qualification:

- PhD;
- Research Masters;
- Taught Masters;
- Graduate Diploma;
- Primary Degree;
- Diploma; and
- Certificate.

3.4 Projections on the Basis of Current Student Numbers

3.4.1 Course-Level Graduate Projections

For each course[17], a projection of graduate numbers was made by applying the historical relationship between student numbers and graduate numbers to the most current student numbers, and to an estimate of recruitment into the course in 2003 derived from CAO data. In the case of a four year primary degree, this allowed graduate projections to be made up to 2007[18]. Thus, if, for example, graduate numbers on a degree course were historically equal to 80% of first year student numbers four years earlier, and first year student numbers were 100 in academic year 2002/03, then 80 students would be projected to graduate in 2007.

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[17] Primary Degree, Diploma, Certificate, Graduate Diploma.

[18] Up to 2006 for a three year diploma, up to 2005 for a two year certificate, and up to 2004 for a one year postgraduate diploma, a one year add-on degree or a one-year add-on diploma.

3.4.2 Aggregating Data and Projections by Discipline and Level of Qualification

Historical data, and all projections made so far, were then aggregated by discipline and level of qualification.

3.4.3 Taking Account of Add-On Undergraduate Qualifications

Extended projections of add-on diploma graduate numbers were made by applying the historical relationships between certificate graduate numbers and subsequent add-on diploma graduate numbers to certificate graduate projections at the level of the individual discipline.

Extended projections of add-on degree numbers were made by applying the historical relationships between diploma (add-on plus ab-initio) numbers and subsequent add-on degree numbers to diploma graduate projections.

Add-on degree graduate projections were added to ab-initio degree graduate projections already prepared to provide totals for degree level graduate projections. The sole function of the analysis at Diploma and Certificate level was to contribute this add-on degree analysis.

3.4.4 Research Degree Projections

Research degree projections were made on the basis of groupings of students and graduates aggregated across institutions by level of qualification and academic discipline. As student data collected by HEA and DES indicates the number of research students in an area by year of registration, it was possible to treat these groupings of students as quasi-courses. Thus, it was possible to make projections of graduate numbers based on historical relationships between student and graduate numbers in much the same way as with undergraduate courses.

3.5 Extending Projections to 2010

While the requirements of the study were to project graduate numbers up to 2010, the procedures described above led to projections that stopped short of that date; Primary degree projections can be made to 2007; graduate diploma projections reach to 2003; and PhD projections to 2006. For this reason, it was necessary to undertake a series of further steps to extend the projections to 2010. This was done by taking the following factors into account.

- Demographic factors, reflected in variations in the size of the school leaving age cohort were assumed to have a proportional impact on graduates in each discipline in the most appropriate year of graduation. Projections of the school leaving age cohort were drawn from the unpublished EGFSN report on the skills implications of demographic trends (2003).
- Variations in graduate numbers at primary degree level were assumed to have a proportional impact on student numbers, and eventually graduate numbers at research degree level.
- It was assumed that there would be a progressive recovery in the intake into courses in Computing and Electronic Engineering. Intake has fallen sharply in recent years in response to the downturn from which the ICT sector now appears to be recovering.

3.6 From Graduate Projections to Supply Projections

3.6.1 Need for Projections of Graduate Supply Separate from Projections of Graduate Numbers

Not all graduates become available for recruitment by Irish employers at the level of qualification at which they are recorded in graduate statistics. Some proceed to further study, and may become available for recruitment at a higher level of qualification. Some leave the country. A few remain, but fail to enter the labour force.

3.6.2 Avoiding Double Counting Graduates

The following steps were taken to avoid double counting graduates.

- Masters graduates were excluded from consideration. Overwhelmingly, these already have primary degrees in a discipline similar to that in which they have gained their masters degree. As both primary degrees and masters degrees form a part of ISCED Level 5A, there was no need to account for them separately.
- Graduate diploma graduates in Computing were included in the supply analysis, but not those in other disciplines. Graduate diploma graduates in Computing mainly come from other disciplines. Graduate diploma graduates in other disciplines mostly come from closely related disciplines, similarly to masters graduates.
- PhD graduate numbers were subtracted from primary degree graduate numbers in such a way as to avoid double counting graduates who successfully complete a PhD.

3.6.3 Accounting for Failure to Enter the Labour Force

To avoid counting graduates who were seen as being likely to emigrate, or to fail to enter the Irish labour market for other reasons, it was assumed that just 85% of primary degree graduates would be available to enter the Irish labour market, and that just 80% of PhD graduates would be available do so. This was based on a review of results from the HEA's First Destination of Award Recipients, and on practices adopted in earlier EGFSN studies.

The analysis made no assumptions as to the number of graduates that would immigrate, viewing graduate immigration as forming a possible response to any shortages of indigenous graduates that might be projected, rather than forming a core part of the graduate supply[19].

The estimates of 85% of primary degree graduates and 80% of PhD graduates entering the Irish labour market are likely only to be realised under circumstances of strong local demand from high quality employers. Emigration is likely to be higher otherwise. PhD graduates are likely to be particularly demanding as to the work that will keep them in Ireland.

3.6.4 Supply Projections

Table 3.1 summarises the graduate supply projections. In some cases, data limitations have made it necessary to present data at a higher level of aggregation than would ideally have been the case. ISCED Level 5A projections for Engineering and Computing are based on the projections in the Forfás/EGFSN ICT Clusters and Skills Study (2003). This report aggregated all Engineering disciplines together in calculating and presenting projections of graduate supply.

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[19] The demand side analysis implicitly excludes some demand for graduates immigrating in its calculation of "Rest of Economy" demand.

Table 3.1 Supply Projections for ISCED Levels 6 and 5A, for 2010, and for the Mean Over the Period 2004 to 2010

	ISCED 6 (PhD)		ISCED 5A	
	2010	**2004-10**	**2010**	**2004-10**
Electrical/Electronic/Computer Eng	13	8		
Mechanical/Production/Industrial Eng	33	38		
Civil/Environmental Engineering	18	12		
Other Engineering	0	0		
Unspecified Engineering	60	49	1,542	1,579
Materials Science / Engineering	0	0	20	19
Physics	19	17	113	115
Instrumentation	3	4	14	19
Chemistry	31	29	355	356
Biosciences - Core Biotech	107	91	278	306
Biosciences - Other	10	10	43	48
Biosciences - Unspecified	6	5	0	0
Food Science	16	17	64	79
Analytical Science			52	50
Medical Sciences	116	59	75	72
Psychology	10	8	159	151
Environmental Science	0	0	189	179
Marine Science	0	0	20	19
Mathematics	17	13	95	99
Computer Science	44	43	2,756	2,014
Agricultural Science	26	32	51	63
Other Sciences	9	11	76	84
Unspecified Science			39	43
Unspecified Physical Science	35	40		
Unspecified Life Science	46	53		
Total	**619**	**539**	**5,941**	**5,295**

4. Balance Between Supply and Demand

4.1 Introduction

This chapter compares the projections of “whole economy” Irish demand for graduates in SET disciplines relevant to research with projections of the supply of those graduates.

4.2 Balance Between Supply and Demand for Graduates at ISCED Level 6[20]

Table 4.1 sets out the projected balance between supply and demand for PhDs in each discipline. This is calculated by subtracting the demand projections for each scenario set out in Section 2 of this report from the supply projections set out in Section 3.

A negative balance is, in principle, an indicator of a projected shortage. However, it should be noted that some negatives may be absorbed, at least partially by positives in more generic categories. Thus, for example, the positive balances under “Unspecified Engineering” are likely to absorb part of the negative balances under Electronic Engineering.

The most significant projections of negative balances are in Computing. There appear to also be significant issues in Electronic Engineering, core biotechnology Biosciences, Chemistry and Materials Science, although some of the negatives here will be offset by generic categories.

Where positives are projected, they are generally not a sign of a significant oversupply. In developing the PhD demand projections, the objective has been to give an indication of the number of PhD graduates required to carry out the volume of research required under each scenario. It is, however, desirable that the supply should exceed this minimum. At a practical level, it is unlikely that the proportions of PhDs qualifying in various broad disciplines will regularly match up exactly with the proportions required by industry, no matter how sound the planning undertaken. Moreover, as the specialist skills requirements of an employer for a particular line of research may be quite specific, a good choice of available research graduates is desirable.

Moreover, there is considerable scope for more PhD graduates to be recruited into non-researcher roles, or to substitute for non-PhD level researchers, with potentially significant positive economic results. This approach to PhD skills supply has operated in the US for many years.

[20] PhD

Table 4.1 Balance Between Supply and Demand for ISCED Level 6 Qualifications

	2010			2004-2010		
	2.5% Scenario	2.8% Scenario	3% Scenario	2.5% Scenario	2.8% Scenario	3% Scenario
Electronic Eng	-39	-47	-52	-33	-39	-42
Mech/Production Eng	-2	-6	-9	8	4	3
Civil/Environmental Eng	6	6	6	2	1	1
Other Engineering	-4	-6	-7	-4	-4	-4
Unspecified Engineering	35	35	35	27	27	27
Materials	-17	-20	-21	-15	-17	-18
Physics	-6	-9	-10	-7	-9	-9
Instrumentation	3	3	3	2	2	2
Chemistry	-22	-30	-35	-20	-25	-28
Biosciences - Core Biotech	-49	-58	-68	-53	-60	-64
Biosciences - Other	-5	-7	-9	-4	-6	-6
Biosciences - Unspecified	6	6	6	-2	-2	-2
Food Science	4	2	0	7	5	4
Medical Sciences	33	32	29	-14	-17	-17
Psychology	-10	-11	-13	-9	-11	-11
Environmental Science	-2	-2	-3	-2	-2	-2
Marine Science	-3	-3	-3	-2	-3	-3
Mathematics	5	3	2	2	2	1
Computer Science	-124	-156	-179	-80	-100	-113
Agricultural Science	8	7	5	16	14	13
Other Sciences	0	0	-1	1	1	1
Unspecified Physical Science	35	35	35	40	40	40
Unspecified Life Science	46	46	46	53	53	53
OVERALL BALANCE	-102	-180	-243	-87	-146	-174

4.3 Balance Between Supply and Demand for Graduates at ISCED Level 5A[21]

Table 4.2 sets out the projected balance between supply and demand for non-PhDs in each discipline. This is calculated by subtracting the demand projections for each scenario set out in Section 2 of this report from the supply projections set out in Section 3.

The most significant projection of a negative balance is in Computing, reflecting the substantial shortfall that was projected in the Forfás/EGFSN ICT Clusters and Skills Study. This has the potential to hold back the development of ICT research in industry. Significant shortages are also projected in Biosciences and in Chemistry, which have the potential to undermine the development of Biotechnology and Pharmaceutical industry research.

[21] Primary degrees, masters degrees and graduate diplomas.

Table 4.2 Balance Between Supply and Demand for ISCED Level 5A (primary degree, masters, graduate diploma) Qualifications

	2010			2004-2010		
	2.5% Scenario	2.8% Scenario	3% Scenario	2.5% Scenario	2.8% Scenario	3% Scenario
Engineering	-17	-8	-6	174	179	182
Materials	-45	-53	-58	-39	-44	-46
Physics	27	21	19	34	30	28
Instrumentation	-34	-34	-34	-29	-29	-29
Chemistry	-86	-99	-109	17	6	1
Biosciences - Core Biotech	-116	-121	-125	-45	-48	-51
Biosciences - Other	1	-1	-3	19	20	20
Biosciences - Unspecified	-50	-50	-50	-35	-35	-35
Food Science	5	2	-3	-12	-14	-18
Analytical Science	33	33	33	32	32	32
Medical Sciences	5	2	11	18	16	15
Psychology	20	19	17	26	25	25
Environmental Science	33	33	32	33	33	33
Marine Science	-6	-6	-7	-3	-3	-3
Mathematics	34	35	34	37	36	36
Computer Science	-694	-671	-656	-600	-586	-577
Agricultural Science	-40	-42	-44	-27	-29	-30
Other Sciences	-81	-81	-81	-64	-64	-65
Unspecified Science	39	39	39	43	43	43
OVERALL BALANCE	-972	-982	-999	-421	-432	-439

4.4 Quality of College Entrants

In addition to being concerned about graduate numbers, any consideration of the supply of graduates to work in research must take some account of evidence as to the intellectual capacity of those progressing through higher education in relevant disciplines. Research work is likely to be most suited to students who are academically highly able.

Table 4.3 sets out evidence as to trends in acceptances of places in relevant degree programmes. It is sorted according to the percentage change in acceptances of places by applicants with more than 450 points between 2001 and 2003. Most relevant disciplines have done well in this regard, with significant increases in acceptances among these high-points applicants. However, Electronic Engineering and Computer Science have both suffered badly, with very substantial falls in acceptances from applicants with high points. Common entry science programmes have also suffered, although much less significantly.

Table 4.3 Evidence on CAO Points of Entrants to Degree Programmes in SET Disciplines, 2001 to 2003

	Accept-ances 2001	Accept-ances 2001 >= 450	% >= 450 Points 2001	Accept-ances 2002	Accept-ances 2002 >= 450	% >= 450 Points 2002	Accept-ances 2003	Accept-ances 2003 >= 450	% >= 450 Points 2003	% Change in Accept-ances >= 450 Points 2001-2003
Electrical/Electronic/Computer	535	224	42%	324	149	46%	293	72	25%	-68%
Computer Science	1796	568	32%	1274	295	23%	1145	194	17%	-66%
Common Entry Science	1162	322	28%	1242	252	20%	1207	288	24%	-11%
Unspecified Science	297	132	44%	319	141	44%	361	129	36%	-2%
Food Science	72	22	31%	136	25	18%	122	22	18%	0%
Agricultural Sciences	183	24	13%	175	26	15%	162	24	15%	0%
Common Entry Engineering	413	194	47%	371	215	58%	423	211	50%	9%
Other Engineering	260	65	25%	216	53	25%	408	74	18%	14%
Chemical/Process	95	84	88%	103	91	88%	105	97	92%	15%
Psychology	148	98	66%	147	84	57%	175	119	68%	21%
Civil/Environmental	218	162	74%	276	194	70%	369	199	54%	23%
Mechanical/Production Engineering	258	118	46%	273	108	40%	311	145	47%	23%
Physiotherapy	101	93	92%	116	109	94%	128	115	90%	24%
Medical Sciences	35	19	54%	66	29	44%	181	28	15%	47%
Materials Science / Engineering	13	6	46%	15	3	20%	26	9	35%	50%
Physics	125	68	54%	155	105	68%	173	105	61%	54%
Chemistry	54	32	59%	144	71	49%	183	51	28%	59%
Other Sciences	117	40	34%	144	59	41%	95	64	67%	60%
Mathematics	58	40	69%	89	70	79%	95	74	78%	85%
Environmental Science	184	23	13%	196	33	17%	230	43	19%	87%
Core Biotech	174	95	55%	256	135	51%	289	261	96%	175%
Marine Science	22	3	14%	32	4	13%	34	8	24%	167%

Source: Based on analysis of data provided by CAO.

4.5 Salary Data

An analysis of HEA First Destination data on salaries obtained by recent graduates shows that graduates in SET disciplines are generally rewarded for higher qualifications with higher starting salaries. Table 4.4 presents an analysis of responses on salary to the survey of graduates of 2000.

There is a generally consistent pattern whereby graduates with masters degrees in a discipline earn more than those with primary degrees, and those with PhDs earn more than those with masters degrees. This provides evidence that higher degrees in SET disciplines are of significant labour market value.

Table 4.4 Mean Responses to Question on Salary for Graduates in Various SET Disciplines with Various Levels of Qualification

	Mean Response					Number of Responses				
	Primary Degree	Grad Dip	Taught Masters	Research Masters	PhD	Primary Degree	Grad Dip	Taught Masters	Research Masters	PhD
Electronic Eng	5.3	5.7	5.5	6.5	7.5	181	9	2	2	2
Mech / Production Eng	5.3	5.7		7.0	8.0	173	7	0	6	1
Civil / Environmental Eng	5.6		6.0	7.3	6.0	110	0	2	3	1
Chemical / Process Eng	6.6	6.5				36	10	0	0	0
Other Eng	6.0		6.0	5.0	8.0	46	0	4	1	2
Unspecified Eng	4.8		6.3		8.0	15	0	4	0	3
Materials Science / Eng	4.2					13				
Physics	4.4	4.2	7.0	7.8	8.0	22	9	2	5	3
Instrumentation	5.4					5				
Chemistry	4.8			4.0	6.3	89			1	13
Biosciences - Core Biotech	4.5	5.0	7.0	5.5	6.9	161	3	2	2	14
Biosciences - Other	3.7		4.3	5.3	5.4	14		4	3	18
Biosciences - Unspecified	5.4	4.0	4.3	6.3		11	1	3	3	
Food Science	4.6	5.0	5.9	5.0	6.7	68	1	8	10	3
Pharmacology	1.0		7.7		7.8	1		3		5
Medical Sciences	5.3	5.3	7.2	7.5	7.2	51	12	9	2	6
Physiotherapy	5.8					32				
Psychology	3.7	5.8	6.9	3.0	7.8	36	6	9	1	8
Environmental Science	5.1		4.7	8.0		56		7	1	
Marine Science	3.0					2				
Mathematics	5.2	4.0	5.6	6.0	5.0	38	2	8	1	1
Computing	5.0	5.0	5.7	5.0	7.7	437	303	70	2	7
Ag Science	4.5		4.9	5.8	6.1	45	0	9	18	10
Other Sciences	3.4		6.1		6.0	97	0	29		4
Unspecified Science	4.8	3.3	6.2	6.6	6.3	90	3	20	22	3

1 = up to €8,999
2 = €9,000 to €12,999
3 = €13,000 to €16,999
4 = €17,000 to €20,999
5 = €21,000 to €24,999
6 = €25,000 to €28,999
7 = €29,000 to €32,999
8 = €33,000 +

Source: Based on original analysis of data from HEA's First Destination of Award Recipients survey of graduates of 2000.

5. Conclusions

5.1 Summary of Key Quantitative Findings

Of the three scenarios presented in this report, the 2.5% scenario is the scenario favoured by the ERA Steering Group. Under this scenario, research spending rises to 2.5% of GDP.

The researcher population rises from 10,214 in 2003 to 18,304 in 2010[22].

In order to attain this population of researchers, an average demand of 512 PhD graduates and 1,258 non-PhD for research work is projected for each year from 2004 to 2010 inclusive. This amounts to a total of 12,390 over the period[23].

Demand from the whole economy for PhD graduates in the relevant disciplines is projected to amount to 4,382 over the period. The equivalent projection for non-PhD graduates (degree level plus) is 40,012[24].

Significant shortages are projected. A net shortage of 609 PhD graduates and 2,947 non-PhD (degree level plus) graduates is projected over the period from 2004 to 2010 inclusive[25]. If one excludes the disciplines in which positive balances are projected, the projected shortage rises to approximately 1,000 PhD graduates and approximately 5,800 non-PhD (degree level plus) graduates over the period.

While these projections of shortages are whole economy figures, research activities are likely to be most severely affected.

- Research is the main projected source of demand for PhD graduates.
- By far the biggest component of the projected non-PhD shortage is of graduates in computing, who are mainly recruited by ICT companies for development work. While not all work of this nature is recorded as research, that which is recorded makes up a substantial part of total recorded research by business in Ireland.

5.2 Summary of Key Qualitative Findings

The main finding of the report is that there is projected shortage of researchers going forward, unless action is taken to increase the supply of suitable graduates. This is a matter of considerable concern for two reasons.

- It will have a direct impact in limiting growth in R&D in Ireland, unless addressed effectively.
- A surplus supply of graduates suitable for research is required to allow the development of Irish research activity to reach its full potential over the period beyond the 2010 time horizon for the study. Without the impetus provided by such a surplus, growth in inward research investment, in creation of research-intensive start-ups and in research by existing companies, is likely to follow a much more gradual path over the period from 2010 to 2020 than would otherwise have been the case.

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[22] See Figure 2.14.
[23] The projections behind these numbers are drawn from Tables 2.9 and 2.11.
[24] The projections behind these numbers are drawn from Table 2.14.
[25] Calculated from totals of relevant columns in Tables 4.1 and 4.2.