Future Requirement for High-level ICT Skills in the ICT Sector

Expert Group on Future Skills Needs
2008

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To the Minister for Enterprise, Trade and Employment and the Minister for Education and Science

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Acknowledgments

Forfás would like to thank the many industry executives, academics and staff at expert organisations who gave their valuable time for interviews. Thanks are due to the Skills and Labour Market Research Unit at FÁS, which provided data on student and graduate numbers and to the Central Applications Office which responded to request for data on acceptances. The report is substantially based on research carried out by Publica Consulting and McIver Consulting on behalf of Forfás and the Expert Group on Future Skill Needs. Forfás would like to acknowledge the quality of their work.

Foreword

The ICT sector is of strategic economic importance to Ireland in terms of inward investment, sales, exports and high quality jobs. Both productivity and profitability in the sector are rising and the overall picture is of a vibrant sector which is forecast to increase in employment over the coming years. The aim of this study is to determine the future requirements for high-level skills in the sector and to identify the proactive actions required to ensure that the supply of these skills will support its growth potential.

The upturn in employment experienced from 2000/01 has been underpinned by the emergence of new-Irish owned start up companies and by continued inward investment. The sector, which currently employs around 70,000 people, has moved into higher value added activities. There are challenges facing the industry – including a need to increase the supply of people with high-level ICT skills. This should be seen against the background of a global shortage of high-level ICT staff with many countries facing similar challenges.

The demand for high-level skills can be met from the supply of graduates from third-level institutions, by upskilling those at work and through inward migration. A major challenge identified in the report is to reverse the recent decline in the domestic supply of high-level computing and electronic engineering graduates – particularly among women. There is a need both to increase the total number of graduates and also to develop strong technical skills and knowledge of the use of products and services. This report makes several recommendations aimed at boosting the supply of high-level skills from both domestic sources and inward migration. It identifies a range of proactive actions which can be implemented in the short, medium and long-term. It recognises that the priority for policy action should be on increasing the domestic supply as this is the most sustainable way forward. Migration however will continue to be an important source of supply into the near future. Ireland is seen as a good location to attract experienced talent from all over Europe.

It is clear that the successful implementation of the recommendations will require support at the highest level and the collaboration of a wide range of stakeholders. While the recommendations in this report are designed to address the high-skill needs of the ICT sector, some undoubtedly will have a positive impact on adjacent sectors and support the wider agenda on skills for enterprise.

I would like to thank all those who contributed to the report. Particular thanks are due to the many industry executives and academics and staff at expert organisations who contributed their expertise and experience to the report. I would like to record my appreciation to the IDA Ireland and Enterprise Ireland for their excellent support and sharing of expertise. I wish to express my gratitude to Úna Halligan who chaired the Steering Group that oversaw the completion of the report and to each member of the group for their full commitment and support. Finally, I would like to thank the team at Forfás for leading this project to a successful conclusion.

Anne Heraty
Chairperson, Expert Group on Future Skills Needs

Executive Summary

Scope of Study

Ireland is still one of the best performers in terms of science, engineering, and technology graduates. The aim of this study is to ensure that Ireland is taking the proactive steps necessary to maintain and improve this position.

The study was designed to address two principal objectives:

1. Determine the future requirement for high-level ICT skills in the ICT sector in Ireland; and

2. Identify what proactive actions need to be taken to ensure that the supply of these skills in Ireland is sufficient for the sector.

For the purposes of this report, the requirement for "high-level" skills refers to jobs requiring a high-level of technical proficiency, typically requiring a qualification in computing or electronic engineering at Honours Bachelor Degree (Level 8) or above. It also encompasses roles of comparable level requiring a mix of technical and business skills. The report addresses demand from that component of the enterprise sector, both foreign-owned and indigenous, which is primarily a producer, rather than a consumer, of ICT goods or services.

Employment Trends in ICT Sector

The Irish ICT sector has largely recovered from the global downturn in market demand that started in 2000/01, and is now growing again. Total employment rose rapidly throughout the 1990s peaking at over 80,000 in 2000. It fell to around 64,000 over the following three years, and levelled off in 2004, before resuming growth in 2005. Employment now stands at 70,000. It has moved into higher value-added activities, and is again showing strong demand for people with high-level ICT skills. A greater share of ICT sector employment is now accounted for by people with high-level skills. Key factors for this increasing the share have been:

- A shift in the subsectoral employment mix that occurred during the downturn, away from electronics hardware where many of the lower skills jobs in the sector were concentrated, and towards software, which predominantly employs people with high-level ICT skills; and

- An ongoing shift in the skills mix within electronics hardware and related subsectors, with lower-level skills being replaced by high-level ICT skills (and other high-level skills in areas such as supply chain management).

Employment growth is being driven by expansion in many companies, by a continuing flow of inward investment, and by the formation of new startups. ICT continues to be one of the main sources of new internationally traded indigenous businesses for Ireland. There is a pattern of simultaneous creation and loss of jobs, where creation now outweighs loss, and where lower-skilled jobs are being replaced with higher-skilled jobs.

Economic Underpinnings of ICT Sector

The global downturn in market demand for ICT products and services experienced after 2000/01 was the worst that the industry has experienced. While it partly reflected wider cyclical falls in economic growth and investment, it also reflected a downturn in the share of investment devoted to ICT in most developed countries, reversing a long-term upward trend. This effect was reinforced by the growth of competing locations active in the production of ICT goods and services, with low labour costs, in areas such as China, India and Eastern Europe.

While the international market for ICT goods and services has improved, its rate of growth remains far short of what was experienced in the latter half of the 1990s.

In Ireland, the global downturn was reflected in job losses. Across much of the sector, it was also reflected in a loss of productivity, with real value-added falling faster than employee numbers. With improved market conditions, however, employment has increased, and real productivity has recovered. Profitability is rising again.

Market for High-level ICT Skills in Ireland

ICT companies in Ireland think globally about the supply of skills. As well as considering the domestic supply of high-level ICT skills, they also think of inward migrants to address their labour supply needs. A substantial part of the total demand is now satisfied through inward migration.

Ireland is seen by many companies as a good location in which to attract experienced talent from all over Europe.

The market for high-level ICT skills in Ireland is changing. On the one hand, demand for high-level ICT skills is strong, and employers are becoming more demanding about the skills they require. On the other, the flow of graduates in computing and electronic engineering from the higher education system has declined.

Crucially, companies consulted for the study identified a particular shortage of people with very high-levels of technical skill. They also indicated that a high demand for new graduates with strong engineering skills forms an important part of the picture.

Many also identified an important need for more people with combinations of technical and business skills.

While the demand for people with high-level ICT skills is strong, real pay in the main sectors employing high-level ICT staff grew slowly or fell between 2001 and 2006, despite real pay in many other sectors increasing strongly. However, there is evidence of stronger pay growth from late 2006. Future developments in pay will affect the attractiveness of high-level ICT work in Ireland to school leavers and potential migrants. It is important that the sector continues to improve productivity so as to maintain competitiveness as pay levels rise, given increasing competition from low cost locations that are themselves upgrading their capabilities.

Demand from ICT Sector for High-level ICT Skills

The report presents three scenarios for demand for high-level ICT skills over the period to 2013.

- The base "continuing recovery" scenario assumes a continuation of the employment growth experienced between 2005 and 2006, adjusted so that the growth rate in web-based operations falls over time, growth in electronic hardware moderates, and employment in semiconductors remains constant.
- The relatively optimistic "accelerating recovery scenario" assumes a higher rate of growth, but still a rate that falls far short of that experienced in the latter half of the 1990s.
- The "loss of competitiveness" scenario assumes that growth rates fall, and (for most subsectors) turn negative by 2013, due to a loss of competitiveness.

All three scenarios are based on moderate growth in global ICT markets. Chapter 5 disaggregates demand for high-level ICT skills, separating out demand for skills in computing and skills in electronic engineering. Computing accounts for the majority of the demand.

Supply of ICT Skills

Most ICT companies operating in Ireland think of three main sources of ICT skills; the domestic supply of ICT graduates; upskilling; and inward migration. Ireland is still one of the best performers in terms of science, engineering, and technology graduates. However, Honour Bachelor Degree graduate numbers in computing and electronic engineering have declined from a peak around 2002. Overall, intake into these courses appears to have bottomed out. There was a modest increase in numbers entering computing in 2006, which should be reflected in a small increase in graduate numbers in 2010. The qualifications of those taking up places on Honours Bachelor Degree courses in computing, as measured by CAO points, have disimproved since the late 1990s. Median CAO points obtained by those taking up places on Honours Bachelor Degree Courses in computing fell by 60 between 1998 and 2006.

The number of PhD graduates in computing and electronic engineering available for recruitment by industry will increase steeply over the next few years.

Comparison of Supply with Demand

The supply of high-level skills to ICT companies operating in Ireland comprises both the domestic supply of graduates and inward migration.

The report finds that the projected domestic supply of graduates alone at Level 8 will not be sufficient to meet whole economy demand under either of the two more positive demand scenarios, and will roughly meet demand under the negative "loss of competitiveness" scenario. While projected gaps between graduate numbers and demand vary between scenarios, the shortages projected range up to some hundreds per annum for electronic engineers qualified to Honours Bachelor Degree level or above, and up to an average of about 2,000-3,000 per annum for computing graduates qualified to this level. Inward migration (which currently meets a substantial part of total demand) will continue to be required to bridge the gap for the foreseeable future.

There is also a particular issue with the supply of people with very high-levels of technical skill, attributable in part to the reduced number of high performing school leavers now choosing to study computing and electronic engineering. Interest in studying computing and electronic engineering remains relatively weak because of factors such as continuing feelings of insecurity about the sector, slow growth in pay, competition from other sectors and changes in performance in mathematics at second-level. There appears to be scope to improve the system of incentives perceived by students, as well as continuing to provide encouragement and information, and seeking to improve how science, technology, engineering, mathematics (STEM) subjects are taught and learned.

The report addresses interactions between labour demand, labour supply and the cost of labour for high-level ICT skills, finding that these interact in complex ways, many of which are within the control of the sector.

Conclusions and Recommendations

The conclusions and recommendations set out below correspond to three major strands of issues identified by this report, i.e:

- Providing a sufficient quantity of skills;
- Providing skills of sufficient quality; and
- Providing a sufficient diversity of skills to reflect the complexity and diversity of ICT businesses.

A main conclusion of the report is that the projected domestic supply of high-skilled computing and electronic engineering graduates will need to be boosted to meet future demand. Because of the need to bridge the gap in high-level ICT skills, inward migration – already a significant part of the skills supply – will continue to be an important source into the future. This is against the background that the ICT sector here has largely recovered from the global downturn in market demand experienced in 2000/01 and is now growing again – with both productivity and profitability rising. Labour market demand for high-level ICT skills here is increasing while at the same time the flow of computing and electronic engineering graduates has fallen. This can be seen against the background of a global-wide shortage of high skilled ICT people.

The quality of ICT staff here is also a key issue and is likely to remain so as long as the number of high performing students choosing to study courses in computing and electronic engineering remains modest – even though there are good career opportunities in these occupations.

Based on these findings, the EGFSN are recommending proactive measures designed to increase the supply of high-skilled personnel (both in terms of quantity, quality and diversity of skills) to meet the future needs of the ICT sector. The successful implementation of these recommendations will require a collaborative approach between the many stakeholders involved. While the recommendations are designed to support the ICT sector, and specifically to address its high-level skills needs, some undoubtedly will have a positive impact on adjacent sectors, and support the wider agenda on skills for enterprise.

The main measures the recommendations focus on are:

- A strategic approach towards communicating career opportunities and skill needs;
- Broadening the base of recruits for high-level ICT courses;
- Improving intake at undergraduate level;
- Ensuring third-level courses reflect the skills mix/diversity of ICT business;
- Improving intake from third-level into the ICT sector;

- Supporting computing and electronic engineering educational capacity; and
- Adopting proactive labour market strategies.

The recommendations from the study are summarised as follows. Chapter 8 of the report outlines each recommendation in more detail.

Recommendation 1: Communicating Career Opportunities that Exist in Computing, Software and Electronic Engineering

A major new initiative should be launched to communicate the rewarding and interesting career opportunities that exist in the fields of computing, software and electronic engineering in line with the CAO application process. The vital strategic role that the ICT sector plays in ensuring Ireland's long-term prosperity should be highlighted. It should seek to address concerns (real or perceived) about job security in the ICT sector which influence students' choices. All stakeholders, including employers, their representative bodies and the Higher Education Authority (HEA), should work together to develop a coherent message, containing hard facts, aimed at three specific audiences:

- Students at secondary level;
- Parents; and
- Teachers/Career Guidance Counsellors.

There needs to be a gender dimension to this communication aimed at addressing the relative decline in the number of women taking high-level ICT courses.

This new initiative, (which would include revitalised actions already underway), should be led and coordinated by Discover Science and Engineering given their experience in this area.

The recommendations of the Expert Group on Future Skills Needs *Careers and Labour Market Information Dissemination* report should be implemented expeditiously. In summary, these are about:

- Development of a careers and labour market portal;
- Promotion of existing careers web sites;
- Improving access to useful labour market information; and
- Improving existing career guidance and information resources.

The Expert Group encourages guidance practitioners to be aware of the current positive outlook for the ICT sector both worldwide and in Ireland, and to regularly update their information on the sector.

Recommendation 2: Communicating Future Skill Needs

The Expert Group on Future Skills Needs, the HEA and ICT Ireland should facilitate discussions between industry and third-level institutions on an annual basis with a view to deepening engagement between employers, third-level institutions around ideas to improve:

- Recruitment onto third-level computing and electronic engineering programmes;
- The development of careers paths in the industry; and
- The relevancy of industry programmes.

Recommendation 3: Enhancing the Professional Development of Primary Teachers

- The professional development of primary teachers would be enhanced by including further development in mathematics through Professional Master Courses and opportunities to enhance 'academic mathematics';
- Improve the allocation of time and resources to be given to the development of mathematics competence in teacher training courses; and
- The Primary Curriculum Review indicates that children are enjoying the active engagement with mathematics and the methodologies being employed in class. This should be continued and reinforced at second-level.

Recommendation 4: Tackle the Incentives for Studying Leaving Certificate Mathematics at Higher-level

The Department of Education and Science should work with Higher Education Institutions to address the disincentives to studying Leaving Certificate mathematics at Higher-level. In doing so, it should:

- Promote the development and introduction of a system of bonus college entry points for Higher-level Leaving Certificate maths to compensate students for the greater effort widely considered to be required for success in this subject; and
- Ask the State Examinations Commission to propose and implement a response to the grading penalty that appears to be suffered by students taking Higher-level mathematics in the Leaving Certificate.

These initiatives should be seen in the context of a levelling of the 'playing pitch' in the choice open to students between taking Higher-level maths and other subjects.

Recommendation 5: Enhancing the Professional Development of Second-level Mathematics Teachers

The quality of second-level mathematics teachers is central to driving up interest and mathematics proficiency levels. The Department of Education and Science should continue their support for initiatives aimed at enhancing the quality of mathematics teaching in secondary schools. This should comprise professional development opportunities for second-level mathematics teachers including a Professional Masters Degree (taking account of professional experience) and a part-time Higher Diploma in Mathematical Education. Consideration should also be given to the introduction of a 4 year Honours Degree in Mathematical Education to provide another source of mathematics teachers. Industry and higher education institutions should improve feed back to teachers about the vital practical applications of mathematics. A more interactive, imaginative approach to teaching mathematics as being developed by the National Council for Curriculum Assessment (NCCA) within "Project Maths", should be supported in which students are engaged in discussing real-life situations and how the mathematics involved can be applied to them – so that students can see its relevance to themselves and the world around them.

Recommendation 6: Consider the Introduction of Bursaries to Boost the Recruitment of Highly Qualified Students into Honours Level Computing and Electronic Engineering Bachelor Degree Courses, as a Matter of Urgency

In order to boost the recruitment of high qualified students into Level 8 computing and electronic engineering courses bursaries could be introduced for students entering such courses who achieve a demanding CAO point's threshold of 500 points[1] and a minimum requirement in higher-level maths[2]. The introduction of bursaries, on a pilot basis in the first instance, should be urgently assessed by the relevant Departments as an integral part of the package of measures being proposed. The private and public sectors should pursue the funding for any such pilot scheme from the ICT Sector and the National Training Fund. The involvement of HEA, DETE and Business would be required in the management of the process[3].

Bursaries could be valued at up to €4,000 per annum, and would be conditional on students maintaining acceptable grade averages and undertaking relevant industrial experience (which may be undertaken during the summer break). It is envisaged that between 150 and 180 new graduates per annum may become eligible for this initiative[4] (with an outer limit of 300 on review of uptake).

Similar STEM course incentives exist in several countries such as the UK, USA, Australia and learning from these could be drawn upon.

Recommendation 7: Proactively Encourage High-skilled Overseas ICT Students to Come, Study and Work in Ireland

A major new initiative should be launched aimed at:

- Attracting a greater number of overseas computing and electronic students to come and study here; and
- Seeking to retain such overseas students here, to work in the ICT sector following their graduation.

Employers, HEA, Universities and Colleges, IDA Ireland, Enterprise Ireland and the International Education Board Ireland should collaborate on the development of a major new initiative focused on attracting overseas computing and electronic engineering students that markets Ireland as "*the place to come, study and work*". This should include offering such students an attractive package including the certainty of internships during their study period and graduate placement opportunities following (and subject to) their graduation[5] (The *Third-level Graduate Scheme (2007)* under the new economic migration regulations, enables a non-EEA student who has acquired a primary, masters or doctorate degree from an Irish third-level educational institution to apply for one non-renewable extension to their current student permission for a six-month period[6] to seek employment). This overall package is necessary to compete with other English speaking countries that currently offer such incentives such as the USA, Australia, Canada and New Zealand.

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1 *In 2006, this was achieved by 10% of acceptors (19 students) for Honours Bachelor Degree Courses in Electronic Engineering and 4% of acceptors (42 students) for Honours Bachelor Degree Courses in Computing.*

2 *To be decided in consultation with Third-level Institutions – suggested that it should be between C3 to B3.*

3 *The pilot process could be reviewed annually and its outcomes evaluated at the end of year three, following which a decision would be made either to modify, expand and/or terminate.*

4 *An eligible student would receive the bursary for each of the four years of their study, (conditional on meeting criteria). Therefore, the envisaged total number of students benefiting from the bursary could be 180 in the first year of its introduction, 360 in its second year, 540 in its third year and 720 in its fourth year – thereafter the total would remain at 720 as students exit following their graduation. The estimated cost of the initiative could be €0.72m in the first year rising to an €2.88m (constant prices) in year four and for subsequent years.*

5 *This package would be promoted through Enterprise Ireland and IDA offices abroad and offered directly to prospective students at forthcoming graduate fairs in 2008 being held in the USA, Norway, Mexico, India, Malaya, Singapore etc. which International Education Board Ireland will attend.*

6 *During this six-month period they are allowed to work for up to 40 hours per week.*

Recommendation 8: Produce More Graduates with Strong Engineering Skills

Several ICT companies consulted for the study identified problems in recruiting enough people with very high-levels of technical capability, whether at graduate or experienced level. Those finding difficulties at graduate level tended to identify the need for more technically challenging project work on undergraduate programmes as an issue, and drew comparisons with 'strong engineering schools' in the US, and with challenging degree programmes in countries in Central Europe. More generally, the reduced numbers of students entering college with high Leaving Certificate grades were seen as an issue.

As a majority of companies said they were happy with the capabilities of the graduates they see, the current requirement for change is not across-the-board. As with the US, courses that are highly intensive technically can co-exist well with courses whose differentiating strengths lie in other areas. Thus there is a need not only to boost the number of students with high grades choosing to study computing and electronic engineering at Level 8; but also to strengthen the most technically intensive programmes at this level, and even introduce new technically intensive courses if sufficient demand can be established.

The Higher Education Authority should continue to provide funding to Higher Education Institutions to further develop and improve the attractiveness of the most technically intensive Level 8 programmes in computing and electronic engineering and subject to demonstrating a viable level of student interest, to enable institutions to develop new programmes focused on developing strong engineering skills. A small number of such programmes are required. The graduates of these programmes will provide skills for the most technically challenging work in the ICT sector in areas such as systems software, electronics design and development of complex networked applications.

Recommendation 9: Produce More Graduates with Domain-specific Knowledge

One of the major needs identified by software companies is for more people with expertise both in computing and in business. People with these skills are required for roles in areas such as business analysis, product management, product development, sales and provision of services to customers. While a broad knowledge of business is useful, what companies want most are people who are expert in the application domain in which their products and services are used (e.g. banking).

In order to develop domain specific knowledge (deep knowledge of sectors in which applications will be used) and business competencies, Higher Education Institutions should consider further developments in the following areas, whether through modifying existing programmes or establishing new ones should a sufficient demand from students exists.

- Specialist taught masters programmes combining technology and business, each focused on the specifics of an application sector in which the Irish ICT sector has a strong presence, such as banking or telecommunications, and made available full-time and/or part-time, and targeted on both existing high-level ICT professionals and new Level 8 ICT graduates;
- Undergraduate Honours Bachelor Degree programmes combining technical and domain-specific business skills (such as a BSc in Banking Industry Technology or a BSc in Telecommunications Industry Technology);

- Industry-focused training programmes for working technologists, focused on industry domains that are important to a significant number of Irish technology companies (e.g. financial services); and
- Higher diploma/graduate diploma conversion courses, designed to introduce graduates in any discipline to computing. Where possible these conversion courses should feed masters programmes designed to deepen the technology skills learned.

Recommendation 10: Boosting Postgraduate Training

Postgraduate education has important functions in:

- Upgrading skills – giving students and professionals opportunities to improve and deepen their existing skills in areas such as software engineering; and
- Specialisation – providing opportunities to graduates who already have a strong general foundation of skills from an undergraduate degree in an ICT-related discipline to specialise in a particular technology or industry area.

While some specialisation can be accommodated at undergraduate level, much of the requirement for specialised courses can only realistically be accommodated at postgraduate level.

The HEA should be supported in continuing its strategy of promoting and supporting study on master courses (both part-time and full-time) in order to:

- Boost skill levels;
- Develop industry-relevant skills specialisations; and
- Providing lifelong learning opportunities.

Recommendation 11: Graduate Internship and Placement Programmes

Industry regards internships as an invaluable means of preparing students for work. It is recommended that they should become an integral part of both undergraduate and postgraduate courses. Graduate placement programmes have been useful in providing young people with temporary work experience after graduation and helping them get a job. They should be continued where they remain helpful to students and companies.

Recommendation 12: Support Computing and Electronic Engineering Educational Capacity

The Higher Education Authority should continue their support for Higher Education Institutions computing and electronic engineering departments while undergraduate enrolments continue to be depressed. It should also continue to underpin measures aimed at improving retention and recruitment on ICT programmes.

The Higher Education Authority should fund Higher Education Institutions to innovate within their current Level 8 course portfolios in computing and electronic engineering, in order to increase the marketability and relevance of such programmes.

Recommendation 13: Demonstrate the Attractiveness of Careers in ICT sector

It is important that industry is competitive and able to attract the level of high-skilled graduate recruits it requires to meet its future skill needs. Industry must demonstrate that rewarding and attractive career paths are available for young people taking up employment in their sector. This is something which ICT firms, working together with their representative bodies could best achieve.

Recommendation 14: Continuing Professional Development

Third-level institutions, while having improved in recent years, should do more to engage with enterprises to provide flexible, accredited training course options responsive to the needs of enterprises and individuals.

Computing and electronic engineering are professions in which constant learning is required, both in technology and in related business skills. Continuing professional development should be supported by ICT companies as the main way that high-qualified computer and electronic engineering staff (at Level 8) can upskill and reskill to Level 9 (possibly Level 10). This can be done through part-time master courses, in-company training, self-learning etc. Shorter courses in generic skill areas such as communications, team working, problem solving, report writing, innovation and creativity skills would also be valuable. The establishment of technology focused networks of high-level ICT staff is important (both within companies and beyond) as such networks play an important role in improving company performance and driving innovation[7]. Industry representative bodies should support the development of such networks.

Recommendation 15: Attract Skills Through Foreign Recruitment

Recognising that the domestic supply of high-skilled ICT graduates will not meet the immediate needs of the ICT sector and against a background of a world-wide shortage of high-skilled ICT people another source of supply is through foreign recruitment. Mobility between Ireland and other major centres of ICT industry is also important to the cross-fertilisation of ideas and practices, which underpins innovation.

Ireland has a strong international reputation in IT and high-skilled people in other European countries would be positively disposed to careers here. To attract high-level ICT recruits from within the EEA, employers and their representative organisations should work closely with the European Employment Services EURES programme (operated in Ireland by FÁS). EURES Ireland's good knowledge of labour market conditions across EEA countries and their entrée into European Employment Placement Services can facilitate ICT company recruitment drives. While there is an upturn here in the ICT sector, this is also the case in several other European countries such as Sweden, Finland, Norway and the Netherlands who are also sourcing high-skilled professionals abroad.

High-level ICT staff from outside the EU form an important part of the supply available to ICT companies in Ireland. Where the skills required reside outside the EEA, the Department of Enterprise, Trade and Employment should ensure that applications for non-EEA migrants are processed quickly and efficiently within the boundaries of the economic migration regulations introduced in January 2007, and that the regulations are interpreted consistently and predictably.

The occupations within the ICT sector deemed to have skills shortages should continue to be reviewed by the Expert Group on Future Skills Needs, and advised to the Department of Enterprise, Trade and Employment.

7 *Publica Consulting (2006) Changing Nature of Skills in Selected Occupations: A Report to the EGFSN & Forfás.*

Chapter 1: Introduction

1.1 Introduction

This study was commissioned by Forfás on behalf of the Expert Group on Future Skills Needs. There were two overarching objectives for the study:

1. Determine the future requirement for high-level ICT skills in the ICT sector in Ireland; and

2. Identify what actions need to be taken to ensure that the supply of these skills in Ireland is sufficient for the sector.

1.2 Terms of Reference

Scope-Skills

The terms of reference for the study distinguished between four levels of ICT skill.

1. Generic – Basic ICT literacy (user of common PC applications and internet services);

2. Specialist – Routine administration (help-desk support, installation, maintenance, security), lightweight development (e.g. web design, Visual Basic);

3. Advanced – Heavyweight development (development of systems using high-level languages such as C++ and Java; network & hardware design); and

4. Researcher – Creation of new intellectual property (IP).

The terms of reference specified that the focus be on the latter two levels of skill – advanced and researcher. While they made no distinction based on qualifications, interviews undertaken during the study indicated that most companies see an Honours Bachelor Degree in a relevant discipline as the minimum requirement for entry into roles requiring advanced skills. Researcher roles are staffed by people with qualifications ranging from Honours Bachelor Degree to PhD.

Companies typically have more specific requirements than a particular qualification, often seeking an aptitude for the specific work, good generic skills (in areas such as interpersonal skills, communication skills or problem solving skills) and/or particularly good grades. The steering group for the study indicated that roles requiring a mix of technical and business skills should also be considered to fall within the study's scope, provided that the overall level of skill was at least comparable with the advanced skills described in the terms of reference.

Scope-Sector

The terms of reference for the study specified that the target sector was that component of the enterprise sector, both foreign-owned and indigenous, which is primarily a producer, rather than a consumer, of ICT goods or services. It was to include industries providing the infrastructure, both hardware and software, for the representation, processing, transmission and storage of digital information. It was to exclude the artistic/creative component of the digital content industry.[8] The report covers employment in the ICT sector. It does not cover the significant employment of people with high-level ICT skills outside the ICT sector. Chapter 5 provides some data on the share of those employed in the main occupations employing people with high-level ICT skills who are employed outside the ICT sector.

1.3 Specific Requirements

Specific requirements were as follows:

- Assess the future requirement, both quantitative and qualitative, for high-level ICT skills:
  - Quantify the likely future demand, to the extent that is meaningful, for high-level ICT skills from within the ICT sector;
  - Determine the relative break-down of high-level ICT skills by discipline, particularly computing and electronic engineering based on enterprise needs and international best practice/experience; and
  - Identify qualitative changes in the nature of the future requirement for high-level ICT skills.
- Assess the adequacy of (i) the current flow through the ICT skills supply pipeline and (ii) the pool of ICT skills in the existing workforce in the ICT sector to satisfy the likely demand profile in the sector;
- Explore the potential of complementary supply mechanisms; and
- Put forward recommendations for ensuring that the future high-level ICT skills needs of the sector can be satisfied.

1.4 Methodology

The methodology had the following main components:

- Secondary research;
- Analysis of data on student numbers, graduate numbers and college acceptances provided by the Skills and Labour Market Research Unit of FÁS, and by the Central Applications Office (CAO);
- Interviews with companies – foreign and overseas – from a range of areas within the ICT sector – a total of 25;
- Interviews with the computing and electronic engineering departments at higher education institutions;
- Interviews with interested expert organisations, including industry and professional organisations and State Agencies;
- Modelling of future graduate numbers; and
- Modelling of future industry demand.

8 *This was previously dealt with by the EGFSN Digital Media Industry Study – Future Skills Requirements of the International Digital Media Industry: Implications for Ireland, July 2006.*

1.5 Report Structure

Chapter 2 reports on employment trends in the ICT sector and on the firm level employment dynamics behind the totals. It notes that significant new businesses continue to be formed, and that new inward investment projects continue to come to Ireland.

Chapter 3 addresses a number of perspectives on the economic drivers of the Irish ICT sector. It begins by examining the downturn in employment experienced after 2000/01 and then shows that the economic underpinnings of the Irish ICT sector are improving after the downturn, with productivity and profitability rising.

Chapter 4 addresses the market for high-level ICT skills in Ireland. It describes how the market for ICT skills here is tightening and describes the skills that ICT companies require, and how these requirements are developing. It looks at the role of high-level ICT staff from overseas in the Irish labour market. It explores trends in pay and the cost of labour, and considers how these may affect the sector's future.

Chapter 5 describes the projections of demand developed for high-level ICT skills, and the model behind them. It starts by presenting a summary of three scenarios for future trends in employment in the sector. It then presents projections of demand for high-level ICT skills for the ICT sector.

Chapter 6 presents projections of Honours Bachelor Degree numbers in computing and electronic engineering up to 2010. It then presents data on the recent trends in college entry numbers that underpin the later years of the projections. It reviews trends in the qualifications of entrants into Honours Bachelor Degree courses in computing and electronic engineering. It considers factors limiting demand for places on courses in computing and electronic engineering and looks at measures which could be taken to boost interest in them.

Chapter 7 compares projected trends in graduate demand with projected trends in graduate supply under each of three scenarios for future trends in employment in the sector and whether any likely gap will arise in terms of quantity and quality.

Chapter 8 sets out the conclusions and recommendations corresponding to three major strands of issues identified by this report:

- Providing a sufficient quantity of skills;
- Providing skills of sufficient quality; and
- Providing a sufficient diversity of skills to reflect the complexity and diversity of ICT businesses.

Chapter 2: Employment Trends in ICT Sector

2.1 Introduction

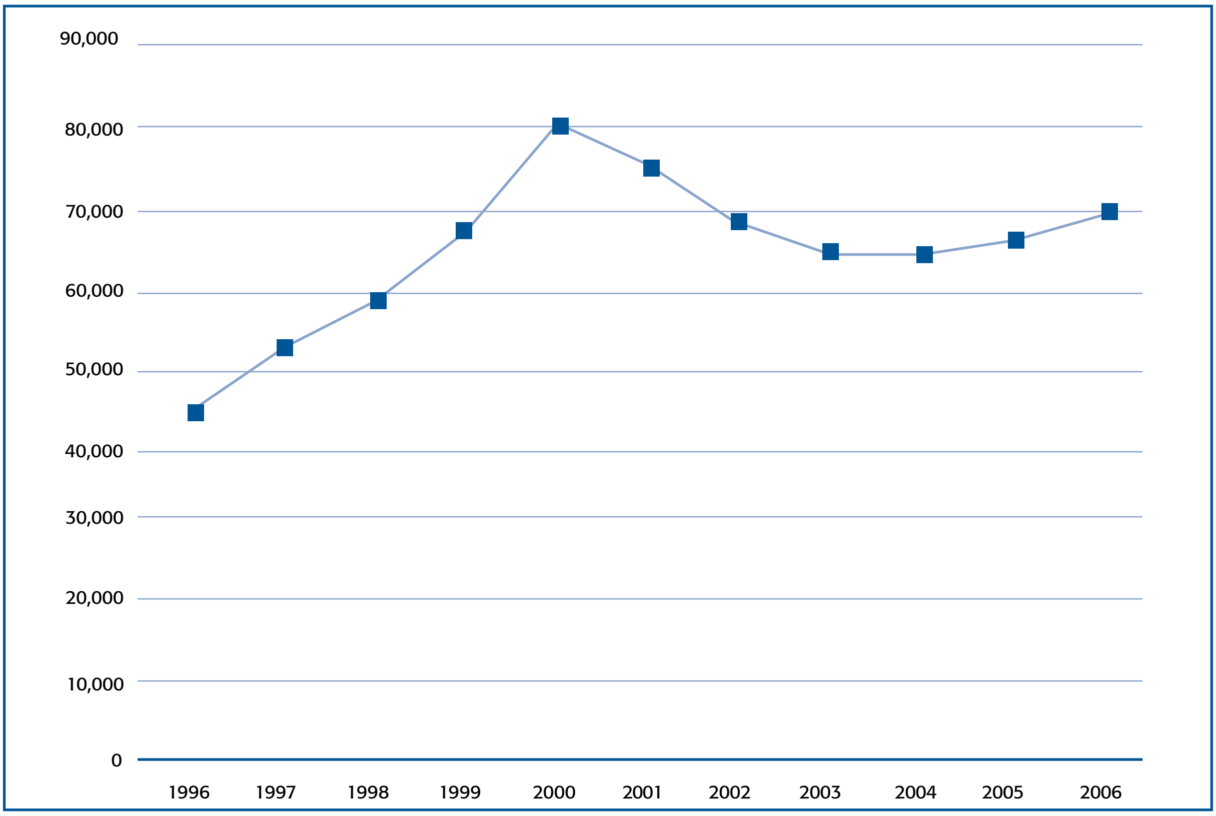
This chapter starts by reporting on employment trends in the ICT sector, finding that employment growth has resumed in most parts of the sector following the downturn that commenced in 2000 and 2001.

It reports on the firm level employment dynamics behind the totals, finding that there is a pattern of simultaneous creation and loss of jobs, where creation now outweighs loss, and where low-skilled jobs are in many cases being replaced with higher-skilled jobs. It notes that significant new businesses continue to be formed, and that new inward investment projects continue to be attracted to Ireland.

2.2 Employment in the ICT Sector

Total employment in the Irish ICT sector rose rapidly through the 1990s, peaking at over 80,000 in 2000. It fell to approximately 64,000 over the succeeding three years, and levelled off in 2004, before resuming growth in 2005 and 2006.

Figure 2.1: Total Employment in Irish ICT Sector 1996 to 2006

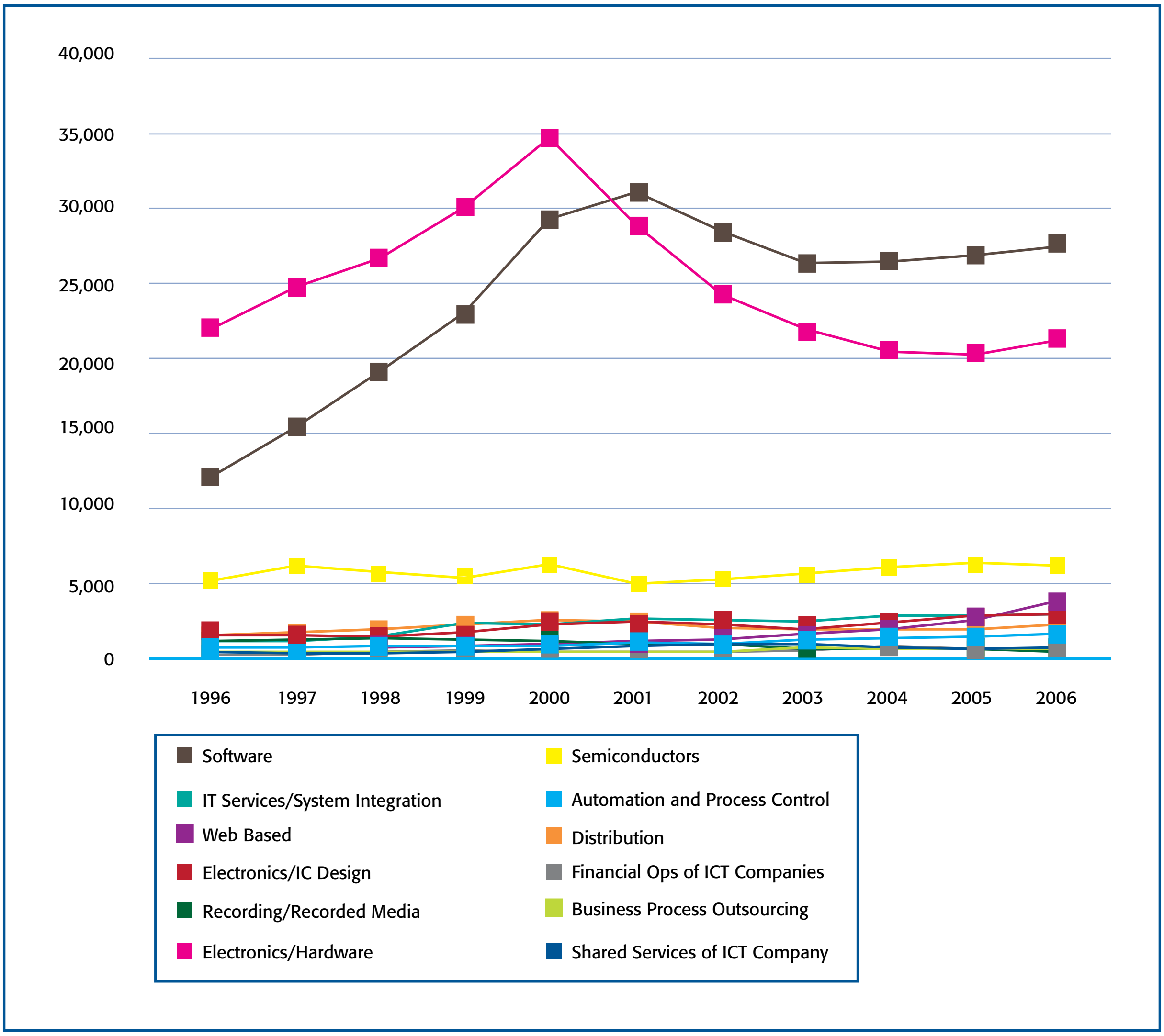


Source: Based on analysis of Forfás Employment Database.

Patterns of change in employment have varied between subsectors. As can be seen in Figure 2.2:

- Employment in electronics hardware reached almost 35,000 in 1999 before falling to just over 20,000 five years later;
- Employment in software increased rapidly to approximately 32,000 in 2001, peaking later than electronics hardware. It fell in 2002 and 2003, but has been increasing steadily since then, at about 1.4% per annum; and
- Total employment in manufacture of semiconductors has remained quite stable over the period, with significant closures being balanced by growth in employment in other companies.

Figure 2.2: Employment in Irish ICT Sector 1996 to 2006 by Subsector (All Subsectors)

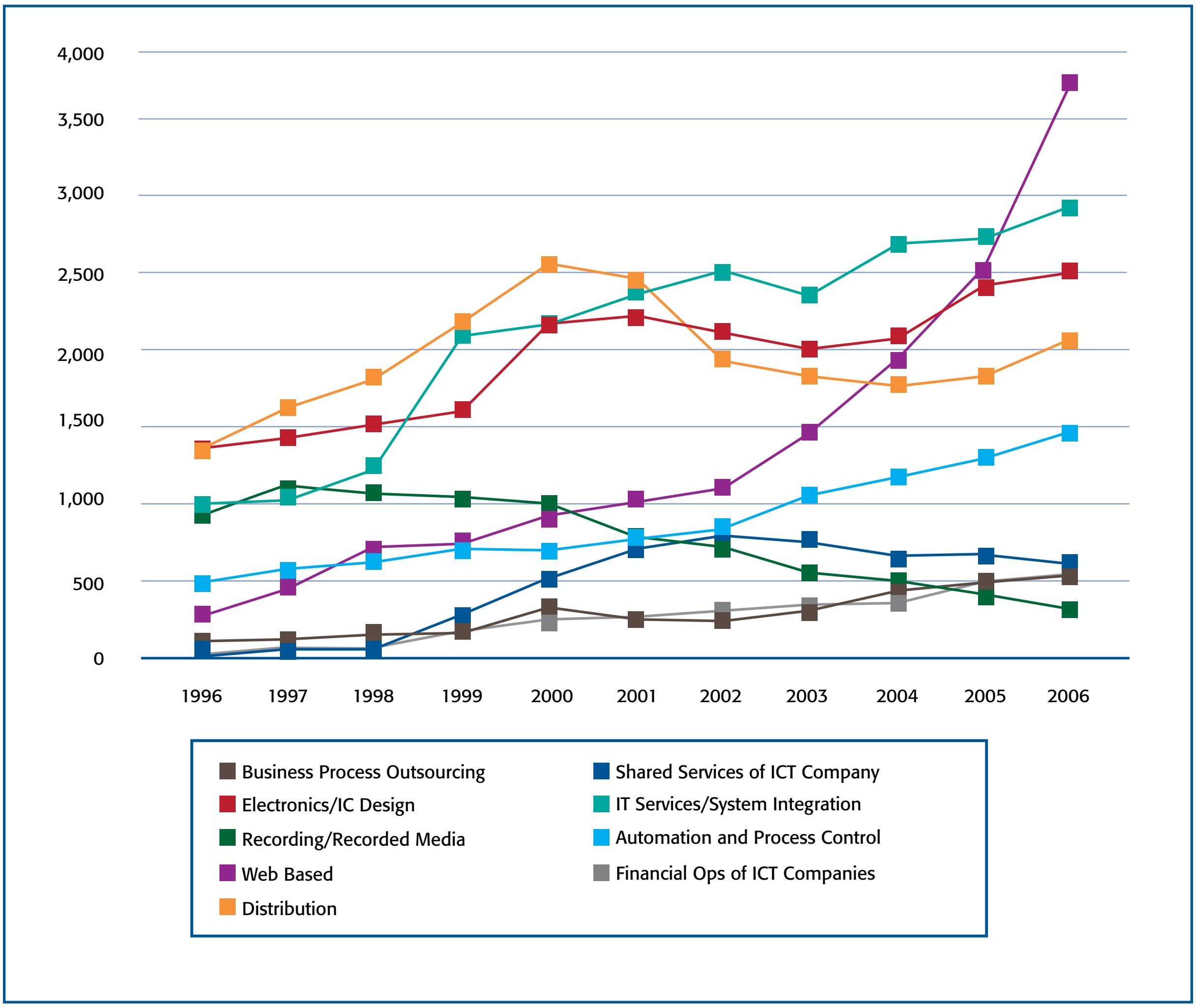


Source: Based on analysis of Forfás Employment Database.

Figure 2.3 shows a subset of the data from Figure 2.2. As can be seen in this Figure:

- There has been a dramatic increase in employment in Web-Based businesses. The increase has come from both indigenous and overseas-owned businesses, although overseas-owned businesses account for the greater part. The numbers do not include web design companies;
- After a period of steady growth (particularly rapid between 1999 and 2000), employment in electronics/IC design peaked in 2001, and then fell in 2002 and 2003. In the main, companies in this subsector design integrated circuits and complementary software. Employment numbers rose subsequently, more than recovering from the downturn;
- There has been a significant rise in employment in companies categorised here as IT services/systems integration, which continued through the downturn in the wider ICT sector. Indeed, many software companies provide services which, if undertaken on a stand-alone basis, would make it appropriate to include them in this subsector.
- Employment in the distribution subsector (ICT logistics companies and those operations of international ICT businesses distributing in Ireland that are included in the Forfás Employment Database) rose to over 2,500 in 2000, decreased to 2004, and increased again in 2005 and 2006;
- There has been significant, steady growth in employment in companies providing automation and process control services, bringing employment to almost 1,500 in 2006;
- Employment in recording/recorded media, which was once central to the distribution of software from Ireland, has been decreasing since 1997, and continues to fall;
- A number of international ICT companies have separate financial operations in Ireland (shown as "Financial Ops of ICT Companies" in the Figure). Total employment in these has been increasing steadily, and passed 500 in 2006;
- Employment in business process outsourcing (BPO – provision of services such as IT operations or customer service on a contract basis) has increased steadily over time, and passed 500 in 2005. This employment total does not reflect the full scale of BPO activity in Ireland, as some organisations have BPO operations that cannot be separated from other operations in their employment statistics; and
- A number of international ICT companies have separate shared services operations in Ireland. Employment in these peaked in 2002, and, overall, has been falling since.

Figure 2.3: Employment in Irish ICT Sector 1996 to 2006 by Smaller Subsectors



Source: Based on analysis of Forfás Employment Database.

Figure 2.4 overleaf shows employment for each subsector by company ownership. Among the key points to note are that:

- Employment in the electronics hardware subsector is predominantly in overseas-owned companies, but there is significant employment in Irish-owned companies too;
- There is substantial employment in both Irish-owned and overseas owned software companies, with Irish-owned companies accounting for 42% of employment;
- Employment in web-based businesses is dominated by overseas-owned companies; and
- Employment in automation/control services is dominated by Irish-owned companies.

Figure 2.4: Employment by Subsector and by Company Ownership, 2006

	Irish-owned	Overseas-owned
Software	11,545	15,866
IT Services	1,119	1,803
Web	316	3,404
Electronics/IC Design	494	1,881
ICT Storage Media	0	329
Electronics Hardware	3,011	18,087
Semiconductor Production	164	5,884
Automation/Control Services	1,393	128
ICT Distribution	987	1,081
Financial Services Unit of ICT Company	0	544
Business Process Outsourcing	154	399
Shared Services of ICT Company	0	622
Total	**19,183**	**50,028**

Source: Based on analysis of Forfás Employment Database.

2.3 Firm Level Employment Dynamics

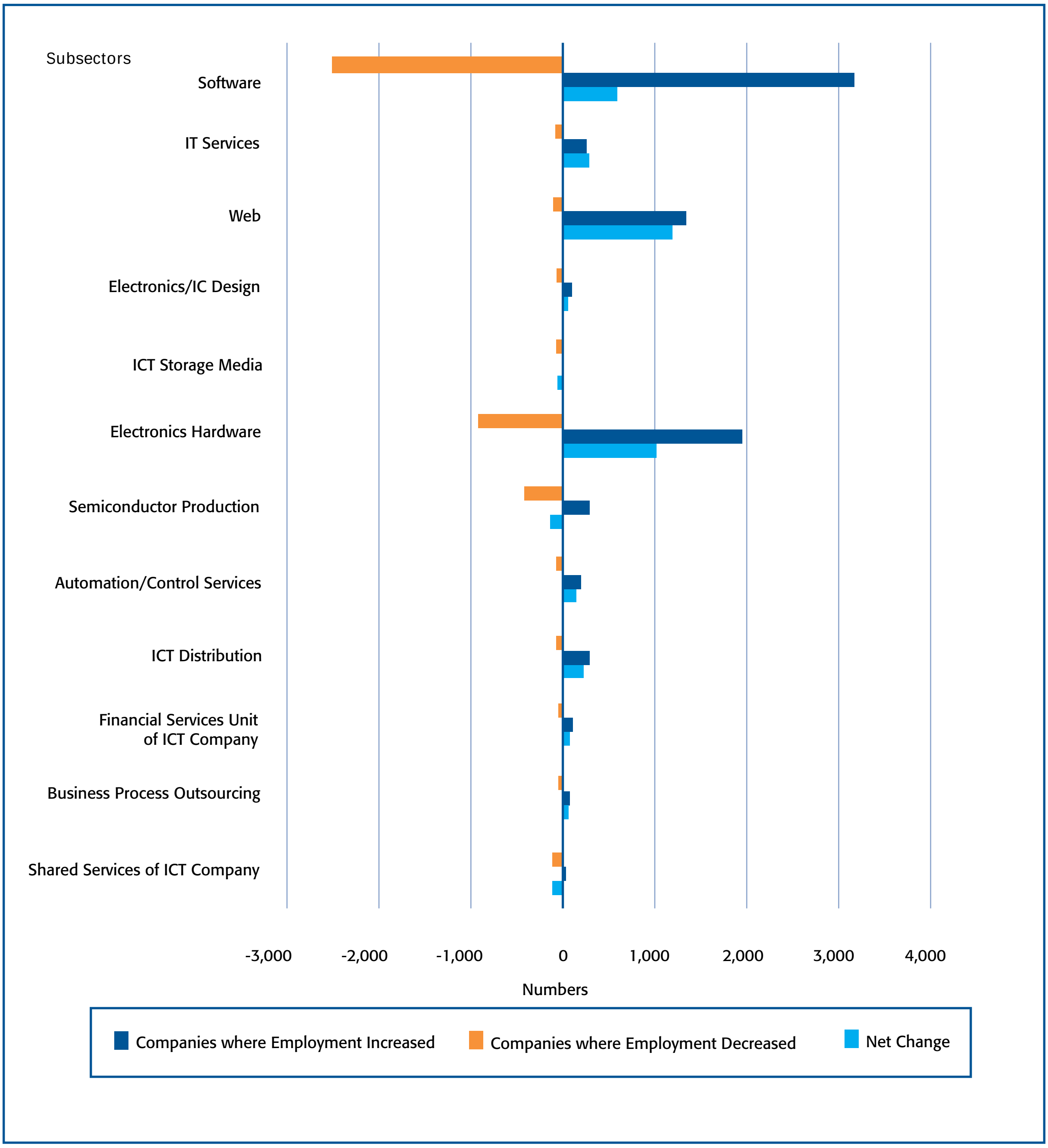
The trends in employment totals in each subsector reflect the net impact of a combination of increases and decreases in employment at different companies. Figures 2.5 and 2.6 illustrate this for changes between 2005 and 2006, with the former depicting absolute increases and decreases, and the latter depicting percentage changes.

The key point to note is that across most subsectors there were significant decreases in job numbers as well as increases[9]. In software, for example, the net increase in employment of a little over 700 was despite decreases totalling approximately 2,500 across companies whose employment levels fell.

Also of particular interest is the electronics hardware sector, where the net increase in employment of just over 1,000 was despite decreases totalling approximately 900.

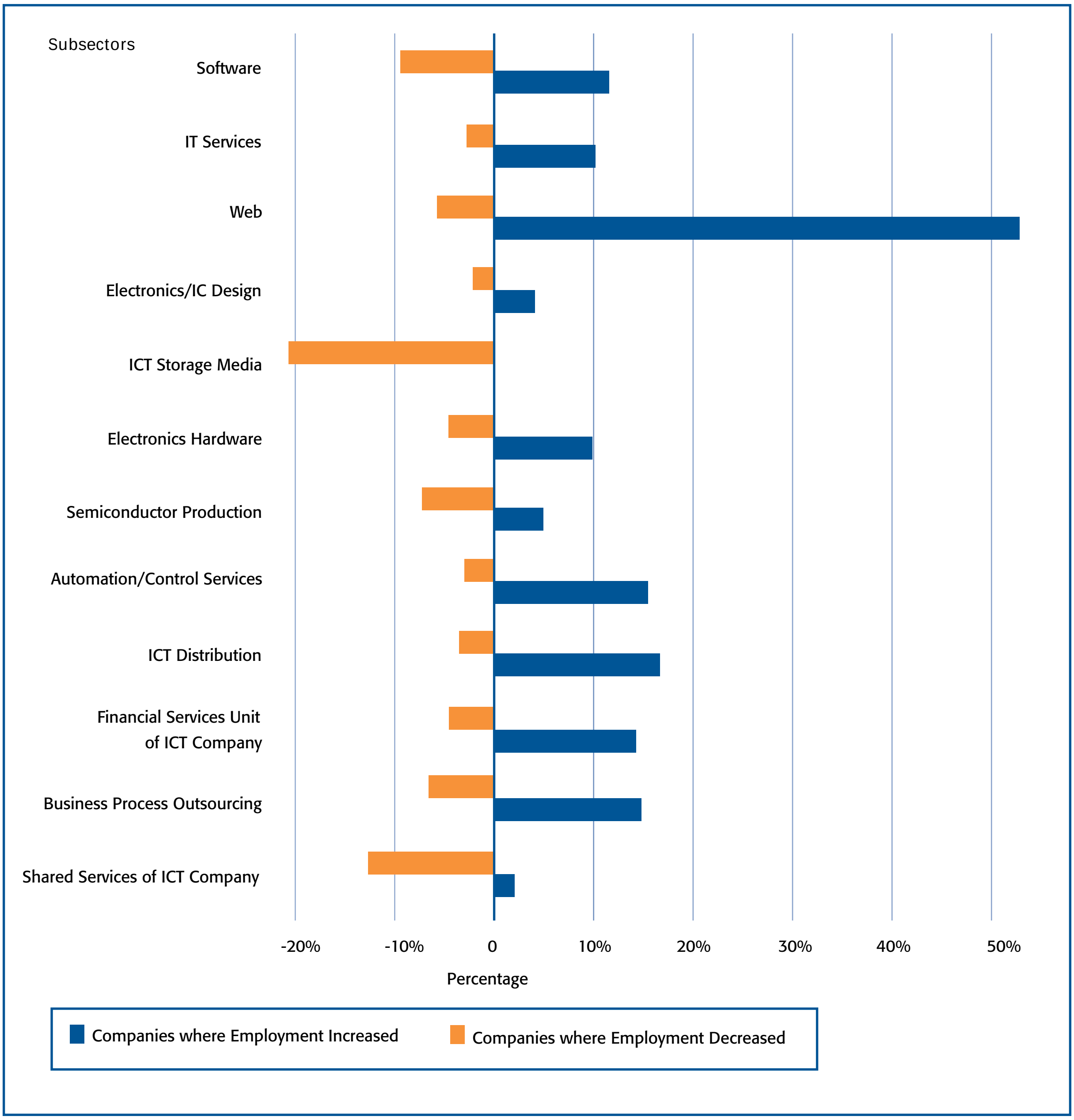
9 This pattern is not unique to the ICT sector. For example, a similar analysis was undertaken on non-ICT manufacturing companies in the Forfás database (those in NACE 29 to 37), which showed employment rising slightly (up 0.6%) between 2005 and 2006, with those firms that lost employment losing an average of 15%, and those that gained employment gaining an average of 17%.

Figure 2.5: Patterns of Employment Change Across Subsectors 2005-2006 (Depicting Absolute Increases and Decreases)



Source: Based on analysis of Forfás Employment Database.

Figure 2.6: % Patterns of Employment Change Across Subsectors 2005-2006 (Depicting % Increases and Decreases)



Source: Based on analysis of Forfás Employment Database.

Growth Areas

Much of the growth in employment in electronics hardware seen in Figure 2.5 is associated with major companies. This appears to arise from increases in production volumes, complemented by increasing development activity.

Growth in employment in software is well distributed between indigenous and overseas-owned companies, and across a wide range of types of company.

Pattern of Simultaneous Creation and Destruction is Not Surprising

The pattern of simultaneous creation and reduction of jobs within subsectors is not surprising. Internationally, the ICT sector is one in which even major companies can rise and fall rapidly. It is not unusual for changing market or competitive conditions to impact on individual businesses in ways that are out of line with the wider trend. It is normal to see businesses in the sector falling while others rise.

Internationally, the pattern is particularly strong at SME level. The failure rate among new ICT SMEs is high, a fact that is well understood by entrepreneurs and investors. The corollary to this is that large numbers of SMEs are formed, are developed for a period, and then fail, are wound down, or are stripped after a trade sale. Moreover, even SMEs that are modestly successful often go through a downsizing phase, either once they have a fairly stable product, or after a period of over-optimistic growth in employee numbers.

Thus, now that the ICT sector is well established in Ireland, it is inevitable that job losses as well as job gains should form a significant part of the employment picture even when the sector is doing well. While any individual closure or downsizing is inevitably a matter of concern for the people involved, it is not automatically a matter of policy concern for the sector as a whole.

Replacement of Low-level Jobs with Higher Skill Jobs

The information presented in these Figures does not present a full picture of the creation and loss of jobs. The interview evidence is that many companies in the sector, particularly in Electronics Hardware and Semiconductor Production, are progressively replacing lower skilled jobs with higher-skilled jobs, without this causing any necessary change in employment totals. While much of this change is being achieved by upskilling existing staff, or encouraging them to upskill themselves by returning to college part-time, some is also being achieved through replacing people in relatively low skilled roles with higher-skilled staff in more highly skilled roles.

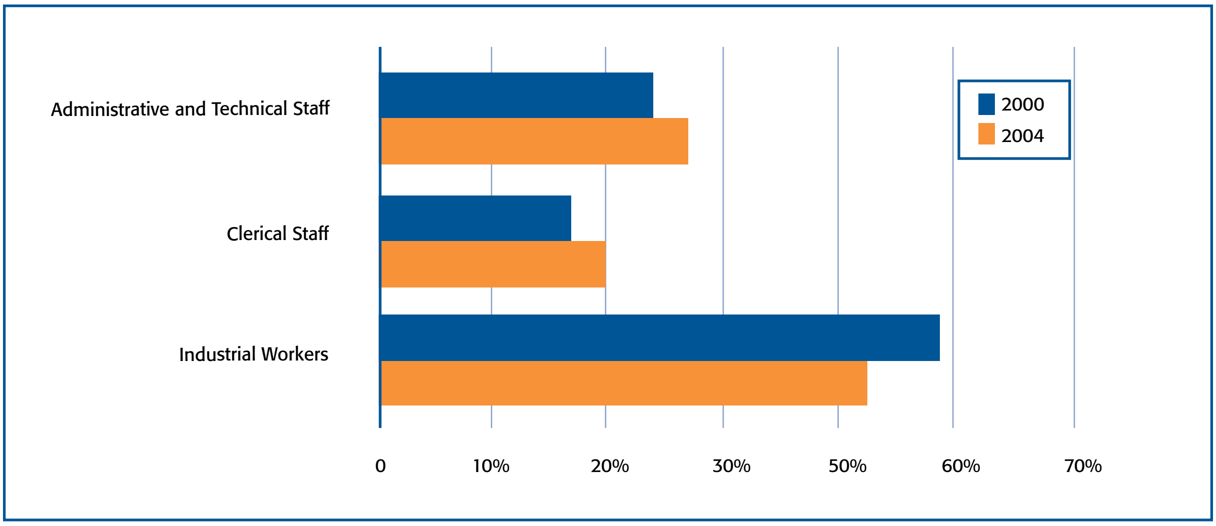
Thus, at least for these two sectors, actual numbers of job creations and job losses are higher than depicted.

Data from the Census of Industrial Production (CIP) corroborates the interview evidence. Companies in the Electronics Hardware and Semiconductor Production subsectors appear in CIP data as a dominant subset of three industry codes:

- NACE 30 – Manufacture of Office Machinery and Computers;
- NACE 31 – Manufacture of Electrical Machinery and Apparatus; and
- NACE 32 – Manufacture of electronic valves and tubes and other electronic components.

Figure 2.7 shows the share of employment accounted for by Industrial Workers (Supervisors, Operatives and Apprentices) falling steeply between 2000 and 2004.

Figure 2.7: % Change in Employment for Different Occupational Categories in NACE 30, 31 and 32 from 2000 to 2004



Source: Based on data from Census of Industrial Production, 2000 and 2004, CSO.

2.4 Start-Ups and New Inward Investment

Start-up and new inward investment activity remains significant. Figure 2.8 shows how operations first appearing in 2003 or later have made a significant contribution to employment in the sector.

Figure 2.8: 2006 Employment in Companies First Appearing in 2003 or Later

	Irish-owned	Overseas-owned
Software	2,503	1,003
IT Services/Systems Integration	123	0
Web-Based	93	2,033
Electronics/IC Design	56	0
Recording/Recorded Media	0	0
Electronics Hardware	403	314
Semiconductors	5	0
Automation and Process Control	111	36
Distribution	0	27
Financial Ops of ICT Companies	0	0
Business Process Outsourcing	105	105
Shared Services of ICT Company	22	22

Source: Based on analysis of Forfás Employment Database.

The employment in new Irish-owned start-ups has been distributed across a large number of companies, most of which were still small by 2006. However, 39 companies had grown past the level of 20 employees by 2006, predominantly software, web-based and electronics hardware businesses, as can be seen in Figure 2.9.

Employment growth associated with inward investment was concentrated among a smaller number of operations. Most of these were in software, with hardware, web-based and automation/process control also featuring.

Figure 2.9: Number of Companies, First Appearing in 2003 or Later, with More Than 20 Employees in 2006

	Irish-owned	Overseas-owned
Software	26	8
IT Services/Systems Integration	1	0
Web-Based	2	5
Electronics/IC Design	1	0
Recording/Recorded Media	0	0
Electronics Hardware	6	4
Semiconductors	0	0
Automation and Process Control	2	1
Distribution	0	1
Financial Ops of ICT Companies	0	0
Business Process Outsourcing	1	1
Shared Services of ICT Company	0	1

Source: Based on analysis of Forfás Employment Database.

2.5 Conclusions

After a fall in employment starting in 2000/01, employment growth has resumed in most parts of the ICT sector, albeit at a much lower rate than in the latter half of the 1990s. Employment in software started to edge back up in 2004; employment in electronic hardware in 2006. Employment in web-based businesses has been growing rapidly.

Net growth in employment has reflected a combination of job creation with significant levels of job loss.

In hardware oriented subsectors, there has been significant upskilling, with many low-skill jobs being replaced by higher skill jobs.

The upturn in employment has been underpinned by the continued emergence of new start-ups, and by continued inward investment in new operations.

Chapter 3: Economic Drivers of Irish ICT Sector

3.1 Introduction

This chapter addresses a number of perspectives on the economic drivers of the Irish ICT sector.

It starts by showing that the downturn in employment experienced after 2000/01 reflected a more fundamental change than past cyclical downturns that have affected the ICT sector in Ireland and globally. It traces this to:

- A downturn in the share of all non-residential investment devoted to ICTs in most developed countries; and
- The emergence of low labour cost locations active in the production of ICT products and services.

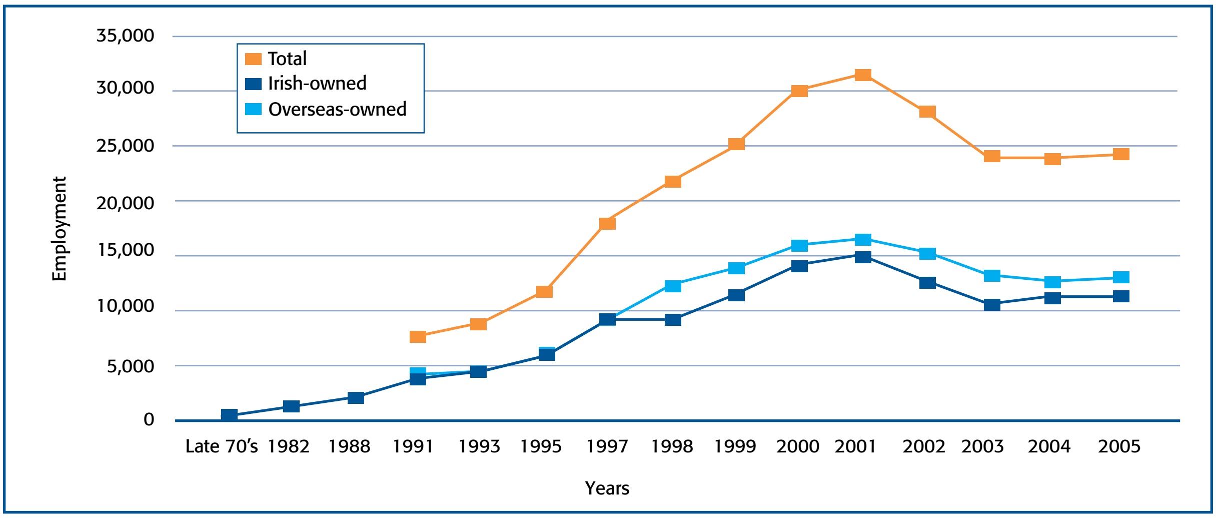
However, it shows that the economic underpinnings of the Irish ICT sector are improving after the downturn, with productivity and profitability rising.

3.2 Longer-term Perspective

Some observers, commenting on the business downturn, that started around 2001, have described it as a cyclical downturn, similar to those that have affected the industry every few years for decades. However, a review of Irish data suggests that the downturn reflected a more fundamental change in employment patterns. After a period of decades of more or less continual growth, the 2001 downturn produced a sharp and lasting drop in employment, from which the sector has been slow to recover.

This pattern of long-term growth, interrupted by a sharp downturn, is visible both in software and hardware oriented parts of the sector, as can be seen in Figures 3.1 and 3.2.

Figure 3.1: Irish Software Sector† Employment, 1970s to 2005*

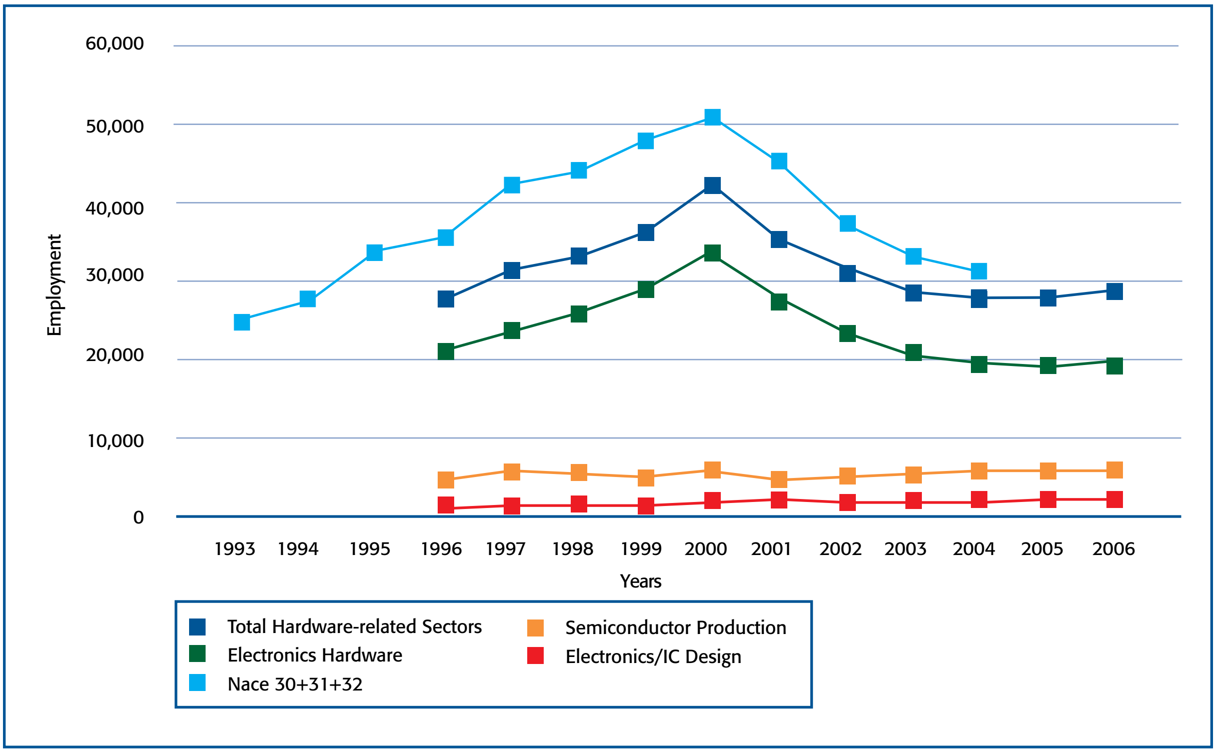


† Sectoral definition does not match exactly that used elsewhere in this report. It is used here to permit the assembly of a relatively long time series.

** Note that the time period between data points varies, so slope is not a reliable indicator of the rate of change.*

Source: EI/National Software Directorate series from 1991; ISA surveys for earlier data points.

Figure 3.2: Irish Employment in Hardware-Related Sectors, 1990 to 2006



"Total Hardware-Related Sectors" includes Electronics Hardware, Semiconductor Production and Electronics/IC Design. This is a subset of the employment total for NACE 30, 31 and 32.

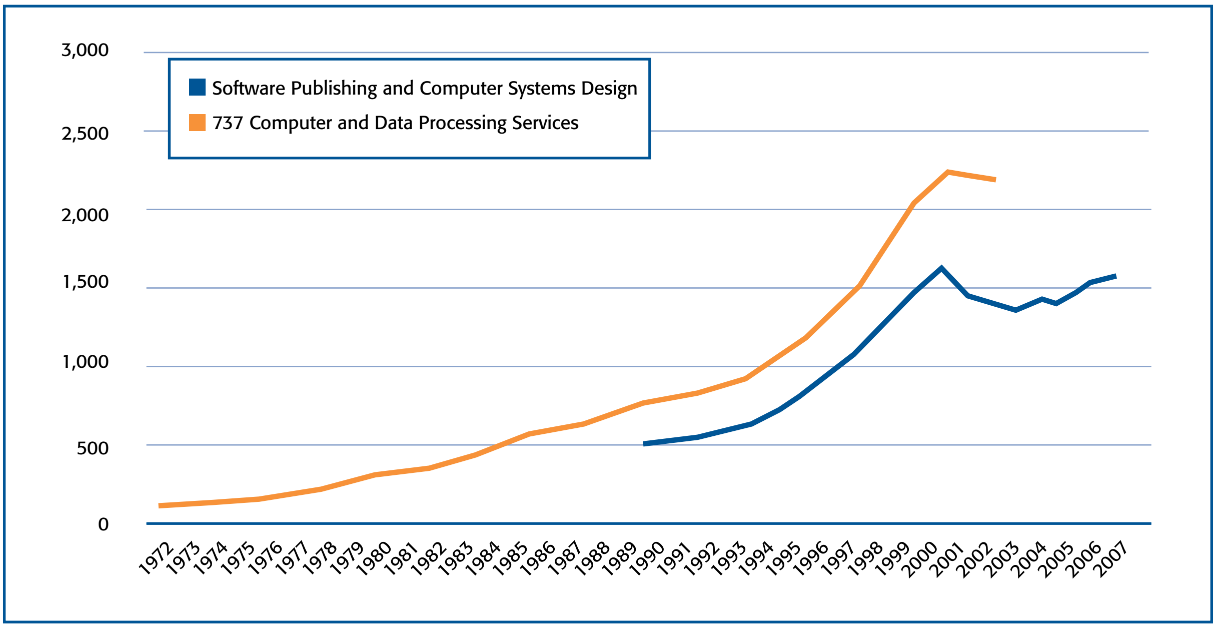
Source: Census of Industrial Production, various years, CSO; Analysis of Forfás Employment Database.

3.3 International Comparisons

3.3.1 Software and Related Subsectors

International comparisons show that the general trend of employment developments in software in Ireland was broadly similar to that in other countries. For example, US data presented in Figure 3.3 shows employment rising more or less continually for three decades, before hitting a peak in the first quarter of 2001, then falling back, and commencing a gradual recovery late in 2003.

Figure 3.3: Quarterly US Employment in Software-Related Sectors ('000s)

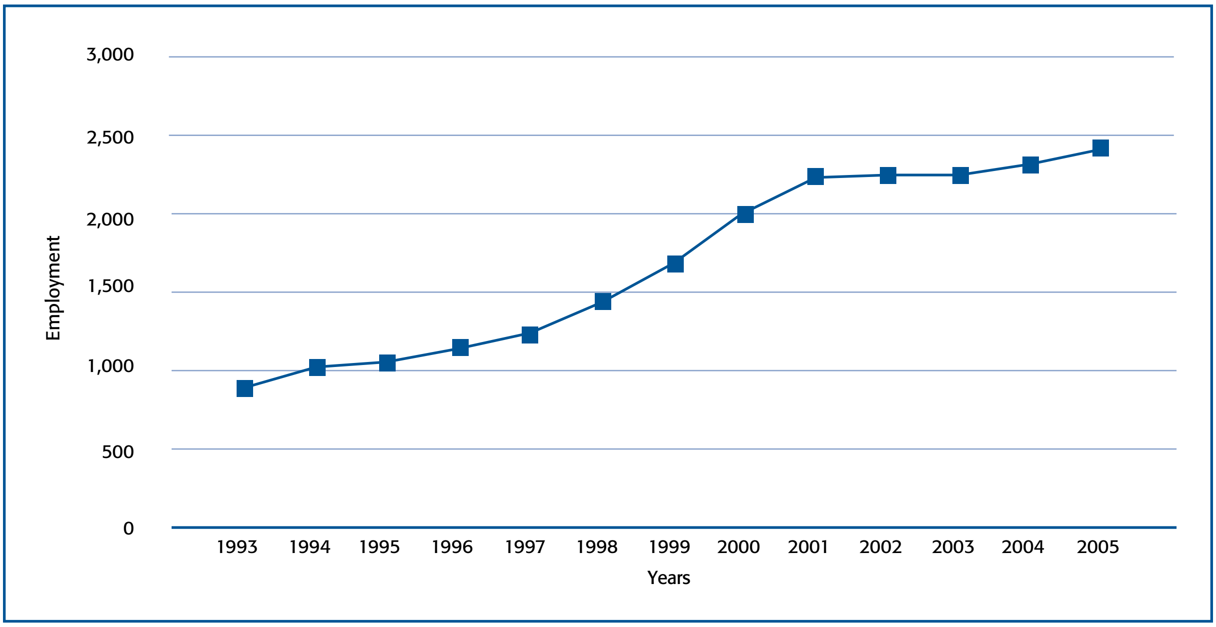


Note that a new system of classification was introduced during 2003, under which components of the main high-level classification relevant to software were repositioned under different high-level classifications. Estimates under the new system were published back to 1990. Data from both systems of classification are included here to provide a long-term view that extends to the present.

Source: US Bureau of Labor Statistics.

Data from the European Union, presented in Figure 3.4, are available only for a shorter time period than for the US. They illustrate the steep ramp up in employment during the 1990s. However, they also show that, during the downturn, total employment went flat rather than falling.

Figure 3.4: Employment in Software and IT Services (NACE 72) in EU 15 ('000s)



Source: Analysis of Labour Force Survey data obtained from Eurostat.

While the reasons for this have not been investigated in any detail for this study, it seems likely that the following had an influence.

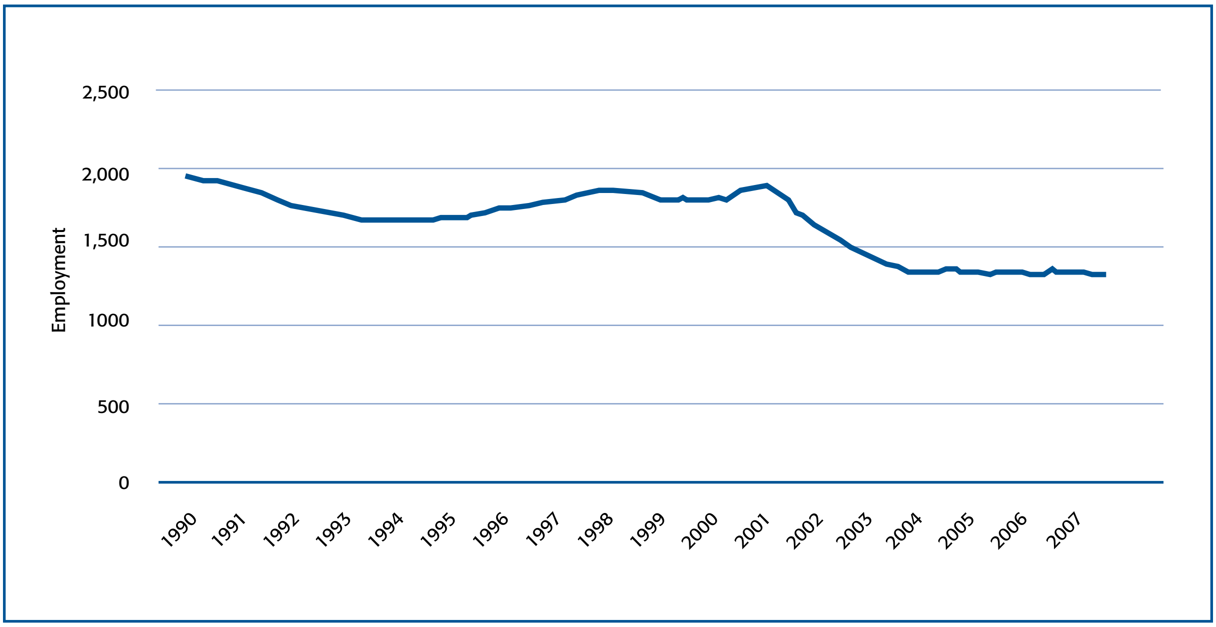
- There is greater security of employment in law and in custom in many EU countries than in most parts of the US.
- There is evidence of pay in the industry stalling in EU countries, while it continued to increase in the US. This may have decreased the pressure to reduce employee numbers in the EU.
- Those employed in software and IT services in the EU predominantly serve EU markets, and segments of those markets that are not heavily traded internationally. These appear not to have been affected as severely as US markets or heavily traded parts of international markets.

3.3.2 Hardware and Related Subsectors

US figures on employment in electronic hardware, presented in Figure 3.5, show an employment downturn fairly similar to that seen in the Irish data (although without the slight recovery of 2006). Even the extent of the fall in employment is similar, with the US industry showing a peak to trough fall of 30%, and the Irish industry showing a comparable fall of 34%.

It is notable, however, that a longer-term view of employment developments shows significant differences between the countries. The fall in employment experienced in the US has precedents in earlier industry downturns, the most recent of which is visible in data for the early 1990s in Figure 3.5. In contrast, Irish employment increased rapidly during this period.

Figure 3.5: Monthly US Employment in Computer & Electronic Products ('000s)



Source: Based on monthly data, US Bureau of Labor Statistics.

During earlier downturns in ICT markets, the Irish industry continued to grow chiefly because it was a major destination for offshoring. During the most recent downturn, while some offshoring to Ireland continued, offshoring away from Ireland, as from the US, was a major part of the picture. It appears to have affected employment in the hardware-related industries of both countries to roughly the same extent.

3.3.3 Regional US Comparisons

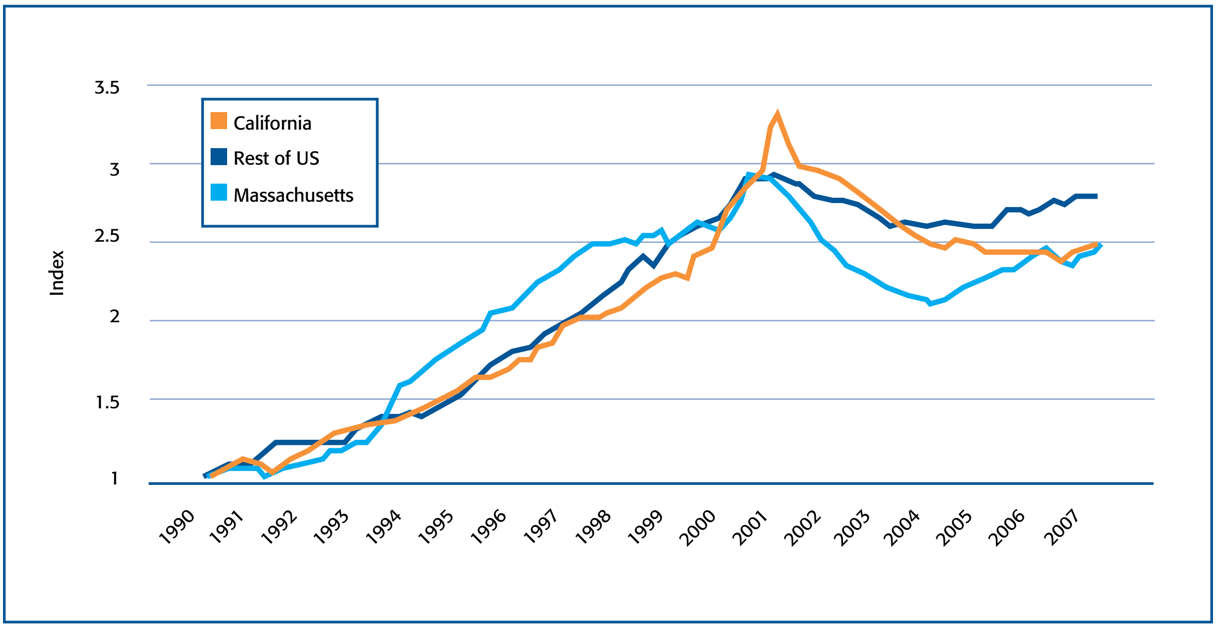
It is useful not just to look at US employment at national level, but also for states that are the home of major ICT industry clusters.

Figure 3.6 tracks developments in employment in Software Publishing – the US sector most closely comparable to the Irish software sector – for California (home to Silicon Valley), Massachusetts (home to Route 128) and the "Rest of US". It demonstrates that employment in the traditional ICT powerhouse of California shows employment barely rising, despite a resurgence in ICT start-up activity.

Even in Massachusetts, which initially bounced back after an even steeper drop in employment, the employment level went flat through 2006, although there has been evidence of renewed growth in 2007. In the "Rest of US", the loss of employment was much shallower, and the recovery appears quite strong.

Issues of cost and access to talent form a major part of the explanation for stagnant employment levels in Silicon Valley. Major Silicon Valley employers are frequently reported establishing operations elsewhere in the US, and indeed outside the US, for these reasons. Even new ventures, which once might have taken some time before establishing remote operations, are now under pressure from funders to have an "India strategy" from early in their existence.

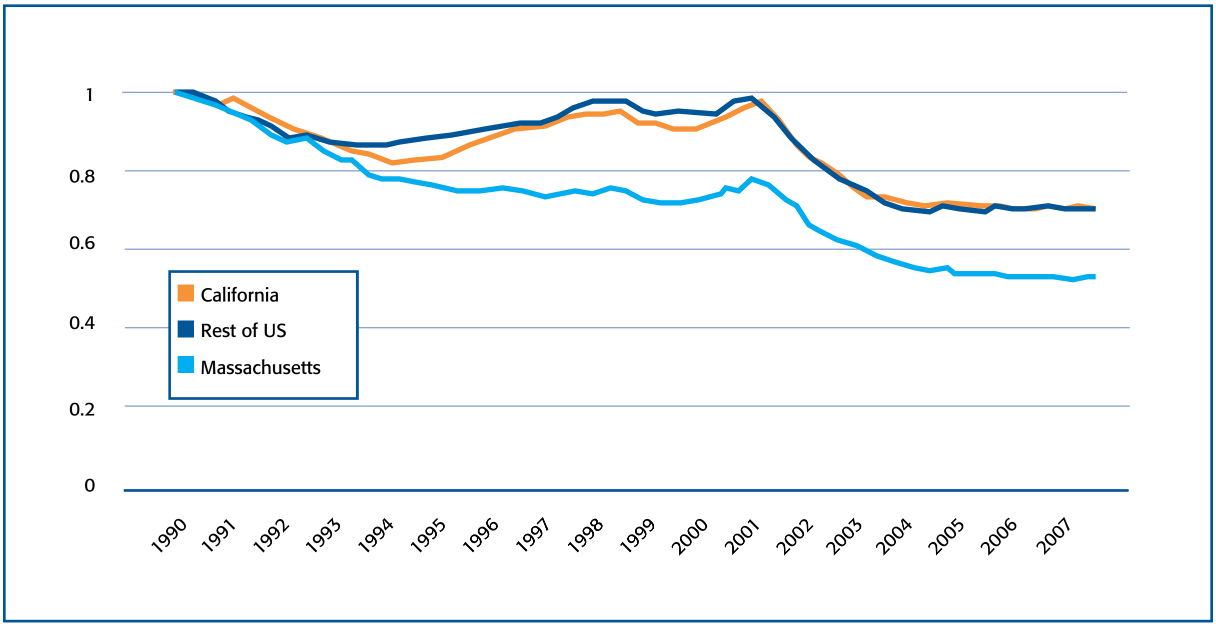
Figure 3.6: Software Publishing Employment – California, Massachusetts and Rest of US (Index) – Monthly Data (Indexed to January 1990)



Source: Based on index monthly data from US Bureau of Labor Statistics.

Figure 3.7 similarly tracks developments in employment in Computer & Electronic Product Manufacturing. It shows employment levels have flattened, whether in California, in Massachusetts or in the "Rest of US".

Figure 3.7: Computer and Electronic Product Manufacturing Employment – California, Massachusetts and Rest of US (Index) – Monthly Data (Indexed to January 1990)



Source: Based on index monthly data from US Bureau of Labor Statistics.

Key conclusions to draw are that:

- The share of ICT activity accounted for by leading ICT clusters is falling, leaving total employment levels flat; and
- Labour costs, and the need to go elsewhere to access talent, form an important part of the explanation.

3.3.4 Shift to Services

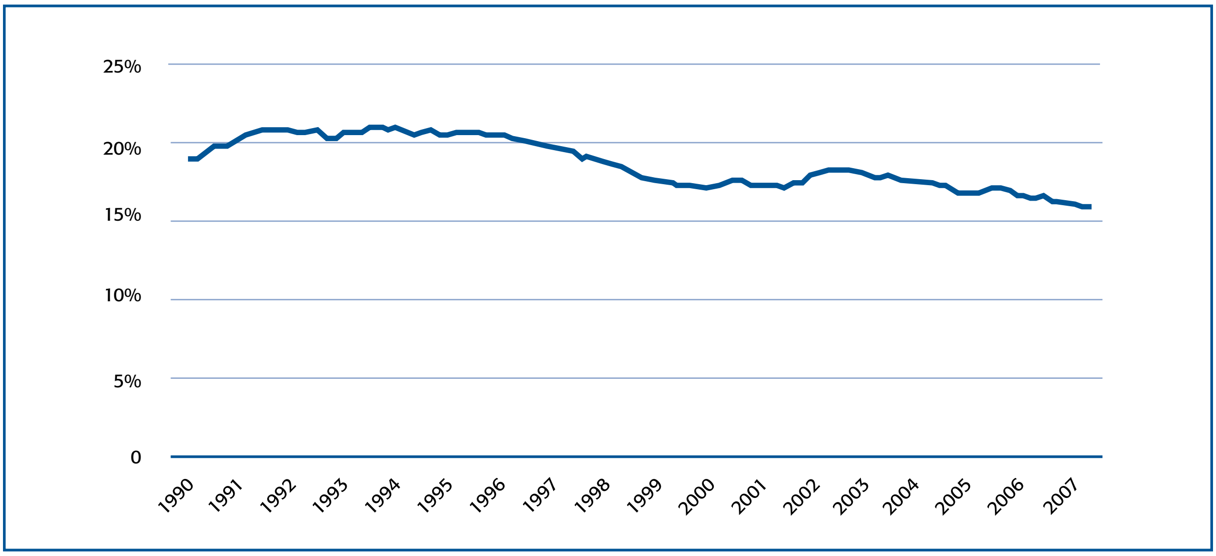
There is a widely recognised "shift to services" underway internationally, within the broad software and IT services industry. This manifests itself in two ways:

- Within the software product space there is a shift towards business models based on providing software as a service[10] and towards providing consulting, development, support and other services that complement the software; and
- The share of the broad market addressed by IT services businesses is growing, while the share addressed by software product companies is shrinking. This can be seen for the US in Figure 3.8, which shows how the share of employment accounted for by Software Publishing as a % of employment in the main US software-producing industries (Software Publishing and Computer Systems Design) has generally been on a downward trend since 1994.

Responding to the first trend, many Irish software companies have remodelled their software and operations so as to provide their software as a service, and to provide complementary services.

However, the second trend means that the share of the total international market for software that is available to the software product companies (that form a large share of the Irish software sector) is contracting.

Figure 3.8: US Employment in Software Publishing as % of Employment in the Main Software Producing Industries (Software Publishing and Computer Systems Design) – Monthly Data



Source: Based on monthly data from US Bureau of Labor Statistics.

10 Software as a service refers to the provision of network/web access to software, which is hosted and managed and maintained centrally by the vendor.

3.4 Emergence of Low Labour Cost Locations

3.4.1 ICT Hardware Industries

The ICT hardware industries of developed countries have been offshoring production for decades: initially relatively low skilled assembly work; later higher-skilled work requiring high-level production skills; and more recently work in development and sometimes research.

Figure 3.9 presents 2004 data on numbers employed by international affiliates of US Computers and Electronic Products companies. Even after the loss of many (mainly relatively low-level) jobs to lower cost locations, Ireland remains the offshore location with the 11th highest number of employees.

Figure 3.9: Employment in Overseas Affiliates of US Companies in Computers and Electronic Products by Country – Top 22 Countries (2004)

Country	Employees ('000s)	Country	Employees ('000s)
China	89.8	Japan	18.5
Mexico	81.4	Israel	16.8
Malaysia	61.2	Brazil	15.0
Canada	38.5	Korea, Republic of	14.8
Singapore	38.4	Taiwan	12.4
United Kingdom	31.1	Hong Kong	11.3
Germany	29.9	Italy	9.6
Thailand	29.1	Czech Republic	8.3
Philippines	26.4	Spain	6.9
France	24.8	India	6.5
Ireland	19.9	Netherlands	5.3
		All Countries – Global Total	**644.8**

Source: US Bureau of Economic Analysis.

The interview evidence is that offshoring from Ireland is continuing. Overseas-owned Electronics Hardware companies are continuing to move jobs overseas to lower cost locations (often in the Central/Eastern European Accession States or in China), frequently replacing them with higher-level jobs so that there is little impact on employment totals.

Electronics/IC Design operations, both indigenous and overseas owned, are also establishing and expanding overseas operations. Locations mentioned in interviews include Central and Eastern Europe, Spain, North Africa and India.

3.4.2 Software-Related Industries

Offshoring of software-related work to countries with low labour costs emerged as a significant trend during the 1990s. It has accelerated since. It has two main components:

- Outsourcing of software-related work to companies based in low cost countries; and
- Offshoring to affiliates established in low cost countries.

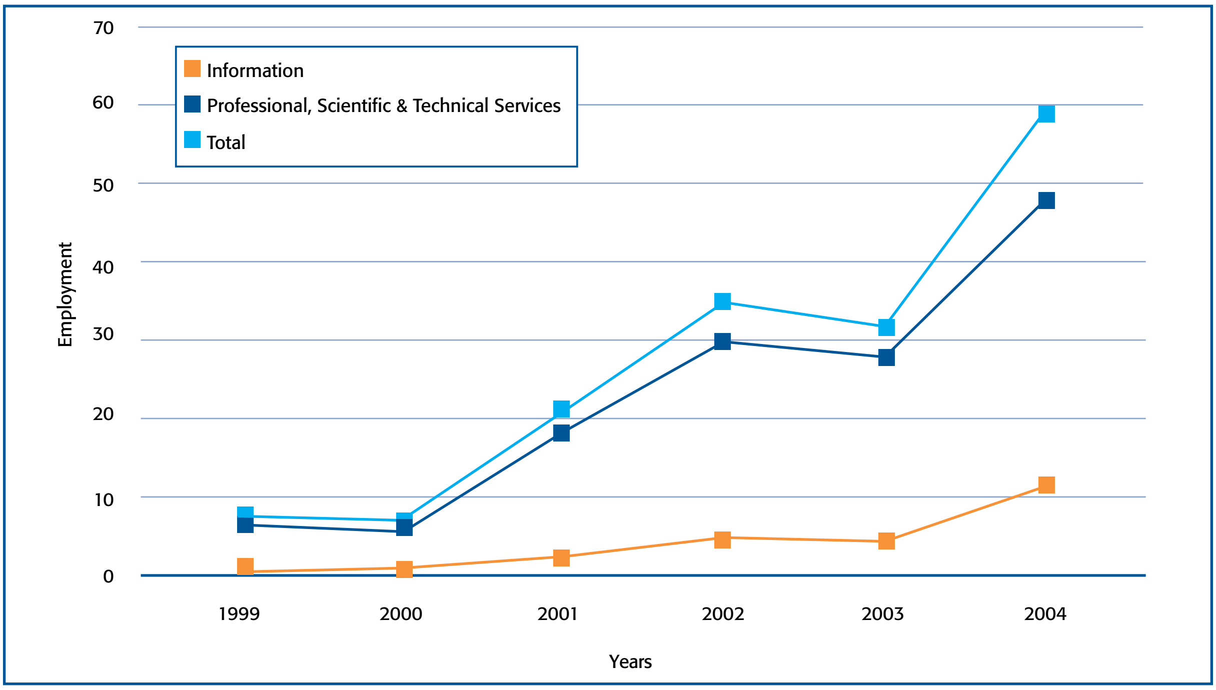
The primary location for software-related offshoring, among companies interviewed for this study, is India. China, the Philippines and parts of Eastern Europe are also destinations.

According to NASSCOM, the Indian IT industry organisation, Indian "IT-ITES"[11] employment grew from 284,000 in 1999-00 to 1,287,000 in 2005-06, an average of 29% per annum. As a whole, the industry was worth $36bn in 2006. IT services exports accounted for 36% of this. Engineering services, R&D and software products together accounted for 13%.

While employment in affiliates of non-Indian companies is growing rapidly, it still accounts for only a minority of total employment. According to NASSCOM, offshoring by "IT majors" accounts for just 10% to 15% of IT services and Business Process Outsourcing (BPO) revenue.

US figures, presented in Figure 3.10, show that employment in Indian affiliates of US companies in Information and in Professional, Scientific & Technical Services (for practical purposes, software & IT services) rose from 7,300 in 1999 to 59,000 in 2004, representing an average rate of increase of 52% per annum. Interview evidence and media reports indicate that rapid growth has continued since 2004.

Figure 3.10: Employment in Indian Affiliates of US Companies in Information and in Professional, Scientific & Technical Services Industries, 1999 to 2004 ('000s)



Source: US Bureau of Economic Analysis.

Similarly, a recent report by Ovum for the Department of Trade and Industry in the UK[12] on software and IT services forecast that "the total number of UK-facing staff employed offshore will double to 131,000" over the three years to 2008.

11 *Information Technology (IT) and Information Technology Enabled Services (ITES). ITES refers to activities such as call centres and financial services back office operations.*

12 *The Impact of Global Sourcing on the UK Software and IT Services Sector, Ovum, June 2006.*

3.4.3 Labour Costs and Labour Availability in Low Cost Locations

It must be recognised that Ireland itself has benefited from being a major destination for offshoring and as highlighted earlier (Figure 3.9) remains the offshore location with the 11th highest number of employees. Labour cost and labour availability are two leading factors driving offshoring. Decisions by firms on what can be offshored are complex.

- The technical complexity of work is an issue. In many offshoring centres, there is a strong supply of people with fairly recent qualifications and moderate technical skills, but there is a shortage of very experienced people and people with very high-levels of technical skill. As a consequence, the cost advantages associated with technically high-level work may be less than for routine work.
- The need for domain understanding[13] is also an issue. Where a development task can be adequately reduced to a well defined specification, this favours offshoring. Where a task requires domain knowledge, and particularly the capability to be creative in responding to customer needs, this favours locating development work where the domain knowledge exists – typically in the developed country base.
- Physical closeness to market, and cultural affinity with customers, can also be issues, depending on the extent of personal interaction with customers that is required, and how far that interaction has to extend into the company.
- Factors such as English language and experience working in a multinational environment can be significant. High-level ICT staff work in teams that are often international, spanning multiple locations. In some offshoring locations there are shortages of people with the skills and experience required to work effectively in this sort of environment. (One major company consulted for the study indicated that it had found it would cost as much to hire people like these in Central Europe as in Ireland.)
- Employee turnover is a major issue in some offshoring centres, notably India. While some companies have learned to address it effectively, it gives rise to major operational problems for others.
- The costs of establishing an operation in a low labour cost location can add substantially to a company's fully-loaded cost of labour in that location. This may not be a major issue for a multinational already operating on a large scale across multiple locations. It may be a big issue for a smaller company.
- Both pay levels and the supply of staff are moving targets in major offshoring centres. Pay is typically rising much faster than in developed countries, but this is in the context of improving skills. For example, AT Kearney's 2007 Global Services Location Index reported average compensation for sample occupations rising by 20% in India and 30% in China, and reported that "these cost escalations have been matched by corresponding increases in skill supply and quality indicators".

13 Domain understanding means understanding of the "domain" in which software or a system will be used. For example, a person with strong domain knowledge in a company producing software for the banking industry will have a strong knowledge of banking, and of how IT can be used in banking.

The interview evidence of this study is that offshoring is a live issue in most companies in the Irish ICT sector. Multinational companies with Irish operations are continually making and revising decisions as to where activities should be located globally. Many indigenous companies that are big enough to cope with splitting their operations have either established offshore operations or would consider doing so.

Not all Irish decisions about offshoring are about getting less skilled people at lower cost. In some instances, they are about tapping into sources of very high-level skills that cannot easily be sourced in Ireland, sometimes in North America, sometimes in Europe.

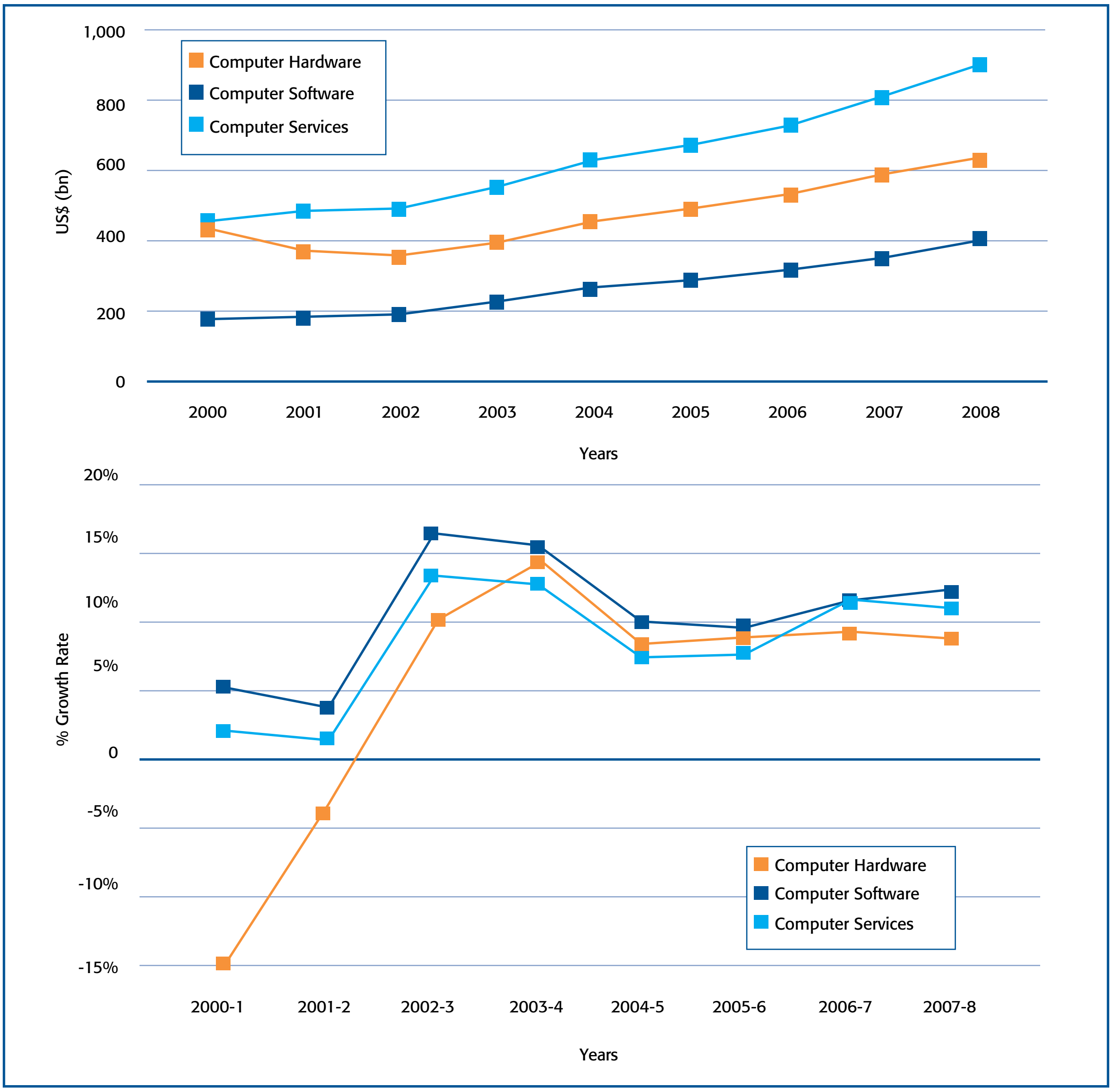
Responding to the above complexities, many companies interviewed say that they (or their overseas management) are dividing development work between the Irish operation and one or more offshore operations, with the Irish operation focusing on work that requires a strong domain understanding, and often a greater degree of technical expertise or affinity with customers.

3.5 Trends in Global ICT Spending

3.5.1 OECD View

According to OECD's Information Technology Outlook 2006, worldwide ICT market growth reached 20% to 30% per annum in the late 1990s. Projections for the period to 2008 are for growth around 9% to 13% at current prices, depending on market segment.

Figure 3.11: Worldwide ICT Spending by Market Segment 2000-08 OECD Data and Projections – Current Prices (US$bn) and Growth Rate



Source: OECD Information Technology Outlook 2006.

The OECD report describes the growth rates of the late 1990s as unsustainable, and predicts that they will not return.

3.5.2 ICT Investment Trends

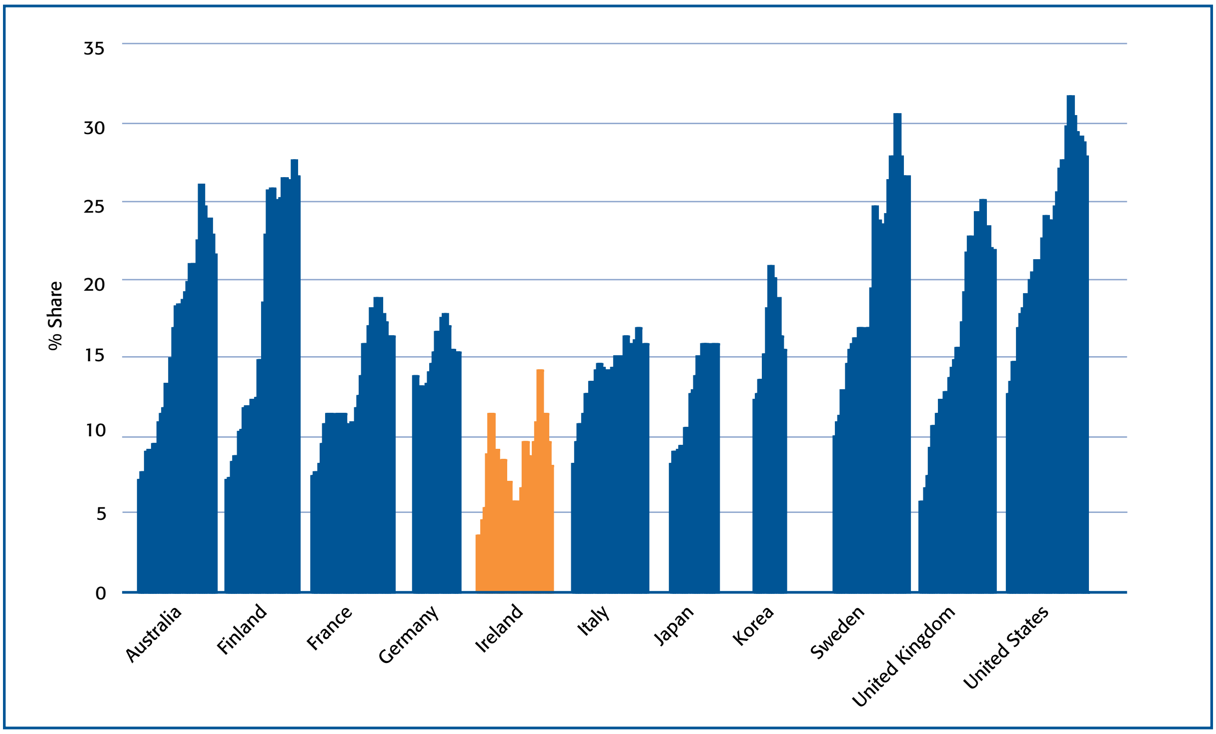
Worldwide market growth is an important factor in any consideration of future ICT sector demand for employees. Numbers employed in developed countries are unlikely to increase at a rate higher than market growth less growth in per employee labour costs, for any extended period. The major costs incurred by most software and IT services companies (which are the dominant employers of high-level ICT staff within the ICT sector) arise from labour costs, so increases beyond this level would unsustainably eat into margins.

ICT spending is heavily influenced by two external cyclical economic factors.

- It tends to vary with GDP; and
- As a form of investment, it tends to vary with the investment cycle, as represented by investment (or Gross Fixed Capital Formation) as a percentage of GDP.

In order to understand longer-term trends, it is useful to filter out the impact of these factors on spending data. Trends in the *Percentage Share of Current Prices ICT Investment in Total Non Residential Gross Fixed Capital Formation* achieve this. Figure 3.12 presents data for a sample of OECD countries. The intention in this Figure is to illustrate the long ramp up, the peak of 2000/01, and the subsequent slide in the share of investment accounted for ICT that has occurred in most developed countries.

Figure 3.12: % Share of Current Prices ICT Investment in Total Non Residential Gross Fixed Capital Formation, 1980 to 2005, Selected OECD Countries



Source: OECD ICT Investment Data spreadsheet 36396989, 13 October 2006.

The period of high growth in global ICT markets, during the latter half of the 1990s, was a period when both GDP and the share of GDP devoted to investment grew rapidly in the main ICT consuming countries. However, the rising share of non-residential investment devoted to ICT drove growth in ICT markets to a level significantly higher than that experienced in most other investment-driven industries.

When the downturn came, around 2000/01, ICT markets were affected not just by reduced GDP growth and general investment confidence, but also by an entirely new trend. Where the share of all non-residential investment devoted to ICT had been increasing broadly continually since the industry first appeared, this trend went into reverse, causing the first ever substantial drop in numbers employed in software and IT services in the US, Ireland and many other countries. The reversal in trend can be seen in Figure 3.12 for all countries included in the Figure other than Japan.

The recovery in ICT market demand following the downturn has been relatively slow and weak in comparison with past recoveries, which appears to be linked to the persistence of the fall in the share of investment accounted for by ICT.

Thus, one of the key questions for the future of ICT employment, and hence for demand for high-level ICT skills, is whether the share of investment devoted to ICT resumes its past upward growth, levels out, or continues to fall in line with the trends visible in Figure 3.12. While this cannot be predicted with certainty, it is possible to draw some pointers from:

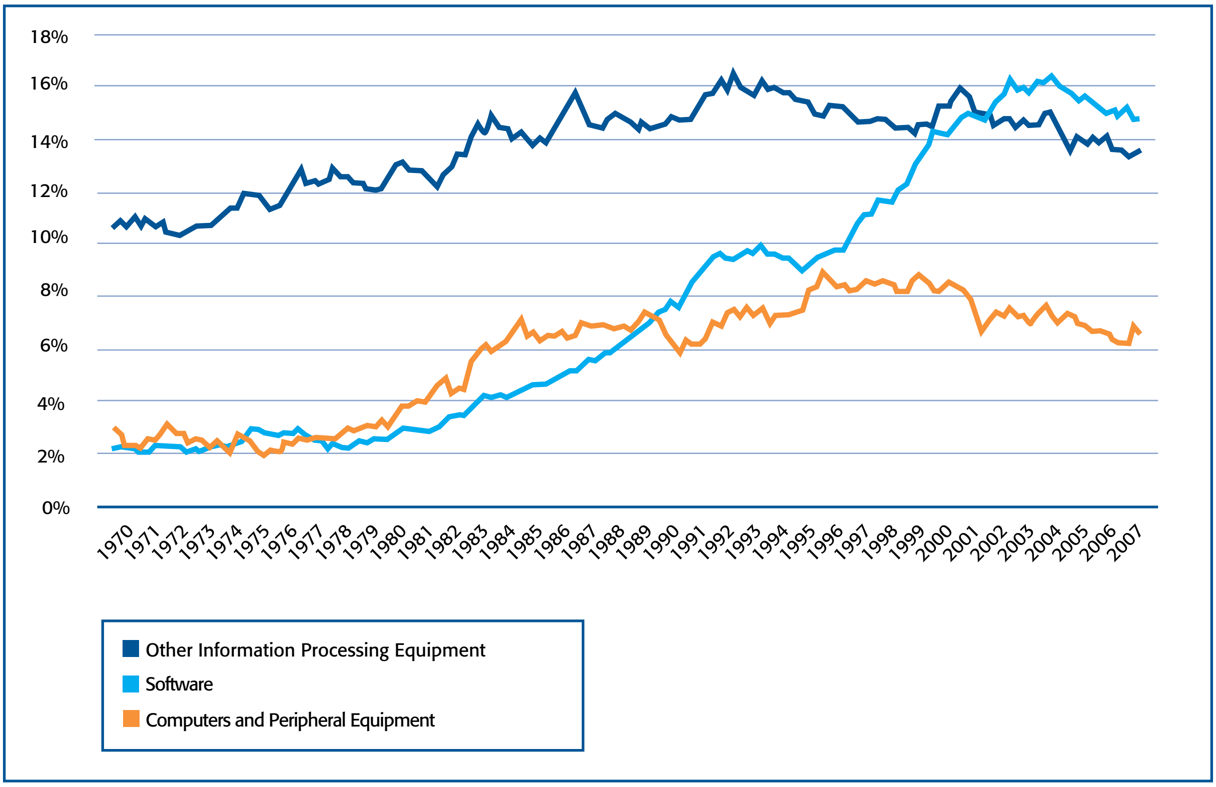
- A more detailed examination of US data (the US still accounts for approximately 40% of the world market for ICT products and services); and
- A consideration of the factors that may now be depressing the share of investment devoted to ICT.

Figure 3.13 presents more detailed data on US investment in ICT, expressed as a percentage of non-residential private fixed investment, disaggregated between: Computers and Peripheral Equipment; Other Information Processing Equipment; and Software.

For each of the two equipment categories, there are apparently well established downward trends. The share of investment accounted for by Other Information Processing Equipment peaked in the early 1990s. It is a matter of interpretation as to whether the share accounted for by Computers and Peripheral Equipment started its decline in 1995 or 1999, but the downward trend has been unequivocal since 2000.

The position is less clear with software (which includes both software products and software developed and integrated by providers of ICT services). There are precedents in the data (around 1976/7 and 1992/3) for downturns similar to that of the last three years preceding the resumption of strong growth in the share of investment accounted for by software.

Figure 3.13: % of Non-Residential Private Fixed Investment Accounted for by ICT Spending (3 Categories) in US National Accounts, Quarterly, Q1 1970 to Q2 2007



Source: Based on quarterly data from US Bureau of Economic Analysis.

There are a number of factors that can plausibly explain why the share of investment accounted for by ICTs might be in decline.

- Part of the issue specifically with the 'Other Information Processing Equipment category' may be with general purpose computers substituting for more specialist equipment. Similarly, part of the issue with the two equipment categories taken together may be with a greater part of the value of an entire system being encapsulated in software, leaving less to be spent on equipment.
- It is possible that enthusiasm for ICT investment relating to the Internet in the latter half of the 1990s raised the rate of increase in investment above the long-term trend, and that the decline that followed represents a correction to this overshoot. This interpretation suggests a resumption of the upward trend.
- It is possible that ICT investment has reached such a large share of all non-residential fixed investment (or gross fixed capital formation) in some countries that there is no further room for it to grow. It peaked at 38.8% in the US, and was 34.6% in Q2 2007. This interpretation suggests that the share of investment accounted for by ICT may plateau out at about the current level.

- It is possible that offshoring of IT services to low cost countries has cut average prices sufficiently so that user organisations have been able to reduce their spend on ICT goods and services, while increasing the volume purchased. To the extent that software and IT service volumes can be measured in person-years, the rapid rate of increase in numbers employed by software and IT services operations in offshore locations to serve North America and Europe represents a steep increase in volumes purchased. This interpretation suggests that the future share of investment accounted for by ICT will depend on complex developments in offshoring. One possibility is that rising costs in offshore locations might arrest, and possibly reverse, the decline in the share of investment accounted for by ICT, although other futures are plausible.

3.6 Impact of 2000/01 Downturn on Irish Industry

While the downturn in Ireland broadly reflected that seen elsewhere, particularly in the US, a number of factors local to Ireland were also significant.

- There was a distinct narrowing in the scope of Ireland's comparative advantage for mobile investment. Rising costs, and the emergence of alternatives in areas such as central and eastern Europe, India and China, made Ireland less competitive for lower value-added mobile investment projects, which had made up a large part of inward investment activity during the 1980s and 1990s.
- Many indigenous companies were caught at a vulnerable point, early in their life-cycle, when the downturn hit. They had made substantial investments, and were employing significant numbers of people, but had not yet had time to develop enough sales to be sustainable. When the downturn hit, they suffered the triple blow of: a smaller crowded marketplace; a more difficult sales environment; and caution in the market about the risks of buying from a small company that might not survive to provide support and an upgrade path.
- The "shift to services" affected the market for software products, where the Irish software industry specialises. While the industry has had considerable success in developing software-as-a-service business models for software products, it has still been affected by the relatively lower growth in markets for software products relative to IT services.
- For much of the 1980s and 1990s, Ireland was a competitive location for relatively weakly differentiated IT services in areas such as bespoke development and systems integration. These services are typically delivered either locally, or at low cost, and Ireland was a credible location for remote low cost development. While many indigenous companies operating in these areas migrated into software products, those that remained found difficulty in competing when the Indian IT services industry emerged.
- There was a particularly steep downturn in telecommunications, which is one of the areas where Ireland has a particular software development specialisation.

3.7 Economic Trends in the Irish Industry

3.7.1 Irish-owned Software[14]

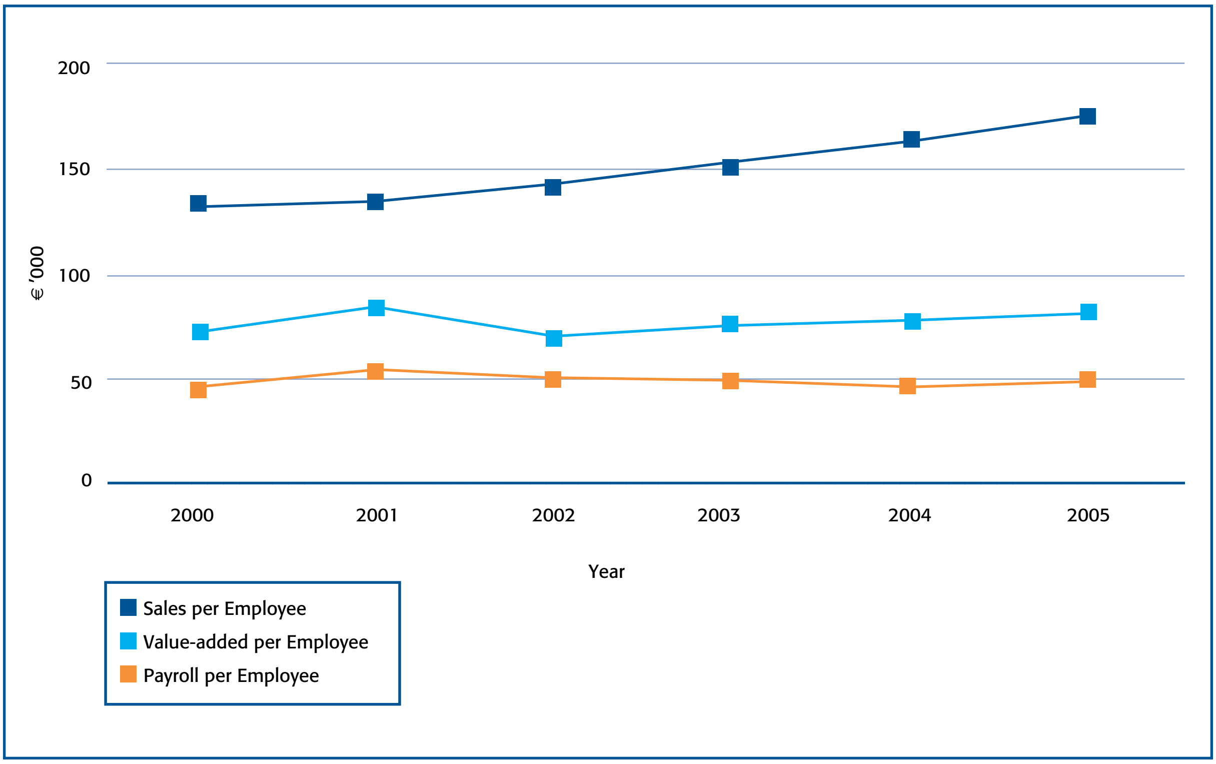
Figure 3.14 shows that real sales per employee from Irish-owned software companies stalled during the downturn, but then grew from 2001 to 2005. The available evidence is that sales have continued to grow in 2006.

Real payroll cost per employee peaked in 2001, and declined slowly to 2004, reflecting weak labour market demand. There was a slight upturn in 2005.

Real value-added per employee, a reasonable measure of productivity, peaked in 2001, and fell in 2002. It recovered gradually through 2005, nearing the level attained in 2001 by that date.

Overall, this indicates a clear recovery in economic performance following the downturn. Interview evidence regarding 2006 and early 2007 indicates stronger growth and increased business confidence. It also indicates that companies, on average, are increasing the numbers they employ, but doing so cautiously, rather than attempting to maximise growth as many did in the late 1990s.

Figure 3.14: Sales, Payroll and Value-added – Irish-owned Software (€'000, Constant 2000 Prices*)



** Deflated to 2000 prices by Consumer Price Index.*

Source: Forfás Annual Business Survey of Economic Impact.

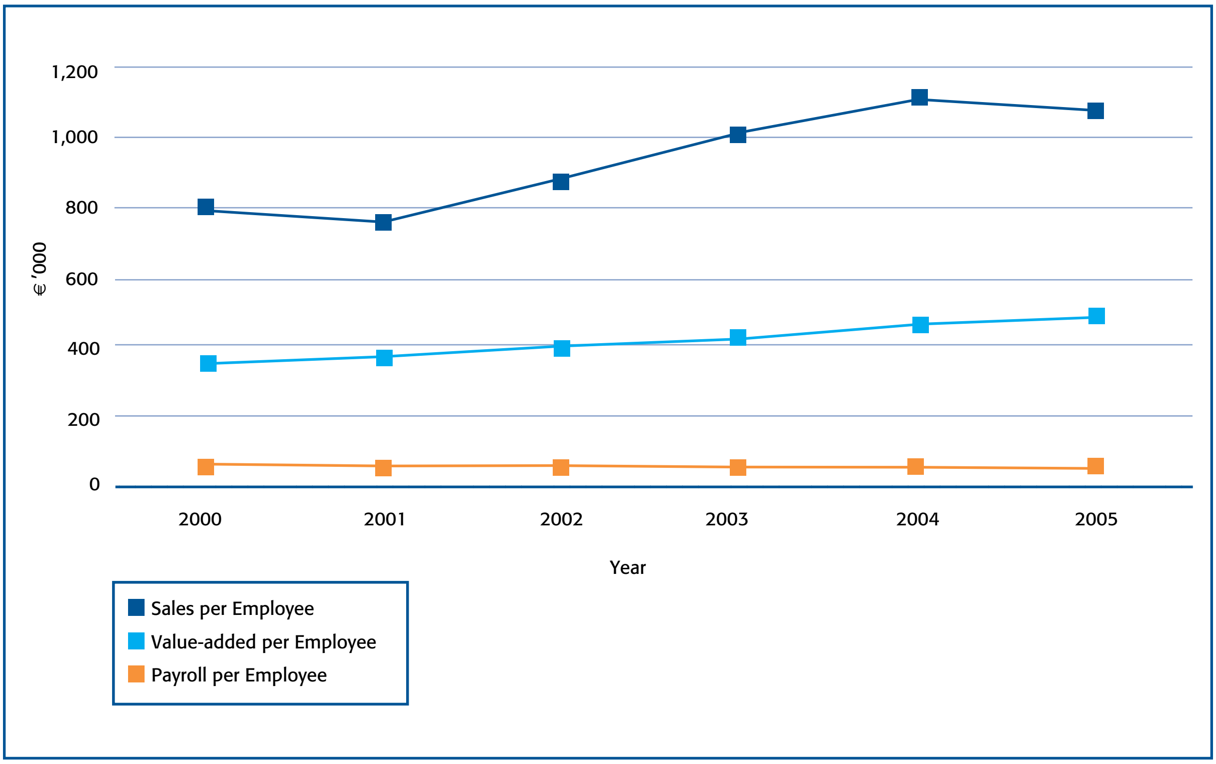
14 "Software" here is similar to, but does not exactly match the definition of the software sector as described elsewhere in this report.

3.7.2 Foreign-owned Software

The key points about the foreign-owned software sector to note from Figure 3.15 are that:

- Productivity, as measured by real value-added per employee, rose steadily through the period, despite the downturn, and despite some sales volatility; and
- Real payroll costs per employee remained near-flat over the period after 2001, reflecting weak labour market demand, and at approximately €50,000 per annum were not much different to costs in the Irish-owned sector.

Figure 3.15: Sales, Payroll and Value-added – Foreign-owned Software (€'000, Constant 2000 Prices*)



** Deflated to 2000 prices by Consumer Price Index.*

Source: Forfás Annual Business Survey of Economic Impact.

3.7.3 Irish-owned Electrical and Electronic Equipment[15]

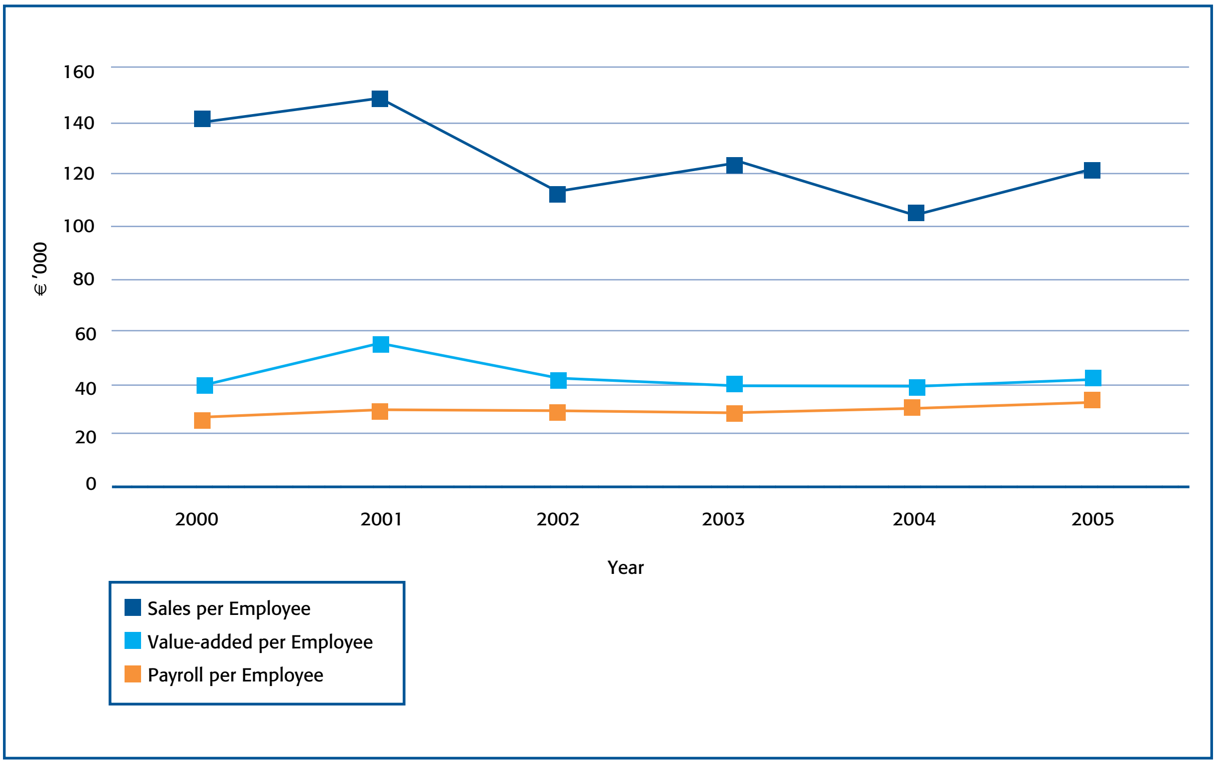
Real sales per employee by the Irish-owned electrical and electronic equipment industry (which is dominated by hardware-related ICT companies) peaked in 2001, and fell overall to 2004. Data for 2005 indicated an upturn.

Productivity, as measured by value-added per employee, peaked in 2001, and then fell. There was a slight upturn in 2005, apparently reflecting a slight recovery in performance after the industry downturn.

Payroll per employee is approximately half that in software, reflecting a relatively small share of all employees having high-level skills.

Overall, the figures reflect a more prolonged downturn in economic performance than that experienced in software, with evidence of a recovery starting in 2005.

Figure 3.16: Sales, Payroll and Value-added – Irish-owned Electrical & Electronic Equipment (€'000, Constant 2000 Prices*)



** Deflated to 2000 prices by Consumer Price Index.*

Source: Forfás Annual Business Survey of Economic Impact.

15 Electrical and electronic equipment encompasses the electronics hardware related sectors discussed elsewhere in this report, and is equivalent to NACE 30 to 32.

3.7.4 Foreign-owned Electrical and Electronic Equipment

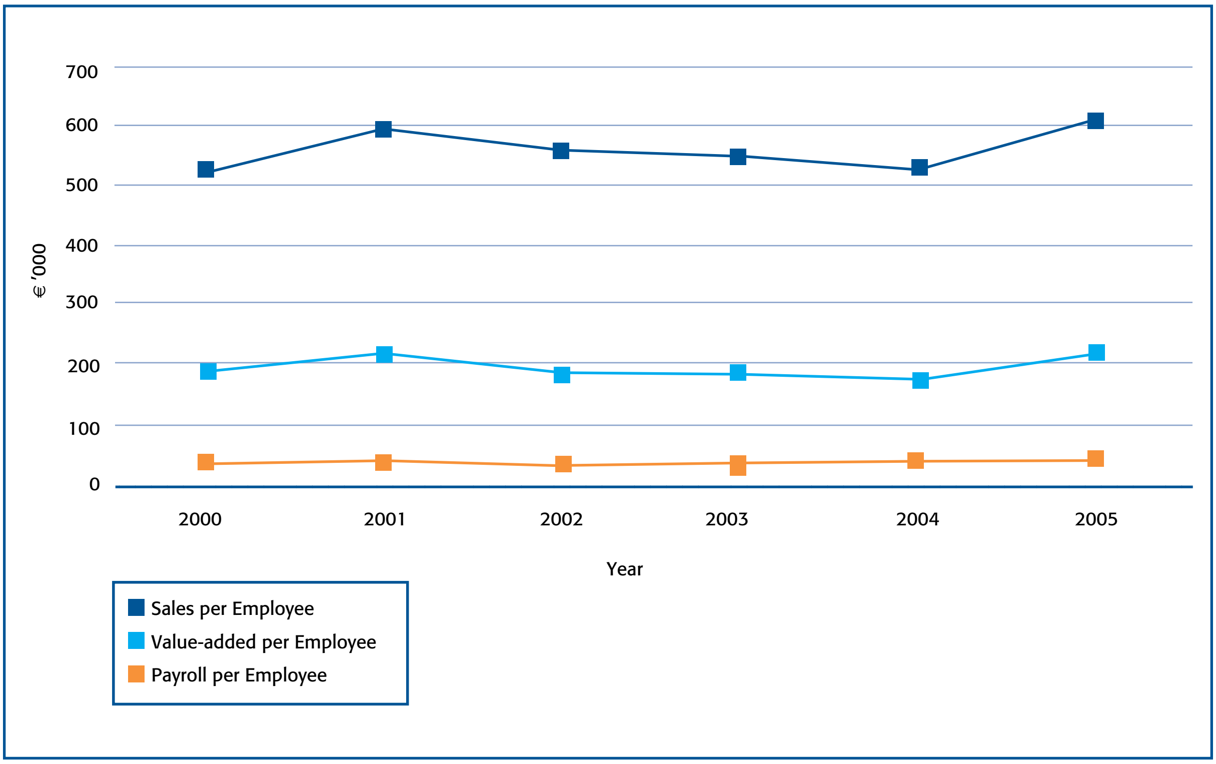
Real sales per employee by the foreign-owned electrical and electronic equipment industry (dominated, to a greater extent than in the Irish-owned sector by hardware-related ICT companies) peaked in 2001, and fell overall to 2004. Data for 2005 shows a sharp upturn.

Productivity, as measured by value-added per employee, peaked in 2001, and then fell. There was a sharp upturn in 2005, apparently reflecting a recovery in performance after the industry downturn. In effect, the loss in productivity sustained between 2001 and 2004 was recovered in 2005. The likelihood is that this reflects a combination of an increase in capacity utilisation, and continuing improvements in underlying operational efficiency.

Payroll per employee is less than that in software, reflecting a smaller share of all employees having high-level skills.

Overall, the figures reflect a more prolonged downturn in economic performance than that experienced in software, with strong evidence of a recovery starting in 2005. This is consistent with the significant subsequent increase in Electronics Hardware employment described earlier that occurred in 2006.

Figure 3.17: Sales, Payroll and Value-added – Foreign-owned Electrical and Electronic Equipment (€'000, Constant 2000 Prices*)



** Deflated to 2000 prices by Consumer Price Index.*

Source: Forfás Annual Business Survey of Economic Impact.

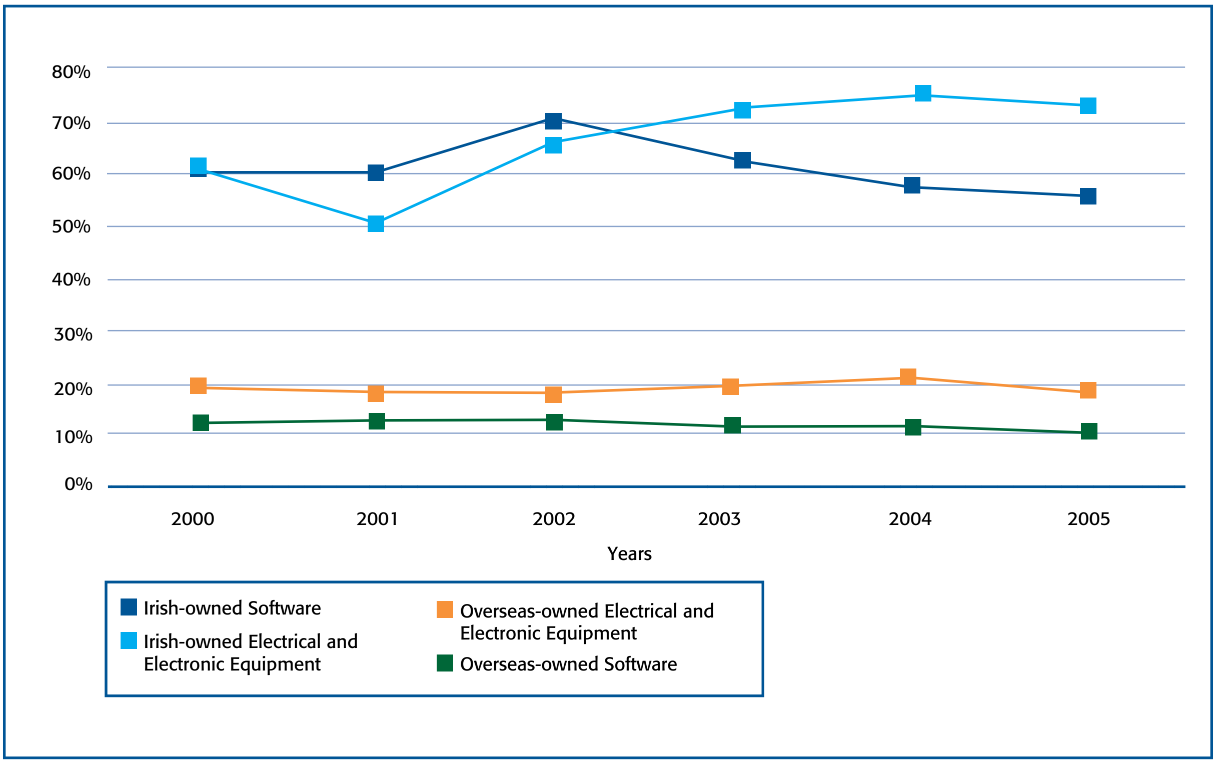
3.7.5 Trends in Profitability

While actual profitability data is not available, trends in payroll expressed as a % of value-added provide a useful proxy. If the share of value-added consumed by payroll is going up, it is likely that profitability is falling. If it is going down, it is likely that profitability is rising.

Figure 3.18 shows:

- Payroll as a % of value-added for Irish-owned software companies rising in 2002 (suggesting worsening profitability), and then falling through 2005 to below the level seen in 2000 (suggesting stronger profitability);
- Payroll as a % of value-added for Irish-owned electrical and electronic equipment companies rising to 2004 (suggesting worsening profitability), and then falling in 2005 (suggesting a marginal improvement in profitability);
- Payroll as a % of value-added for overseas-owned software equipment companies remaining level and then falling in 2005 (suggesting improving profitability); and
- Payroll as a % of value-added for overseas-owned electrical and electronic equipment companies rising to 2004 (suggesting worsening profitability), and then falling in 2005 to around the level seen in 2000 (suggesting a recovery in profitability).

Figure 3.18: Payroll as % of Value-added



Source: Based on data from Forfás Annual Business Survey of Economic Impact.

3.8 Conclusions

This chapter addressed the economic underpinnings of the Irish ICT sector.

It showed that the downturn in employment experienced after 2000/01 reflected a more fundamental change than past cyclical downturns that have affected the ICT sector in Ireland and globally. It traced this to:

- A downturn in the share of all non-residential investment devoted to ICTs in most developed countries; and
- The emergence of low labour cost locations active in the production of ICT products and services.

However, it showed that the economic underpinnings of the Irish ICT sector are now improving after the downturn, with productivity and profitability rising.

Chapter 4: The Market for High-level ICT Skills in Ireland

4.1 Introduction

This chapter addresses the market for high-level ICT skills in Ireland. It describes how most ICT companies in Ireland think of the domestic supply of graduates, upskilling and inward migrants when considering how to address labour supply needs. It describes how the market for ICT skills in Ireland is tightening, despite the rate of growth in employment being modest by comparison with the latter half of the 1990s.

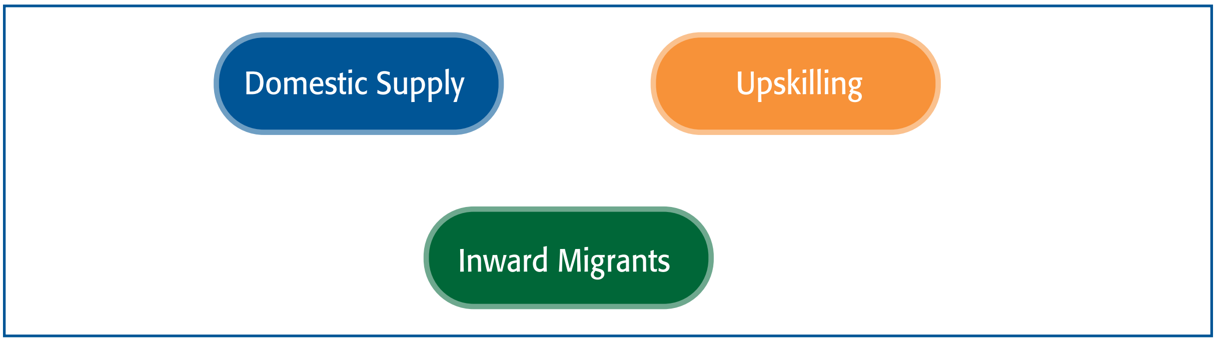
High-level ICT skills account for approximately 40% of employment in the sector.

The chapter describes the high-level skills that ICT companies require, and how these requirements are developing. It considers the extent of active demand for PhD graduates. It looks at the role of high-level ICT staff from overseas in the Irish labour market. It explores trends in pay, the cost of labour, and the importance of productivity and considers how these may affect the sector's future.

4.2 Three Sources of Labour Supply

Company interviews showed that most ICT companies operating in Ireland, both overseas owned and Irish owned, think globally about labour supply. They think of three sources of high-skill labour supply; the domestic supply of graduates from third-level institutions; by upskilling those at work; and through inward migration, as set out in Figure 4.1.

Figure 4.1: Three Sources of High-level ICT Skills



Companies are choosing between these three sources primarily on balance of business advantage, rather than out of any fixed preference.

Inward migrants now form a large part of the labour supply, with many companies consulted saying that they now account for half or more of new recruits into high-level ICT roles. There are some instances where the normal operation of the labour market tends to favour recruiting locally: when operating internships or graduate recruitment programmes; or where, in college towns and cities outside Dublin, the local supply is fairly strong. In other circumstances, however, and particularly when recruiting for roles that require experience, the over-riding focus is on skills.

Business realities, the checks and balances within large companies and the high profile of offshoring in the financial markets and at board level, ensure that companies give active ongoing consideration as to where work should be located globally, and that decisions on this are made primarily on their business merits.

4.3 Increasing Demand for High-level ICT Skills

4.3.1 Software Skills

The interview and statistical evidence is of a tightening of the market for people with high-level software skills, with an increase in the level of migration required for companies to secure an adequate supply of people[16]. The last time the market tightened dramatically was in the latter half of the 1990s, when growth in employment in software and IT services (where the greatest concentration of people with these skills is located) peaked at a level in excess of 25% compound per annum.

The current rate of employment growth is much lower than this. Data presented earlier shows growth in the software sector between 2005 and 2006 of approximately 1.4%. The interview evidence suggests that growth into 2007 will be greater than this. Interviews conducted in the first half of 2007 still indicated caution in recruitment (whether in software or in other ICT sectors), with few companies planning major recruitment initiatives, although there is recent anecdotal evidence of more ambitious recruitment plans.

Thus, in contrast to the late 1990s, the current labour market conditions seems to be driven by something more complex than a rapid rise in employment. The following factors appear to be significant.

- While the current percentage rate of employment growth is not dramatic, it still makes a significant contribution to demand. This is underpinned by the fact that the parts of the ICT sector where the main concentrations of people with high-level ICT skills are located are much bigger than they were in the mid-1990s when serious shortages first emerged. Because of this difference in size, 1% growth in employment in these areas now will create roughly as much as 2% employment growth did then.
- The greater size of the parts of the sector where people with high-level software skills are concentrated also has an impact on replacement demand. In rough terms, if the percentage of people needing to be replaced each year remained constant, then roughly twice as many people would be required to maintain existing employment levels as were required then.
- There is now a much stronger focus on skills quality and relevance than in the past. When much of the sector's development work was concerned with producing relatively undemanding software code, many employers could satisfactorily recruit graduates from a wide range of degree courses, focusing more on their potential than on specialist skills and understanding. Now, the depth of understanding that comes from four or more years of specialist study is required for most roles. In addition, demand for the highest performers (with or without industry experience) has increased sharply, reflecting the much greater value that people with exceptionally strong engineering skills can bring to many roles. These changes have narrowed the population and effective supply from which the ICT sector can recruit and have been taken into account when modelling graduate supply and demand for this study.

16 See section 4.6.

- There has also been a sharp increase in demand for people who have not only strong skills in software, but also a good knowledge of the domain that a company's software products and services are to serve. Many companies have difficulty in recruiting people with these combination skills, needing not just software engineers, but software engineers specialised in banking, or telecommunications, or any of a range of other domains. With a growing requirement for specialised combinations of skills such as these, and few courses designed yet specifically to address them, it is almost inevitable that there would be difficulties.
- As will be seen later, there has been a fall in numbers graduating with Honours Bachelor Degrees in computing, following from the progressive downturn in numbers entering college to study computing that started in 2001.
- Finally, demand for software skills is buoyant throughout Europe, and globally. Irish people with strong software skills can go abroad if they wish, and those from overseas have other options than coming to Ireland.

4.3.2 Electronics Skills

Electronics/IC design companies are the main, concentrated source of demand for electronic engineers. Interviews with a number of these companies indicated, not precisely a shortage, but a sense that the supply of suitable graduates is constraining the share of engineering employment that they can locate in Ireland. As their main work is in design engineering, they tend to look for graduates with an aptitude for technical design, and typically wish to recruit graduates with good honours grades.

Graduate numbers in electronic engineering have fallen, but these companies (while very concerned about the fall) have learned to live with the labour supply consequences. They do this partly by recruiting engineers who have migrated to Ireland, partly, in some cases, even by headhunting key people from overseas, but also through developing bigger offshore operations than they would otherwise require.

4.4 Skills Requirements

4.4.1 Introduction

Companies interviewed were asked how well graduates and other people available in the labour market meet their recruitment needs.

4.4.2 Graduates

Some of the companies interviewed do not recruit regularly at graduate level. Among those that do, there was a division of opinion regarding graduates.

- A majority said that they are generally happy with the graduates they see. Many of these interviewees, unprompted, said that the internships that are part of many courses are invaluable in preparing students for work, and that graduates who have done internships tend to fit in very well. They were keen to endorse internships (also known as co-ops or student placements) as a mechanism to smooth the transition from college into the workplace, and indicated that they very frequently offered jobs to graduates who they had hosted as students.

- However, a number of companies said that they have problems finding enough graduates with the level of engineering skill and creativity they require, and that courses are not yet designed to produce the graduates they need. This view was more common among industry leading companies than among the general population of companies. It arose in relation to both computing and electronic engineering. The issue is more prevalent among companies recruiting electronic engineers, as the available jobs are concentrated particularly in electronics design, which is technically demanding work.

The division of opinion appears, primarily, to reflect differences in skills needs rather than a divergence of view as to the abilities of graduates. The companies saying they have difficulty in finding enough graduates with very strong engineering skills have a high technical skill threshold for recruitment that appears to reflect the nature of the work they do. A number of them talked about "attracting talent".

When asked about what was required to produce the graduates they need, the most common response was that few higher education courses in computing include enough technically challenging project work to produce the sort of graduates they require. Some pointed to well-resourced "strong engineering schools" in North America that attract highly able students and offer a very challenging educational experience for comparison. Some pointed to universities in Central and Eastern Europe that also attract highly able students, and offer a challenging and theoretically rigorous educational experience.

They were clear that these skills should be learned at undergraduate level, supplemented in some cases by taught Masters qualifications, as they see happening elsewhere. They did not see research degrees as substitutes.

A number of interviewees pointed to a reduction in college entry points requirements for computing and electronic engineering, and suggested that the share of students entering college with the potential to be high performers technically had fallen, compounding the decline in student numbers.

Companies of all types were clear that strong programming skills are important in a computing graduate, despite the migration of much routine programming work offshore, and despite the fact that some students who are otherwise capable find it difficult. While skills in other technical areas are becoming more important, they are complementary to programming in the skill sets that companies require, and do not replace it.

Aside from the quality of technical skills, some companies identified areas that they would like to see developed further.

- A significant number of companies indicated that they would like to see more graduates with a mix of skills in computing and business, with a focus on the business domain (e.g. banking) in which the business operates. They were positive about the Business Information Systems degrees programmes run by many institutions, but would like to see graduates with greater depth and narrower focus in their business skills. This requirement is distinct from the requirement for people with very strong engineering skills. While companies would like to have staff with excellent all-round skills, they do not expect individual undergraduate degree programmes to produce people with both very strong engineering skills and these mixes of technical and business skills.

- In electronic engineering, the suggestion that arose repeatedly is that there is a need for a greater focus on RF (Radio Frequency) and Mixed Signal design. More generally, there were some suggestions that courses in electronic engineering should focus more on modern technologies, and somewhat less on underlying principles. (This is a matter of long-standing debate, and contrasts with the praise some other employers had for the theoretical rigour of courses at many universities in Central and Eastern Europe.)

- A number of software companies commented on specific technologies. However, while there were cases where technologies important to a company were not being taught, there was very little sense that companies saw colleges unjustifiably missing out on technologies that they should be covering. A number of companies referred to course changes at undergraduate level, and to new taught courses at master's level, that had benefited them. Some specific areas where companies made comments include the following:
  - Some suggested that there should be a greater emphasis on J2EE, although there was a recognition that colleges have already gone a long way towards integrating Java and J2EE into their courses;
  - A telecommunications software company suggested that there will be a growing need for software engineers with skills in SIP, and that colleges should look at responding to this emerging need; and
  - A web-oriented company mentioned a need for Web 2.0 technologies.
- Some companies noted the need for improved writing skills among graduates, and suggested that colleges should put more emphasis on this area.

4.4.3 Experienced Hires

Almost all of the companies consulted recruit at experienced level, whether software professionals or electronic engineers. The key messages about the market for experienced hires that emerged from interviews are as follows, many of them paralleling similar messages heard about graduate level recruitment.

- There is a particular shortage of experienced people who are very highly skilled technically, to do technically demanding development work.
- Companies need more experienced people with a deep understanding of the business domain in which they operate, as well as strong technical skills. The issue is all the sharper because inward migrants with high-level ICT skills typically do not have the domain knowledge that companies need.

A number of companies (mostly in software) indicated that they see Ireland as a good location in which to recruit and employ experienced talent from all over Europe. Rather than seeing Ireland as a country of Irish-born "young Europeans", they see it as a great place to find talented "young Europeans" from all over Europe.

4.5 PhD Degrees

4.5.1 Transition of PhD Graduates into the Labour Market

Interviews and a review of HEA data on first destinations of graduates show that few companies in the Irish ICT sector have an established pattern of hiring regularly at PhD level. Only in a small minority of cases did companies indicate that they had specifically sought to fill a role with a person qualified to PhD level, and some of these related to chemistry and materials science rather than computing or electronic engineering. Most commonly, when a person with a PhD in computing or electronic engineering was hired the role could instead have been filled by a highly able person qualified to a lower-level.

Many ICT companies employ no PhDs. Some doing relatively advanced development work employ up to around 10% PhD graduates in high-level ICT roles. Among the companies interviewed, however, it appeared that many of these had obtained their degrees through part-time study while remaining in employment, rather than through the full-time programmes that have been the mainstay of developments in PhD education in recent years.

As will be seen later, PhD student numbers in computing and electronic engineering have ramped up rapidly in recent years, and PhD graduate numbers have started (with a time lag) to ramp up as a consequence. So far, it appears that the increase in supply is being absorbed mainly by the Irish higher education system itself, mainly in postdoctoral research roles, and with some emigration to take up positions in higher education overseas. Such mobility is normal in academic careers. It is notable that the propensity of non-Irish PhD graduates to move to academic posts overseas appears to be greater than that for Irish graduates.

This pattern is only possible because of the high rate at which higher education research activity is ramping up. Over time, the higher education research system will release increasingly large numbers of PhD graduates in computing and electronic engineering into the Irish labour market, some of whom will also have undertaken research at postdoctoral level.

One of the major rationales for the State's heavy investment in research is, in the words of An Taoiseach's Foreword to the Strategy for Science, Technology and Innovation (SSTI)[18], "to see a doubling of postgraduate researchers, with significant numbers of these going on to take up employment in the enterprise sector". The rationale is also to develop human capital to attract Foreign Direct Investment and to seed high-level indigenous entrepreneurship and intrapreneurship. There is little doubt but that this will be beneficial to the ICT sector, provided the transition into employment occurs.

We should expect to see some PhD graduates leaving Ireland to pursue careers elsewhere, as new graduates at this level are often relatively mobile. At least in the case of Irish graduates, experience with past generations of technically qualified emigrants suggests that many will return eventually, and others will eventually prove valuable as contacts for Irish businesses, institutions and agencies.

Work needs to be done to ensure PhDs can make the transition from academia to enterprise as outlined in the SSTI, because it is not a foregone conclusion that their transition into the Irish labour market will be smooth, or that even a majority of those exiting higher education research will make the transition.

- Companies are not accustomed to recruiting large numbers at PhD level.
- Many of those entering the labour market may have had intentions of pursuing a career in academic research.
- A substantial proportion of PhD graduates will be non-nationals[17]. These may be particularly disposed to look elsewhere if they cannot quickly find an attractive employment opportunity in Ireland. The pattern of recruiting large numbers of non-Europeans into PhD research has only emerged within the last four years, so there is very little experience on which to base an assessment of how likely they are to remain.

17 *A Science Foundation Ireland analysis of 248 PhD students on 73 funded ICT-related research programmes found 47% to be of international origin of a very wide variety of nationalities (20% EU; 27% non-EU). An IRCSET analysis of research masters and PhD students funded in ICT-related disciplines found 90% to be Irish, 9% from within the EU and 1% to be from outside the EU.*

18 *Strategy for Science, Technology and Innovation 2006-2013, Department of Enterprise, Trade and Employment.*

4.5.2 Disciplinary Focus of ICT Research in Ireland

ICT along with biotechnology, is one of two main areas in which State-funded research in Ireland is focused. The research undertaken under the ICT heading occurs in a range of disciplines, in the physical sciences as well as in computing and electronic engineering. Computing and electronic engineering together accounted for just 18% of all PhD students registered in 2005.

However, relative to computing and electronic engineering, there is very little existing demand for physical scientists in the ICT sector. Where PhD graduates in computing and electronic engineering can fit into, and enhance, existing roles, the demand for PhD level physical scientists is prospective in nature. It depends on the creation of new research operations, and on the creation of new businesses in areas of ICT where the Irish sector now has only a weak presence.

4.6 Inward Migrants with High-level ICT Skills in the Irish Labour Market

Data from the Quarterly National Household Survey[19] show that 15% of those employed as computing professionals in NACE 72 (software and IT services) in Q2 2006 were non-Irish. This had increased to 22% by Q2 2007, a rapid increase, indicating heavy recruitment of non-Irish computing professionals.

The interview evidence is that the share of new recruits who are from overseas has increased sharply since around 2003, which is consistent with the QNHS data. In some companies, it is now well in excess of 50%. It may average something close to 50% in the Dublin region, but less than that in other centres (such as Cork, Galway and Limerick/Shannon) where the local supply of graduates appears to come closer to meeting local demand.

A recurring theme emerging from interviews was that it is difficult to recruit software people with very high-levels of engineering ability, that there are not enough Irish software people with such high-levels of engineering ability, and that companies are bridging this gap by recruiting people who have obtained their qualifications and initial experience overseas.

In the main, they are recruiting people who come to Ireland on their own initiative, or who apply speculatively from their home country. Some also use the personal networks of high performing non-Irish staff to identify and attract highly skilled people with whom they have studied or worked. Except in exceptional circumstances, few recruit actively overseas – not wanting to take responsibility for relocation, and having been discouraged from recruiting outside the EU/EEA by past experience with the operation of immigration controls. However, Ireland has recently introduced new economic migration regulations to help streamline the attraction of key skills.

Most companies interviewed did not have major immediate concerns about their ability to retain inward migrants. Some reported that they had actually found migrants less likely to move than Irish engineers once they had found a company where they felt comfortable and there were reasonable prospects for career progression. Some companies that had employed overseas staff for relatively long periods had found them putting down roots, getting married here and buying houses. Others reported less stability, with some engineers from overseas returning home, or continuing to live in rented accommodation. However, the most common position was that companies had not been recruiting non-Irish engineers in substantial numbers for long enough to be clear on how likely they are to stay.

19 The Quarterly National Household Survey, or QNHS, is undertaken four times a year by the Central Statistics Office.

4.7 Cost and Pay Issues

4.7.1 Introduction

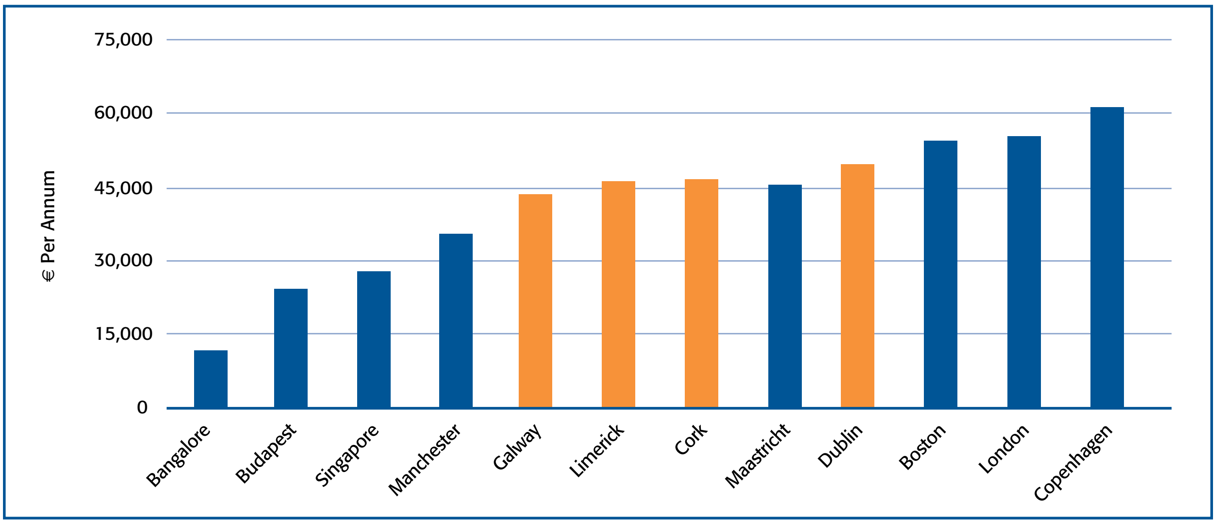
The cost of doing business in Ireland arose as an issue in company interviews. Pay is one of the main costs incurred by ICT companies, and is the principal cost for most in Ireland. As a major component of the cost of doing business in Ireland, the level of pay has a major influence in decisions as to whether work should be undertaken in Ireland or in a competing location.

However, as well as pay and costs impacting on Ireland's attractiveness as a location for companies, it also impacts on Ireland's attractiveness as a destination for inward migration, and also on the attractiveness of careers in high-level ICT occupations to school leavers.

4.7.2 Pay Levels and Trends

There are many surveys showing that, on average, pay for high-level ICT occupations in Ireland is broadly in line with that for competing locations in other developed countries. Figure 4.2 presents a sample from a report commissioned by the National Competitiveness Council.

Figure 4.2: Telecom Software Programmer Wage Cost per Annum, 2005

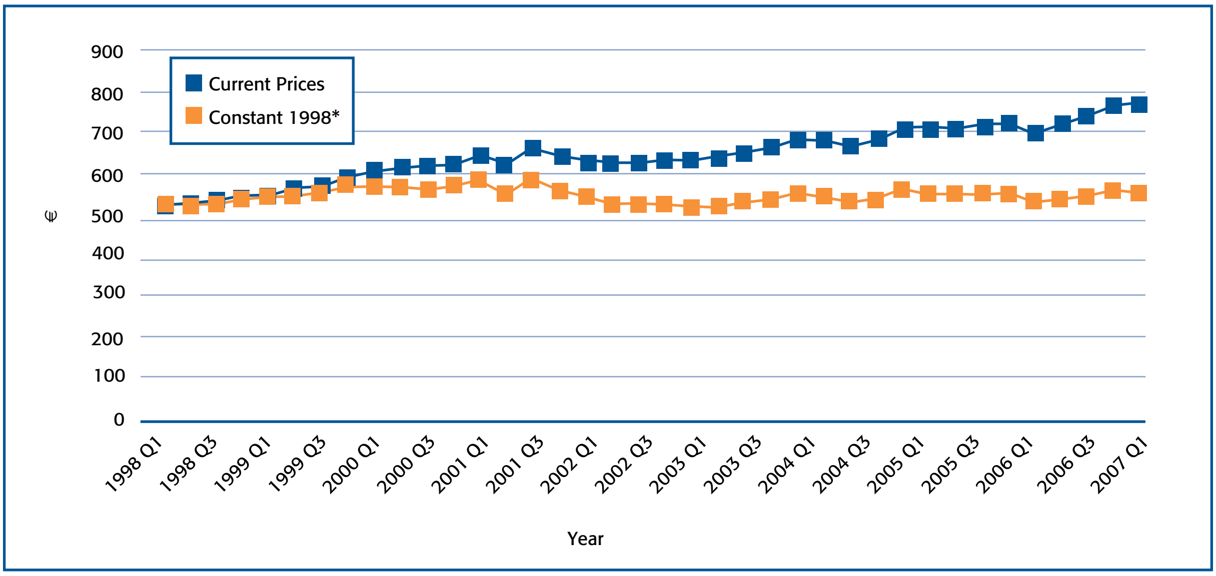


Source: http://www.forfas.ie/ncc/pdfs/ncc_costs_background_report.pdf.

After allowing for inflation, average real pay in software and IT services peaked in 2000/2001. It has not yet returned to the level seen then, as can be seen in Figure 4.3[20]. As more than half of those employed in the sector fit the high-level ICT skills definition used for this study, the direction of the trend is likely to reflect actual developments in pay for people in the sector in roles requiring high-level ICT skills.

However, data since Q1 2006 show some acceleration in the rate of growth in pay.

Figure 4.3: Average Weekly Earnings (€) for Full-time Employees in NACE 72 and 73 (Software & IT Services and R&D)



** Constant 1998 prices deflated by Consumer Price Index.*

Source: Earnings in Distribution & Business Services, CSO, various releases.

The flat trend in real pay in software and IT services seen from 2000 to 2006 is in contrast to most other sectors, where real earnings have risen, in many cases quite sharply.

Figure 4.4 provides data on the percentage by which average pay changed in a range of sectors between Q1 2001 and Q1 2007.

- Reflecting the trends seen in Figure 4.3, average real pay fell in "computing activity/R&D" (NACE 72 and NACE 73).
- Real average pay rose strongly in "manufacture of office machinery & computers" (NACE 30) and in "manufacture of radio, television and communication equipment and apparatus" (NACE 32), which appears to be related more to the loss of large numbers of relatively low paid jobs in these sectors, and increases in high skilled jobs than to substantial increases in pay for jobs in any particular occupational category.

20 NACE 73 (R&D) is much smaller than NACE 72, and is likely in any case to include a significant proportion of software employment.

Figure 4.4: % Increase in Average Pay in Various Sectors Q1 2001 to Q1 2007

Sector	% Change Current Prices	% Change Constant Prices†
Manufacture of Radio, Television and Communication Equipment and Apparatus (Industrial Workers)*	61%	30%
Manufacture of Office Machinery & Computers (Industrial Workers)*	58%	28%
Construction Clerical and Operative	39%	13%
Public Sector (excl. Health)	39%	12%
Banking, Insurance, Building Societies	38%	11%
Manufacturing Industries	35%	9%
Distribution	30%	5%
Business Services	27%	3%
Computing Activity, R&D	19%	-4%

** Refers to industrial workers only, not clerical, administrative or technical workers.*

† Constant 1999 prices deflated by Consumer Price Index.

Source: Various CSO releases.

In contrast, in some sectors where employment has been stable or has grown, there have been increases in average real pay that are not primarily a function of the loss of low paid jobs.

Of particular note are:

- The construction industry, where the major increase in pay, along with clerical and operative staff, has been shared by civil engineers, construction engineers, buildings services engineers and architects – all academic disciplines that compete with computing and electronic engineering for technically-oriented students; and
- The public sector, most parts of which have gained strongly in real pay terms, most likely making public sector employment more attractive relative to employment in the private sector in general, and relative to sectors experiencing lower rates of increase in pay, such as the ICT sector, in particular.

4.7.3 Pay, Costs and Inward Migration

Pay and the cost of living must also be of concern to people with high-level ICT skills considering migrating to Ireland. Companies interviewed indicate that Ireland is an attractive destination, despite a high cost of living, which is reflected in the significant inflow of people with high-level ICT skills that is underway.

International cost surveys position Dublin, the destination for many inward migrants, as a location with a high cost of living. The 2006 Mercer Worldwide Cost-of-Living survey, for example, positioned Dublin as the 18th most expensive city out of 144 for expatriates (although as can be seen from Figure 4.2, Galway, Limerick and Cork are less expensive than Dublin).

The survey does not reflect the cost of buying a home, which may be significant to putting down roots in the city, and remains high by international standards.

The future relationship between pay and the cost of living will be an important factor affecting Ireland's ability to continue to attract inward migrants with high-level ICT skills.

4.7.4 Future of Pay

Given the demand for high-level skills, companies interviewed say that there is now upward pressure on pay. The issue of pay is intrinsically linked to the issue of productivity. Pay improvements that come about through increased productivity ensure that companies remain competitive – higher rates of increase in pay without increased productivity open the prospect of driving more work offshore. The scope for real increases in pay must be accompanied by corresponding improvements in productivity levels. With pay in India reported to be increasing at 15% or 20% per annum (albeit from a much lower base than in Ireland), there is some scope for pay in Ireland to increase without loss of competitiveness, even in the context of India's improving competitive capabilities. The point here is not that Ireland can compete on cost with India on like-for-like capabilities. It is that rising costs in India are likely to affect marginal decisions on the location of operations, possibly moderating cost pressures in areas where Irish operations are more capable than an Indian alternative.

Thus, into the future Ireland will have competing priorities on ICT pay. Too low, and student recruitment into ICT-related disciplines may suffer, compromising the domestic supply of graduates to the industry. Too low, also, and inward migration may suffer. Too high, and competitiveness will be affected.

While key elements of this trade-off particularly improvements in productivity and innovation, will be within the industry's control, much will also depend on pay trends in the rest of the Irish economy, and in the main offshoring locations.

The Department of Finance Pre-Budget Outlook projects slower economic growth over the period 2008 to 2010, with GDP growth averaging 3.5%, with employment growth averaging 1.5% per annum, and with tightening budgetary conditions. This points towards moderation in the rate of growth in pay across the economy, and towards reduced competition from other employment sectors for the services of graduates. This may make it easier for ICT sector employers to compete for graduates, and to offer levels of pay that are attractive in comparison with those offered by other sectors of the economy.

4.8 Conclusions

The chapter described how most ICT companies in Ireland think of the domestic supply of high-level ICT skills, upskilling and inward migration, when considering how to address labour supply needs. It noted that the market for high-level ICT skills in Ireland is tightening, despite the rate of growth in employment being modest by comparison with the latter half of the 1990s. Factors such as the greater size of the parts of the sector that mostly employ high-level skills, reduced graduate output, and more demanding skills requirements are contributing to this.

The chapter describes the skills that ICT companies require, and how these requirements are developing. It identifies a view among companies that there is a particular demand for people with very high-levels of technical skill, and that a need for new graduates with strong engineering skills forms an important part of the picture.

Many also identified a need for more graduates with combinations of technical and business skills.

The chapter identified the possibility that there may be challenges in transitioning increasing numbers of PhD graduates into industry, as the outflow from higher education research ramps up. As outlined in the Strategy for Science, Technology and Innovation, work needs to be done to ensure PhDs can make the transition from academia to enterprise.

The chapter explored trends in pay and the cost of labour, highlighting the fact that real pay in the main sectors employing high-level ICT staff has grown slowly or fallen since 2001, while real pay in many other sectors has increased. Future developments in pay will affect the attractiveness of high-level ICT work in Ireland, and will also affect the ICT sector's future competitiveness. The scope for real increases in pay must be accompanied by corresponding improvements in productivity levels.

Chapter 5: Demand for High-level ICT Skills

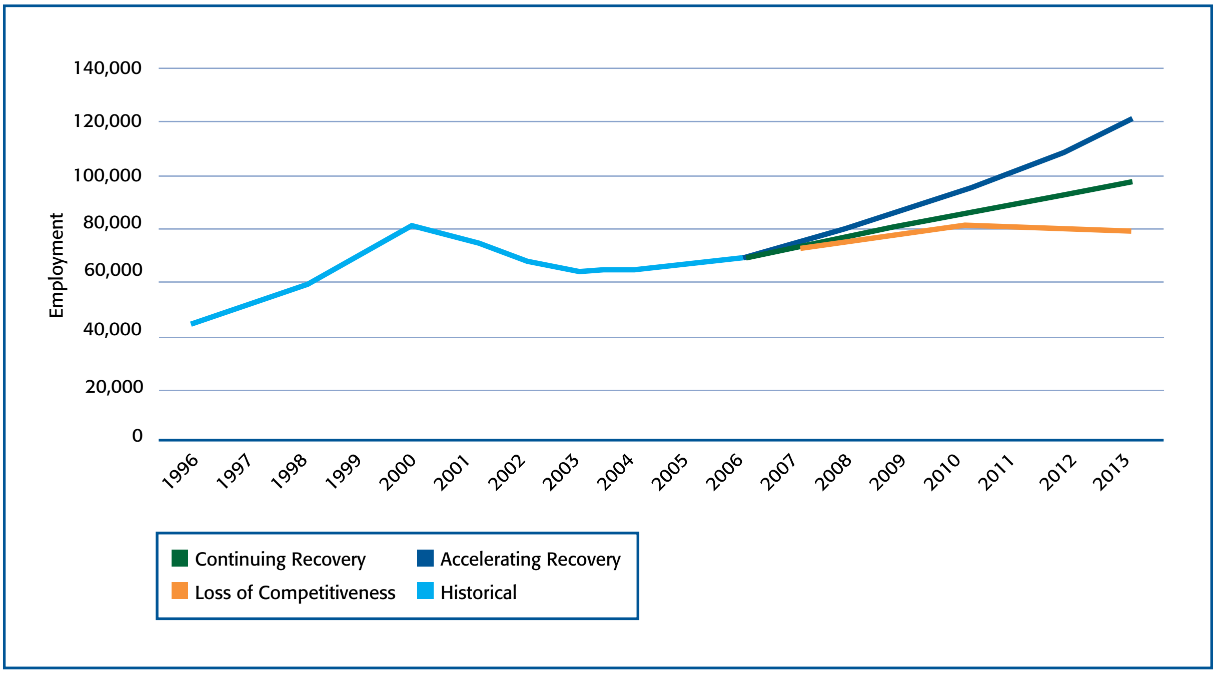
5.1 Introduction

This chapter describes the projections of demand developed for high-level ICT skills, and the model behind them. It starts by presenting a summary of three scenarios for future trends in employment in the sector. It then presents projections of demand for high-level ICT skills in the ICT sector, first for all high-level ICT skills, and then with computing and electronic engineering disaggregated from the total. Based on this, it presents projections of ICT sector demand for researchers, and addresses what this means for demand for PhD graduates.

5.2 Employment Scenarios

Three scenarios for future employment in the ICT sector were developed, taking the 2005 and 2006 subsector employment data presented in Figure 2.2 as the starting point. Figure 5.1 summarises the employment totals for each year under each scenario.

Figure 5.1: ICT Sector Employment Under Three Scenarios Modelled



The base "**Continuing Recovery**" scenario represents a continuation of the growth experienced between 2005 and 2006, adjusted so that:

- The high rate of growth in the Web-based subsector moderates over time;
- While the recovery in electronics hardware employment continues, the rate of increase moderates over time; and
- Employment in Semiconductors remains constant, which is in line with the longer-term trend.

Key values for growth rates in the model include:

- Software employment growing at 2.2% per annum;
- Electronics hardware employment growing at 5.1% per annum, reducing to 2.0% per annum by 2013;
- Web-based employment growing at 35.0% per annum initially, falling to 15.0% per annum;
- Electronics/IC design employment growing at 2.9% per annum;
- Semiconductors employment static; and
- Additional development of new research centres in electronics hardware and semiconductors employing an additional 75 staff each year.

The "**Accelerating Recovery**" scenario represents an increase in the rate of employment growth above that experienced between 2005 and 2006. There is a relatively strong pick-up in employment growth in Software, and Electronics/IC Design, although rates of growth in employment in these sectors are still very modest in comparison with any extended period prior to 2000 (employment growth in software peaked at over 25% per annum between 1995 and 1997).

Growth in employment in the Web-based subsector is assumed to moderate over time, but to a lesser extent than with the base scenario.

Growth in other subsectors is assumed to be slightly stronger than between 2005 and 2006.

Key values for growth rates in the model include:

- Software employment growing at 7.0% per annum;
- Electronics hardware employment growing at 6.0% per annum;
- Web-based employment growing at 35.0% per annum initially, falling to 20.0% per annum;
- Electronics/IC design employment growing at 6.0% per annum;
- Semiconductors employment growing at 2.0% per annum; and
- Additional development of new research centres in electronics hardware and semiconductors employing an additional 100 staff each year.

The "**Loss of Competitiveness**" scenario reflects a gradual slowdown in employment growth, with most subsectors eventually experiencing falling employment.

Key values for growth rates in the model include:

- Software employment initially growing at 2.0% per annum, but falling at 3% per annum by 2013;
- Electronics hardware employment growing at 4.0% per annum, but falling at 1% per annum by 2013;
- Web-based employment growing at 30% per annum initially, but static by 2013;
- Electronics/IC design employment initially growing at 2.0% per annum, but falling at 3% per annum by 2013;
- Semiconductors employment falling at 3% per annum; and
- Additional development of new research centres in electronics hardware and semiconductors employing an additional 40 each year.

All three scenarios assume no major shifts in the current global ICT spending trend over the period to 2013. However, shifts in spending either above or below the current trend are plausible. If the share of investment devoted to ICTs was to rebound in the US and North America (see Chapter 3), this would most likely drive a boom in demand for ICT products and services from Ireland, driving increased employment growth. On the other hand, if it were to fall further, this could trigger difficult market conditions, particularly if it coincided with a wider economic downturn in North America and Europe.

5.3 Demand for High-level ICT Skills under each Scenario

Projections of demand for high-level ICT skills were developed, based on assumptions about the share of employment growth in each subsector that would be accounted for by ICT skills. Assumptions ranged from 70% in subsectors that make very heavy use of high-level ICT skills (Software, IT Services/Systems Integration, Electronics/IC Design, Automation and Process Control) to 3% in subsectors with little or no development work.

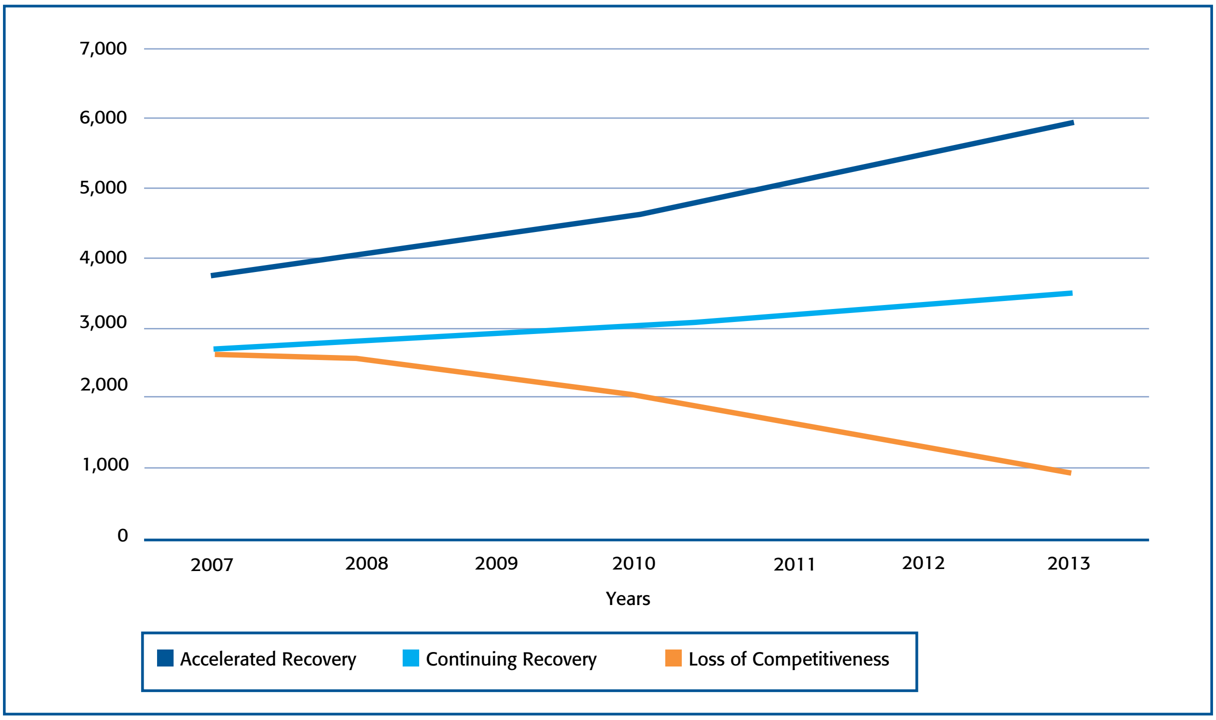
In electronics hardware and semiconductors, it was assumed that high-level ICT skills would account for 8% of staff, other than in the additional new research centres where it would be 80%.

In web-based and in business process outsourcing, it was assumed that 20% of staff would have high-level ICT skills, reflecting the fact that these sectors employ significant numbers of high-level ICT staff, but also employ substantial numbers of staff in areas such as administration, editorial (web), lower-level IT support and lower-level IT administration.

In addition, it was assumed that 5% of high-level ICT staff employed in the sector would have to be replaced each year. In fact, the percentage tends to vary over time, but 5% is fairly neutral.

Figure 5.2 presents the resulting demand projections.

Figure 5.2: Projections of Total Demand for High-level ICT Staff Under Three Scenarios Modelled



5.4 Disaggregation of Demand by Discipline

Overall projections of demand for ICT skills were disaggregated between the following four disciplinary categories:

- Computing (including computing courses with a substantial business or audiovisual/multimedia component to them);
- Electronic engineering (including computer engineering and telecommunications engineering);
- Physical sciences (chemistry, physics, materials science); and
- Other.

The "other" category primarily represents situations where there is scope for people without Level 8 or higher ICT qualifications to take up ICT work. This occurs mainly in software related work. While this was once very common, it has become much less so in recent years. For example, it is assumed that 90% of high-level ICT staff recruited by the software sector should now be qualified in computing, but 60% in IT Services/Systems Integration where recruitment of graduates in other disciplines remains more common.

Figure 5.3 presents the demand projections for people qualified in computing under each scenario.

Figure 5.3: Projections of Total Demand from ICT Sector for High-level ICT Staff in Computing Under Three Scenarios Modelled

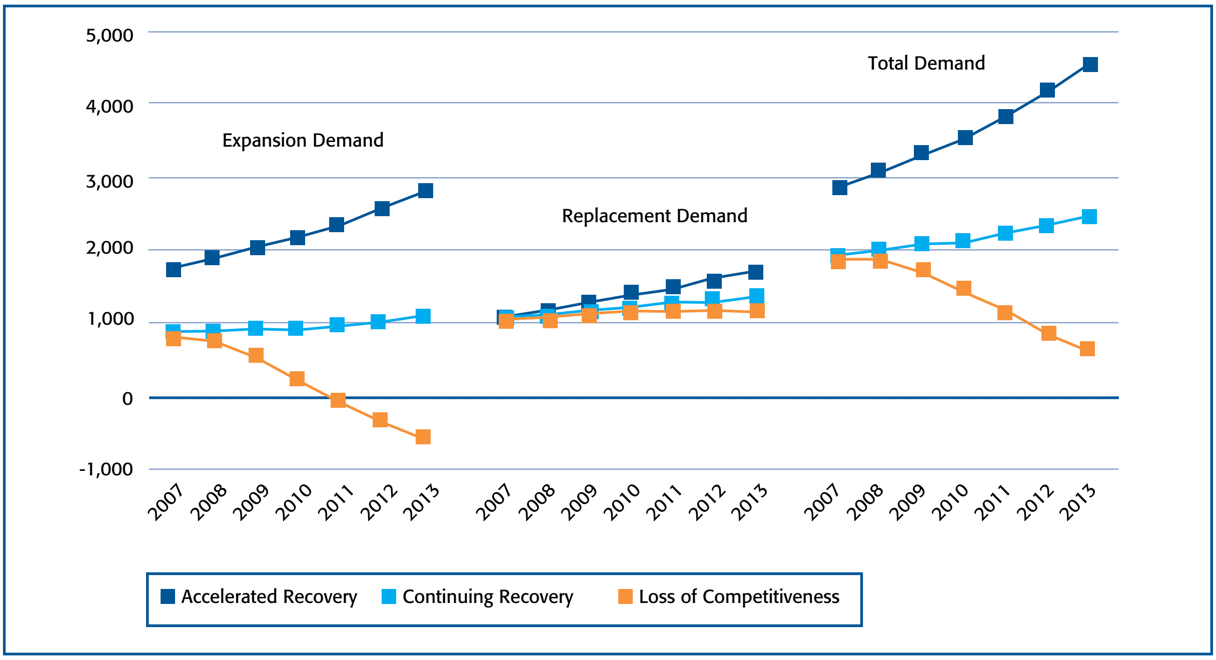
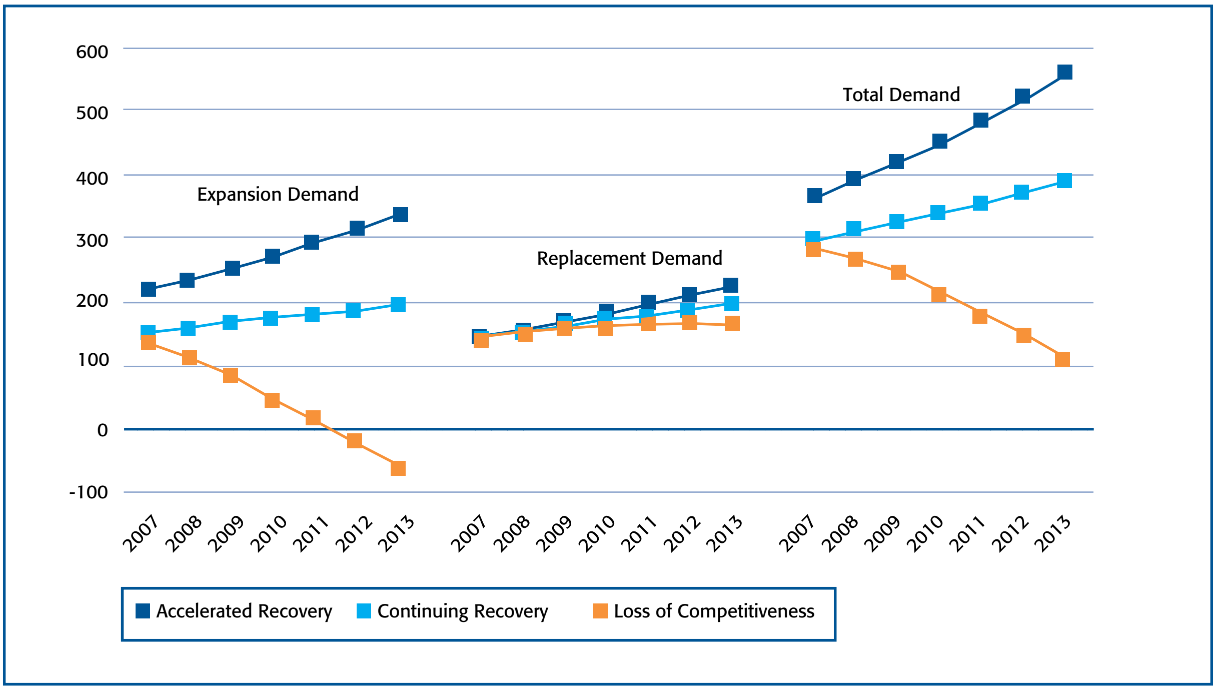


Figure 5.4 presents the demand projections for people qualified in electronic engineering under each scenario. The main component of the demand (accounting for more than half) is from the Electronics/IC Design subsector.

Figure 5.4: Projections of Total Demand from ICT Sector for High-level ICT Staff in Electronic Engineering Under Three Scenarios Modelled



The demand projections for people qualified in physical sciences are low (under 100 per annum in all cases). They are so subject to future industry decisions about investment in research operations that it is not useful to include them here.

5.5 Researcher Level Employment

The Terms of Reference for this study asked that a distinction within "high-level ICT skills" should be made between a lower "advanced" tier of skills and a higher "researcher" tier, concerned with the creation of new intellectual property. In practice, however, it is difficult to draw a clear distinction.

Possession of a research degree qualification is not a reliable guide.

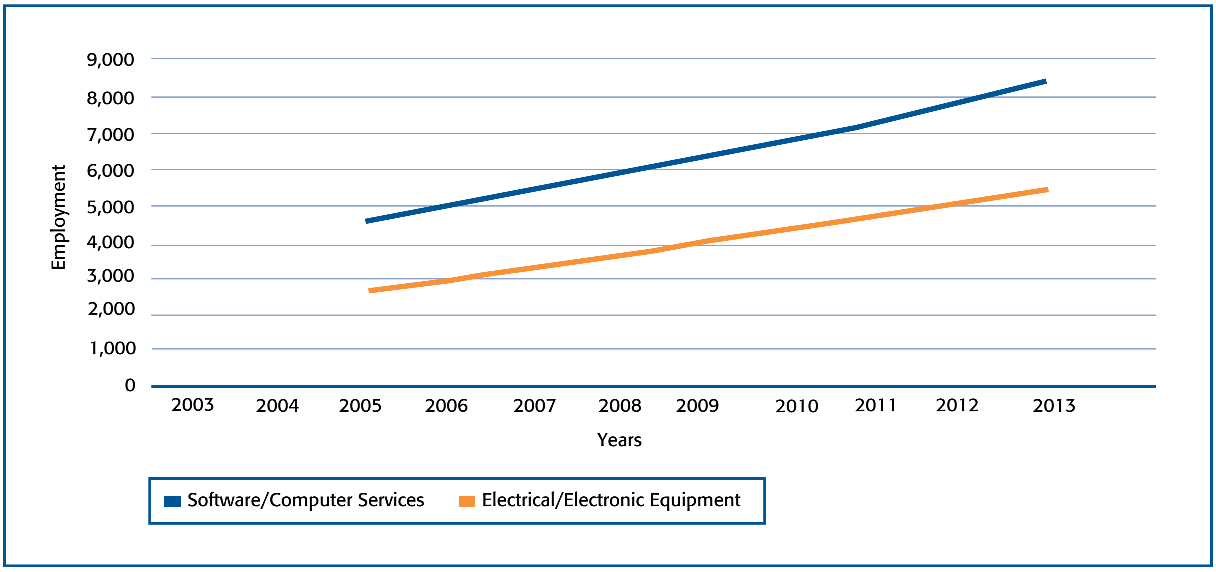
- Based on interview evidence, PhDs are mostly to be found working in groups of people that predominantly hold Honours Bachelor and taught Masters qualifications.
- Across the economy, just 10.8% of researchers held PhDs in 2005[21], and data from 2003 suggests that the share was much lower than this in the ICT sector.

However, the biannual Forfás survey of R&D in the business sector reports that:

- The number of researchers employed in Software/Computer Related Services was 4,537 in 2003 (2.7% with PhD) and 4,586 in 2005; and
- The number of researchers employed in Electrical/Electronic Equipment was 2,263 in 2003 (3.9% with PhD) and 2,624 in 2005.

Figure 5.5 projects these numbers forward under the base scenario. It assumes that the share of employment in Software/Computer Related Services that can be classified as researcher employment rises slowly, reflecting greater sophistication in development work being done in software (it fell between 2003 and 2005). It assumes that the share of employment attributable to researchers in Electrical/Electronic Equipment continues to rise at the same rate as between 2003 and 2005.

Figure 5.5: Projections of Researcher Employment Under Base Scenario



21 *Research & Development Performance in the Business Sector Ireland 2005/6, Forfás, January 2007.*

5.6 Demand for PhDs

In its 2003 report modelling supply and demand of researchers in the context of European Research Area targets, the Expert Group on Future Skill Needs said the following:

> "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."

> "It is … believed 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 above the level at which demand is projected in the model, even over the period to 2010, and more so over the period to 2020."

These observations still hold true. Moreover, a corollary to the second point is that the optimum share of non-researchers made up of PhD graduates is also likely to be significantly above the current share.

In considering future ICT sector demand for PhDs based on the current qualifications profile of the sector, on current recruitment patterns, and on expectations of employment levels in formally designated research centres it is better to reframe the question as one about the number of PhDs that could usefully be employed in:

- Inward research investment;
- Research-related start-ups;
- Investment in research by indigenous companies; and
- Profitably substituting PhDs for non-PhDs.

For PhDs in computing and electronic engineering, providing positive ICT market conditions persist over the period to 2013, the available supply should be the principal constraint on the numbers who can usefully be employed in the ICT sector. Even so, there may be teething problems, as the industry and others adjust to the new availability of significant numbers of PhDs in these disciplines, and as PhD programmes adjust to the need to place significant numbers of graduates in industry.

5.7 Demand for High-level ICT Staff from Other Sectors

Demand for high-level ICT staff from outside the ICT sector was outside the scope of the study. However, as can be seen from Figure 5.6, the ICT sector employs most of those working in the main occupations in which people with high-level ICT skills are employed.

Figure 5.6: % of those Recorded in Relevant Occupational Codes Employed in ICT Sector, Q2, 2005

SOC Code	Description	% in ICT Sector (NACE 30, 31, 32, 72)
126	Computer Systems Managers	51%
213	Electronic Engineers	66%
214	Software Engineers	74%
320	Computer Analyst/Programmers	69%

Source: SLMRU, QNHS.

Figures 5.7 and 5.8 show which industries 2004 Level 8 graduates in computing and electronic engineering entered after graduation. Demand from the ICT sector was relatively weak that year, which resulted in graduates going to a wide range of sectors. Just 46% of mainstream computing graduates and 45% of mainstream electronic/electrical engineering graduates entering employment went to the main ICT-producing sectoral categories listed in these Figures[22]. In times of stronger ICT sector demand, the sector usually attracts a much greater share of computing and electronic engineering graduates.

Figure 5.7: Destinations of 2004 Honours Bachelor Degree Graduates in Computing Entering Employment

Computer Applications/Computer Science/Software Engineering		Business Information Systems	
Agriculture, forestry and fishing	1.0%	Agriculture, forestry and fishing	6.0%
Food and Drink industries	1.2%	Food and Drink industries	2.4%
Pharmaceuticals, perfumery and toilet preparations	2.1%	Pharmaceuticals, perfumery and toilet preparations	0.6%
Other chemical products (incl. fertilisers, rubber and plastics)	0.4%	Other chemical products (incl. fertilisers, rubber and plastics)	0.6%
Metals, Metal Products, Mechanical and Electrical engineering (incl. appliances)	1.2%	Metals, Metal Products, Mechanical and Electrical engineering (incl. appliances)	1.2%
Computer and electronic equipment, office machinery, instrument engineering (incl. healthcare equipment)	8.1%	Computer and electronic equipment, office machinery, instrument engineering (incl. healthcare equipment)	1.8%
Other Industries (incl. mining etc.)	1.4%	Electricity, gas and water supply	0.6%
Electricity, gas and water supply	1.6%	Other (private) building and construction	1.2%
Other (private) building and construction	1.9%	Food retailing etc	0.6%
Wholesale distribution	0.2%	Other Retailing (excl. bars etc.)	3.6%
Food retailing etc	1.0%	Banking, Finance and Insurance	23.8%
Other Retailing (excl. bars etc.)	3.9%	Accountancy and Legal Services	6.5%

22 Computer and electronic equipment, office machinery, instrument engineering (incl. healthcare equipment), Metals, Metal Products, Mechanical and Electrical engineering (incl. Appliances), Computing and Software Applications, and Other Business services (incl. Management and IT Consulting).

Computer Applications/Computer Science/Software Engineering		Business Information Systems	
Banking, Finance and Insurance	11.8%	Consultant engineering and architectural services	0.6%
Accountancy and Legal Services	2.9%	Call Centres and Shared Services facilities	0.6%
Consultant engineering and architectural services	0.2%	Other Business services (incl. Management and IT Consulting)	16.1%
Call Centres and Shared Services facilities	0.4%	Computing and Software Applications	23.8%
Other Business services (incl. Management and IT Consulting)	14.0%	Transport, storage and support services	0.6%
Computing and Software Applications	23.1%	Telecommunications, postal services	1.8%
Transport, storage and support services	1.0%	Civil Service, Local Authorities (other than Building and Construction)	3.0%
Telecommunications, postal services	7.2%	Other education (incl. language schools)	0.6%
Defence Forces, Gardai	0.6%	Health Services (both Health Board and other)	0.6%
Civil Service, Local Authorities (other than Building and Construction)	2.3%	Social and charitable services	0.6%
Primary education	0.2%	Professional services (not elsewhere classified)	1.8%
Secondary education	0.6%	Hotels and guesthouses, bars, restaurants etc.	0.6%
Third-level education	3.5%	Other industries or industry not stated	0.6%
Other education (incl. language schools)	0.4%		
Health Services (both Health Board and other)	1.2%		
Research, Planning, Art Galleries etc.	0.2%		
Professional services (not elsewhere classified)	1.9%		
Hotels and guesthouses, bars, restaurants etc.	1.6%		
Other personal services (incl. recreational activities)	0.6%		
Other industries or industry not stated	2.7%		

Source: Comparative Starting Salaries and Career Progression of Graduates in Science, Engineering and Technology (SET), Forfás, 2006.

Figure 5.8: Destinations of 2004 Honours Bachelor Degree Graduates in Electronic Engineering Entering Employment

Electronic & Electrical Engineering		Computer Engineering and Telecommunications Engineering	
Agriculture, forestry and fishing	1.0%	Agriculture, forestry and fishing	1.8%
Food and Drink industries	0.5%	Metals, Metal Products, Mechanical and Electrical engineering (incl. Appliances)	1.8%
Pharmaceuticals, perfumery and toilet preparations	4.0%	Computer and electronic equipment, office machinery, instrument engineering (incl healthcare equipment)	12.5%
Metals, Metal Products, Mechanical and Electrical engineering (incl. Appliances)	8.4%	Other Industries (incl. mining etc.)	3.6%
Computer and electronic equipment, office machinery, instrument engineering (incl healthcare equipment)	17.3%	Other (private) building and construction	1.8%
Other Industries (incl. mining etc.)	3.0%	Banking, Finance and Insurance	3.6%
Electricity, gas and water supply	4.5%	Accountancy and Legal Services	3.6%
Other (private) building and construction	5.0%	Other Business services (incl. Management and IT Consulting)	5.4%
Food retailing etc	0.5%	Computing and Software Applications	26.8%
Other Retailing (excl. bars etc.)	2.0%	Transport, storage and support services	3.6%
Banking, Finance and Insurance	1.0%	Telecommunications, postal services	14.3%
Accountancy and Legal Services	1.5%	Defence Forces, Gardai	3.6%
Consultant engineering and architectural services	8.4%	Civil Service, Local Authorities (other than Building and Construction)	1.8%
Other Business services (incl. Management and IT Consulting)	6.4%	Third-level education	5.4%
Computing and Software Applications	12.9%	Other education (incl. language schools)	1.8%
Transport, storage and support services	1.0%	Professional services (not elsewhere classified)	3.6%
Telecommunications, postal services	11.4%	Other personal services (incl. recreational activities)	1.8%
Civil Service, Local Authorities (other than Building and Construction)	0.5%	Other industries or industry not stated	3.6%
Third-level education	2.0%		
Health Services (both Health Board and other)	2.0%		
Professional services (not elsewhere classified)	2.0%		
Hotels and guesthouses, bars, restaurants etc.	0.5%		
Other personal services (incl. recreational activities)	1.5%		
Other industries or industry not stated	3.0%		

Source: Comparative Starting Salaries and Career Progression of Graduates in Science, Engineering and Technology (SET), Forfás, 2006.

5.8 Conclusions

The chapter has presented three scenarios for ICT sector demand for high-level ICT skills over the period to 2013.

- The base "continuing recovery" scenario is based on a continuation of the employment growth experienced between 2005 and 2006, adjusted so that the growth rate in web-based operations falls over time, growth in electronic hardware moderates, and employment in semiconductors remains constant.
- The relatively optimistic "accelerating recovery scenario" assumes a higher rate of growth, but still a rate that falls far short of that experienced in the latter half of the 1990s.
- The "loss of competitiveness" scenario assumes that growth rates fall, and (for most subsectors) turn negative by 2013, due to a loss of competitiveness.

All three scenarios are based on moderate growth in global ICT markets, and do not factor in economic cycles. Thus, actual demand could be above or below that set out in the three scenarios.

The chapter disaggregated demand for high-level ICT skills, separating out demand for skills in computing and skills in electronic engineering. Computing accounts for the majority of the demand.

The chapter has observed that the sector recruits relatively few PhD graduates, and concluded that the available supply should be the principal constraint provided that any teething problems in adjusting to the available supply of PhD graduates can be resolved.

Chapter 6: Supply of ICT Skills

6.1 Introduction

This chapter starts by presenting projections of Honours Bachelor Degree numbers in computing and electronic engineering up to 2010. It then presents data on the recent trends in college entry numbers that underpin the later years of the projections, and also reviews trends in the qualifications of entrants into Honours Bachelor Degree courses in computing and electronic engineering.

Next, it reviews trends in PhD graduate numbers in computing and electronic engineering. It also presents data on graduate numbers at other levels of qualification.

It reviews factors limiting demand for places on courses in computing and electronic engineering among students, and looks at what measures could be taken to boost interest.

6.2 Projections of Honours Bachelor Degree Numbers

The key indigenous source of supply of high-level ICT skills is that of Honours Bachelor Degree graduates in computing and electronic engineering. Most Irish people qualifying with higher qualifications in these disciplines already hold an Honours Bachelor Degree, and so do not form a new part of the supply.

Figure 6.1 provides statistics on past graduate numbers from 2002 to 2004, estimates of the numbers who graduated in 2005 and 2006, and projections of numbers likely to graduate from 2007 to 2010. The estimates and projections are based on the available historical data on numbers of students enrolled for the period up to 2008, and on historical CAO acceptances data for estimating 2009 and 2010 (see Section 6.3). They take account of progression from Higher Certificate and Ordinary Bachelor Degree courses.

While Level 8 college acceptances numbers provided elsewhere in this report are for students accepting places on Level 8 courses specifically in computing and electronic engineering through the CAO system, other significant streams of students also contribute to actual graduate numbers. In electronic engineering (and to a much lesser extent in computing), many students initially enter through common entry mechanisms, under which they are initially admitted to study engineering or science, and only specialise later, so they are not recorded as electronic engineering (or computing) students at college entry. Also, in both electronic engineering and computing, substantial numbers of students are initially admitted to college to study at Level 6 or Level 7, but ultimately leave college with a Level 8 qualification after taking an add-on Honours Bachelor Degree or transferring into an Honours Bachelor Degree programme. The projections of graduate numbers take account of all these student streams.

There was a steep ramp-up in admissions into courses in computing (and to a much lesser extent electronic engineering) during the latter half of the 1990s, culminating in 1998 and 1999. As Honours Bachelor Degree courses are of four years duration, graduate numbers peaked in 2002 and 2003.

A sharp fall in graduate numbers in computing commenced in 2005, reflecting a loss of confidence in opportunities in the ICT sector that took hold among college entrants in 2001.

It is projected that graduate numbers in computing will bottom out in 2008, and undergo a modest recovery in 2009 and 2010, driven mainly by increased interest among college entrants in courses combining computing and business, and by the success of new courses in computer games development etc.

The pattern for electronic engineering is broadly similar to that for computing. However, the downturn in numbers started a little earlier, and it is projected (based on CAO acceptances for 2006) that the modest recovery in graduate numbers expected in 2009 will be reversed in 2010. The projections for electronic engineering assume that the share of students entering common entry engineering courses choosing electronic engineering remains constant, so it is possible that any loss of interest in other branches of engineering could result in higher numbers of electronic engineering graduates.

Figure 6.1: Numbers of Honours Bachelor Degree Awarded, and Projected to be Awarded, 2002 to 2010

Computing	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Core Computing	1,892	1,773	1,597	1,121	769	654	616	594	584
BIS and other combinations of Business & Computing	253	299	345	418	378	387	351	379	456
Multimedia, Computer Games etc. with substantial Computing Content	0	28	47	48	66	86	66	144	195
Total Computing	**2,145**	**2,100**	**1,989**	**1,587**	**1,212**	**1,127**	**1,033**	**1,117**	**1,236**
Electronic Engineering	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**
Accredited Electronic/ Computer/ Communications Engineering	594	531	354	331	323	322	299	371	294
Other Electronic/ Computer/ Communications Engineering	279	273	220	200	133	76	104	94	94
Total Electronic Engineering	**873**	**804**	**574**	**531**	**456**	**398**	**403**	**466**	**389**

Source: Analysis and modelling by Publica Consulting and McIver Consulting, based on data extracted by the Skills and Labour Market Research Unit of FÁS, and on microdata provided by CAO.

In addition to Honours Bachelor Degree programmes, postgraduate conversion courses leading to higher diplomas and graduate diplomas in computing make a contribution to the supply of high-level ICT skills. These courses are mostly of one year in duration, and targeted on Honours Bachelor Degree graduates from other disciplines.

Generally, graduates from these courses do not have the depth of technical knowledge associated with an Honours Bachelor Degree in computing, but the combination of technical knowledge and knowledge from the prior qualification can be valuable in high-level ICT roles requiring a mix of business and technical skills. However, while numbers graduating from these courses exceeded 1,000 at peak, by 2004 graduate numbers had fallen to 168.

6.3 Recent Trends in Acceptances of Places in Computing and Electronic Engineering

6.3.1 Numbers of Acceptances

Figure 6.2 sets out recent trends in numbers accepting places in higher education in computing and closely related disciplines, whether Higher Certificate (Level 6), Ordinary Bachelor Degree (Level 7) or Honours Bachelor Degree (Level 8). At Levels 6 and 7 it distinguishes between the core computing courses from which many students progress to eventually graduate with mainstream Honours Bachelor Degrees in computing, and a combination of office information systems and IT support courses which are targeted more on IT operations than on development. Courses at Levels 6 and 7 are relevant to this study mainly to the extent that they feed Level 8 courses. They are not directly a major source of high-level ICT skills within the meaning defined by this study.

At Level 8, the Figure distinguishes between: core computing; combinations of computing and business, including business information systems; and combinations of computing and audiovisual media including multimedia and computer games development.

Figure 6.2: Acceptances of Places on Courses in Computing and Related Disciplines, 2004 to 2006

		Numbers of Acceptances		
Level		**2004**	**2005**	**2006**
6	Core Computing	665	500	387
6	Office Information Systems & IT Support	502	448	377
7	Core Computing	409	346	543
7	Office Information Systems & IT Support	54	107	181
8	Core Computing	733	739	668
8	Business Information Systems and Other Combinations of Computing & Business	279	290	356
8	Multimedia, Computer Games Development etc. with Substantial Computing Content	121	202	275

Source: Based on analysis of anonymised microdata provided by CAO.

Key points of interest are as follows.

- There has been a shift away from entry at Higher Certificate level, which has been compensated by an increase at Ordinary Bachelor Degree level. This is unlikely to lead to major changes in manpower supply, as graduates from Higher Certificate programmes most frequently continue their studies to Ordinary Bachelor Degree level, while students taking an Ordinary Bachelor Degree have the option of leaving with a Higher Certificate after two years.

- While there has been a net increase in numbers entering ab-initio Honours Bachelor Degree courses, this has arisen from increased numbers in courses combining computing with business and computing with audiovisual media, whereas there has actually been a moderate decline in numbers entering core computing courses. The increase in numbers entering courses combining computing with audiovisual media arises from new courses in computer games development.

Figure 6.3 sets out recent trends in numbers accepting places in higher education in electronic engineering and closely related disciplines. It groups electronic, computer and telecommunications engineering.

It also provides information on two disciplines that share a good deal of the content of electronic engineering – mechatronic engineering and electrical engineering. This information is provided for context; graduates in these disciplines are not counted as a part of the supply.

At Level 8, it distinguishes between engineering courses that are IEI (Engineers Ireland)-accredited and those not accredited. It is useful to make this distinction partly because non-accredited courses in electronics have a history of accepting less well qualified applicants than accredited courses (in terms of college entry points, and in terms of a minimum requirement for a C3 in Higher-level Leaving Certificate mathematics or equivalent for accredited courses). IEI-accredited courses account for the vast majority of college acceptances.

In addition to the courses included in the analysis behind Figure 6.3, there is also a significant flow of students into electronic engineering from common entry engineering courses, where students decide between branches of engineering only after the first or second year of study[23].

Figure 6.3: Acceptances of Places on Courses in Electronic Engineering and Related Disciplines, 2004 to 2006

		Numbers of Acceptances		
Level		**2004**	**2005**	**2006**
6	Electronic/Computer/Communications Engineering	399	417	267
6	Mechatronic or Electrical Engineering	123	90	70
7	Electronic/Computer/Communications Engineering	140	162	262
7	Mechatronic or Electrical Engineering	114	218	207
8	Electronic/Computer/Communications Engineering (IEI Accredited)	175	202	160
8	Electronic/Computer/Communications Engineering (Other)	17	23	28
8	Mechatronic or Electrical Engineering	16	25	16

Source: Based on analysis of anonymised microdata provided by CAO.

23 *In some common entry courses, choices are limited to electronic, computer and telecommunications engineering. These courses are included in the analysis behind Figure 6.3.*

6.3.2 Qualifications of Students Accepting Places at Level 8

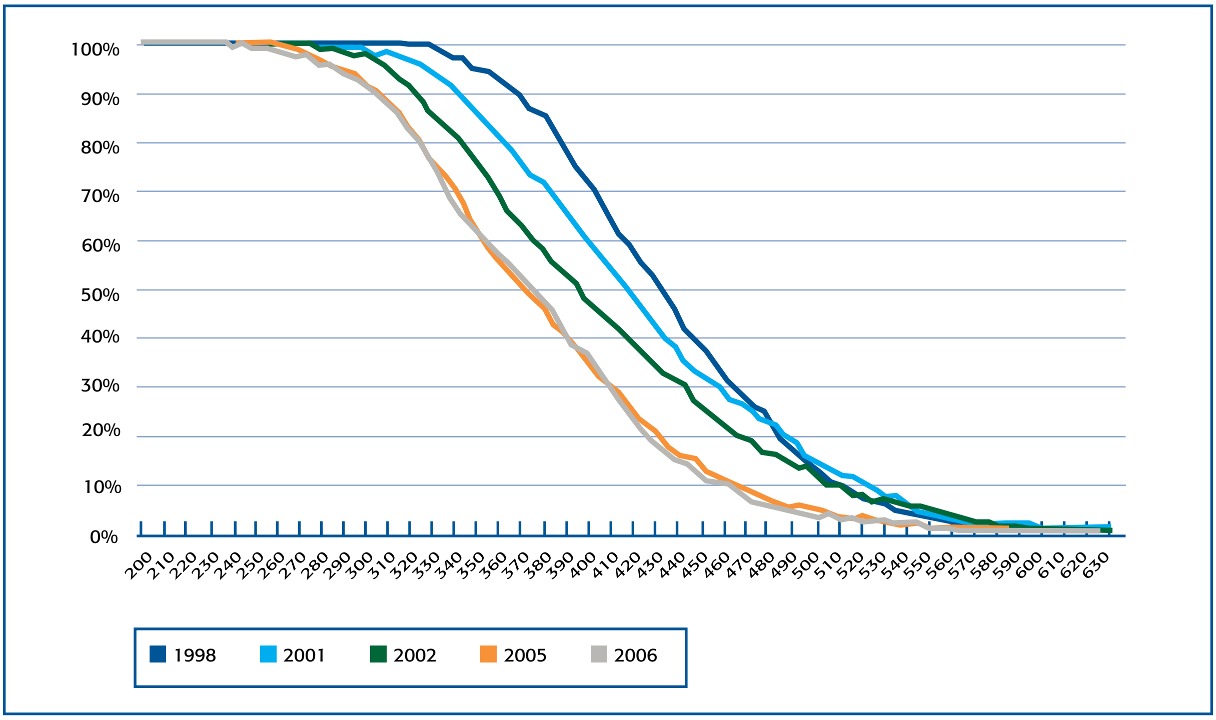
In both computing and electronic engineering, there has been a significant negative shift in the qualifications of students accepting places on Honours Bachelor Degree courses since 1998, as measured by college entry points.

While trends in minimum points requirements for courses attract considerable attention each year, it is more useful for an analysis relating to skills to review the actual points obtained by students accepting places. The minimum points requirement for a course gives very incomplete information about the points actually obtained by those taking up places.

Figure 6.4 documents how the distribution of points among those accepting places on computing courses changed between 1998 and 2006, with median points falling from 435 to 375, and with the percentage obtaining 450 points or higher falling from 39% to 12%. Some colleges say that a sharp fall in applications from bright female students has had a particularly severe impact on the distribution of college entry points among the students to whom they offer places.

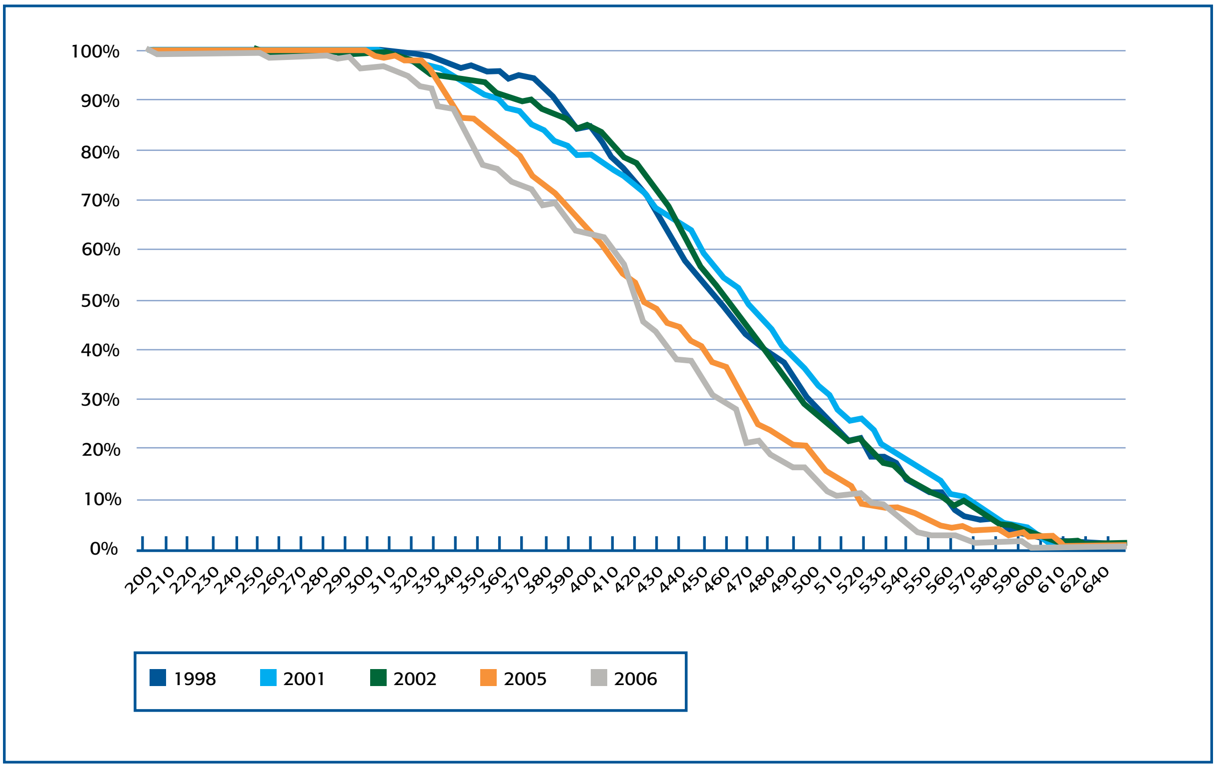
Figure 6.5 documents a similar, but lesser, shift for electronic engineering, with the median falling from 450 to 410, and the percentage obtaining 450 points or higher falling from 50% to 30%. The lesser shift is probably related to the requirement for a minimum of a C3 in Higher-level Leaving Certificate mathematics for entry into most Honours Bachelor Degree courses in engineering.

Figure 6.4: Points Distributions for Those Accepting Places on Honours Bachelor Degree Courses in Computing



Source: Based on microdata provided by CAO.

Figure 6.5: Points Distributions for Those Accepting Places on Honours Bachelor Degree Courses in Electronic Engineering



Includes Communications Engineering and Computer Engineering.

Source: Based on microdata provided by CAO.

These data do not cover the full picture on trends in the qualifications of entrants, however. They do not cover entry into common entry courses, or into courses in computing and electronic engineering at Levels 6 and 7 that lead to students eventually graduating at Level 8 with add-on qualifications. They also do not cover entry through mechanisms other than college entry points, in areas such as mature entry, disabled entry, mechanisms for progression from FETAC awards and mechanisms for progression from access courses. The share of students admitted through these routes has increased over time.

Despite the worsened points distribution, however, there are positives.

- Many colleges say that places are now mostly taken up by people who have a genuine interest in the discipline they have chosen, which improves their suitability.
- Colleges are placing a greater emphasis on effective teaching and mentoring, making major efforts to get the best out of their students, and to overcome any learning difficulties that arise.
- The worsening trend in points distributions seems to have bottomed out, which provides a basis for an improvement. There is little difference between 2005 and 2006.

Even so there are issues.

- Some colleges have significant retention problems among less well qualified entrants.
- The relatively small share of students in computing and electronic engineering who are very well qualified (in CAO points terms) on entry into their courses may have downstream implications for the supply of the high performing graduates that the ICT industry increasingly needs to differentiate itself. It is likely that this is one of the main root reasons why some companies consulted identified a particular shortage of highly technically able graduates.
- The relatively small share of students in computing and electronic engineering who are very well qualified on entry into their courses may have downstream implications for the supply of the very bright graduates needed if PhD places are to be filled with Irish graduates.

6.4 Trends in PhD Numbers in Computing and Electronic Engineering

HEA data for academic year 2004/05 shows 49 PhD graduates in computer science and 23 in electronics and automation, based on data for six universities for computer science and four universities for electronic engineering respectively. Making allowance for the other universities and also the Institutes of Technology, it is estimated that the total across all higher education institutions was approximately 60 PhD graduates in computer science and 35 in electronics and automation.

Evidence from interviews, and data collected from academic institutions, make it clear that PhD student numbers have been increasing rapidly, and will continue to increase at least over the next two to three years. This is driving a rapid increase in graduate numbers, which will take a number of years to work through, as the typical duration of full-time PhD studies is in the region of four years. Based on an analysis of historical HEA data, and on a number of data points obtained directly from colleges, existing trends are likely, by 2010, to drive PhD graduate numbers in both computing and electronic engineering to a level somewhat more than twice the 60 and 35 respectively seen in 2004/05.

6.5 Trends in Graduate Numbers in Computing & Electronic Engineering

Honours Bachelor Degree (at Level 8), Higher/Graduate Diploma (Level 8/9) and PhD (at Level 10) are the key qualifications for analyses of the supply of high-level ICT skills. Those entering the labour market with qualifications below these levels typically enter support and operations roles, or roles in user organisations, rather than development roles in the ICT sector.

Masters degrees are typically obtained by graduates who already have a relevant Honours Bachelor Degree. While ICT companies value a masters degree, masters holders are recruited into much the same pool of jobs as Honours Bachelor Degree holders. Because of this, it is reasonable, as a simplifying assumption, to think of Masters degrees as raising the skills of Honours Bachelor Degree graduates, without moving them into a separate demand bracket.

Figures 6.6 and 6.7 provide historical data on graduates from the wider population of courses in computing and electronic engineering, as well as from the Honours Bachelor Degree and Higher/Graduate Diploma courses that have already been referenced.

Figure 6.6: Trends in Graduate Numbers in Computing, 2002 to 2004

		Numbers of Graduates		
Level	**Computing**	**2002**	**2003**	**2004**
6	Core Computing	1144	920	561
6	Office Information Systems and IT Support	662	646	550
7	Core Computing (Add-on)	650	651	518
7	Core Computing (Ab-initio)	378	440	312
7	Office Information Systems and IT Support (Add-on)	129	154	188
7	Office Information Systems and IT Support (Ab-initio)	21	77	68
8	Core Computing (Add-on)	410	438	429
8	Core Computing (Ab-initio)	1,482	1,335	1,168
8	BIS and other combinations of Computing and Business (Add-on)	109	166	236
8	BIS and other combinations of Computing and Business (Ab-initio)	144	133	109
8	Multimedia, Computer Games Development etc. with Substantial Computing Content (Ab-initio)	0	28	47
8	Core Computing – H.Dip	263	164	94
8	B I S and other combinations of Computing and Business – H.Dip	103	54	15
9	Core Computing – Grad Dip	197	67	59
9	Core Computing – Masters	137	158	88
9	BIS and other combinations of Computing and Business – Masters	137	135	106

Source: Based on data extracted by Skills and Labour Market Research Unit, FÁS.

Figure 6.7: Trends in Graduate Numbers in Electronic Engineering, 2002 to 2004

		Numbers of Graduates		
Level	**Electronic Engineering**	**2002**	**2003**	**2004**
6	Electronic/Computer/Communications Engineering	421	375	265
6	Mechatronic or Electrical Engineering	107	173	129
7	Electronic/Computer/Communications Engineering (Add-on)	281	258	253
7	Electronic/Computer/Communications Engineering (Ab-initio)	99	78	92
7	Mechatronic or Electrical Engineering (Add-on)	54	61	73
7	Mechatronic or Electrical Engineering (Ab-initio)	88	79	117
8	Accredited Electronic/Computer/Communications Engineering (Ab-initio) – Level 8	594	531	354
8	Other Electronic/Computer/Communications Engineering (Add-on)	43	80	66
8	Other Electronic/Computer/Communications Engineering (Ab-initio)	236	193	154
8	Mechatronic or Electrical Engineering (Add-on)	22	12	19
8	Mechatronic or Electrical Engineering (Ab-initio)	158	133	81
8	Electronic/Computer/Communications Engineering – H.Dip.	5	2	2
9	Electronic/Computer/Communications Engineering – Grad. Dip	18	12	9
9	Electronic/Computer/Communications Engineering – Masters	100	114	88
9	Mechatronic or Electrical Engineering – Masters	43	53	33

Source: Based on data extracted by Skills and Labour Market Research Unit, FÁS.

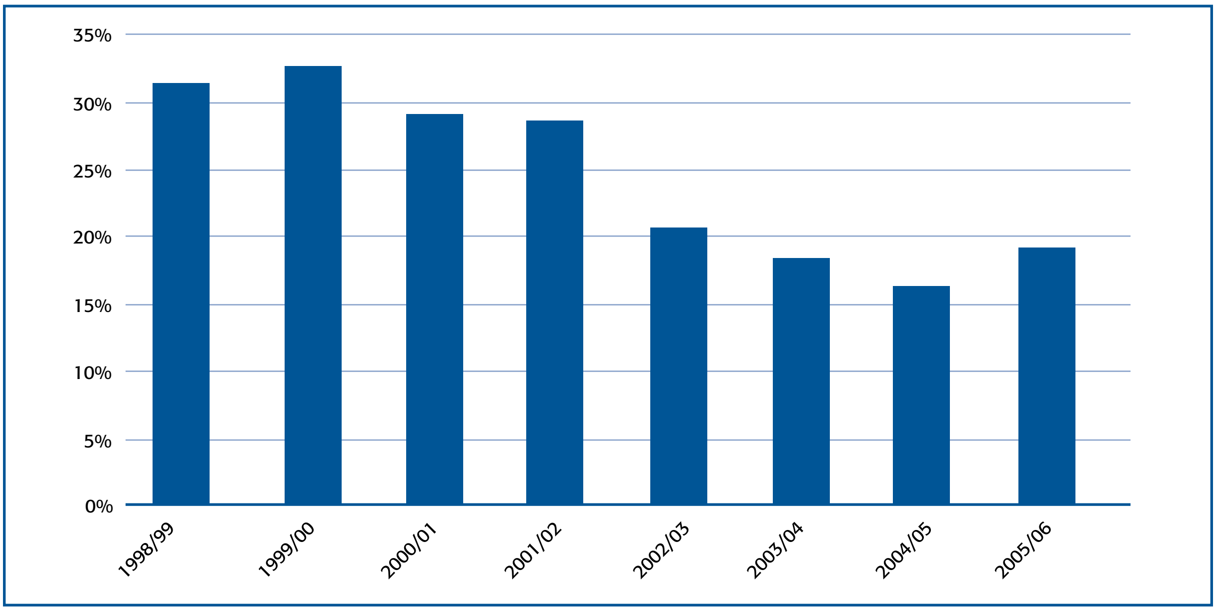
6.6 Factors Limiting Student Interest

There has been a fall in the numbers of students entering college to study computing and electronic engineering. Despite a modest net improvement for computing in 2006, the number of entrants into both disciplines is now far below peak, and their average qualifications prior to entry have disimproved significantly.

There has also been a sharp fall in numbers taking up higher diploma and graduate diploma courses in computing, generally taken after first obtaining an Honours Bachelor Degree in another discipline.

The decrease in interest in computing at new college entrant level has been considerably steeper among females than among males, as can be seen for the universities from Figure 6.8.

Figure 6.8: % Share of Females Among University Entrants into Computing



Source: Based on data from HEA.

A number of factors appear to have contributed to the general fall in numbers entering courses in computing, and to the continuing low levels of interest in computing among school leavers.

- The downturn in the ICT market that occurred from 2000/01 had a major labour market impact in the ICT sector. While the impact was greatest among relatively low skilled people, particularly those employed in the electronics hardware subsector, people with high-level ICT skills were also affected. There were substantial net job losses in software and a number of other areas (see Figures 2.2 and 2.3). Even in subsectors where there were no net job losses, career prospects often appeared diminished. There was significant job churn as new graduates continued to enter the sector, and as some job losses were offset by gains in other companies. Many of those employed in the sector went from great optimism about job prospects to being worried about job and career security. While school leavers and their parents were probably influenced in part by newspaper headlines relating primarily to the loss of low skilled ICT sector jobs, the likelihood is that word of mouth about current labour market realities seen by high-level ICT staff also had a major impact on choices made by school leavers and by graduates who might otherwise have undertaken graduate diploma conversion courses.

- The labour market experience of new graduates during the downturn was mixed. During the latter half of the 1990s, graduates in computing and electronic engineering at Level 8 and above were overwhelmingly recruited into ICT sector jobs relevant to their degrees at salaries above the average for other disciplines. During the downturn, the sector continued to recruit graduates, but at a lower level than in the past, and at salaries that were no longer far above average. Some graduates had difficulty in obtaining employment in areas relevant to their degree. To illustrate this, Figures 6.9 and 6.10 present data on the employment situation of 2004's Level 8 graduates in computing and electronic engineering when they were surveyed in 2005. While the employment situation has improved greatly, some graduates are still having difficulty in making the transition into employment, in the face of a preference that some companies in the sector have for recruiting experienced staff, although company recruitment activity targeted at graduate level is now increasing, which seems likely to alleviate this problem.

- Despite the fact that shortages of high-level ICT staff have re-emerged, the downturn has left a legacy of concern about career security for high-level ICT staff. It is possible that this insecurity has continued in part because of job churn, with substantial job gains and losses co-existing within many ICT industry subsectors[24], and also because of competitive threats from overseas.

- Real average pay in software and IT services has barely changed (at least up to 2006), and indeed has fallen slightly since 2001, as seen in Figure 4.3. This is in the context of strong growth in pay in most other sectors of the economy, notably construction and much of the public sector, as seen in Figure 4.4. While jobs in the ICT sector requiring high-level ICT skills remain well paid, remuneration is slipping relative to that associated with graduate level employment in other sectors. This trend is likely to be visible to school leavers and to graduates in other disciplines who might otherwise have been interested in undertaking graduate diploma conversion courses.

- During the downturn, there was arguably sometimes a disconnect between the case made to students that they should choose computing and electronic engineering, and the labour market conditions that were apparent when they or their parents investigated. Understatement of the difficulties may have affected the credibility of the well founded message that demand for skills in these areas would strengthen.

- There have been significant shifts in disciplinary interest among school leavers, as revealed by CAO application statistics. Data quoted here are for first preference applications at honours bachelor degree level.

  - There has been a significant overall fall in interest among college applicants in "engineering/ technology", the CAO subject category that includes most computing and electronic engineering courses. Excluding numbers applying for nursing from consideration (entry into nursing through Honours Bachelor Degree courses commenced in 2003), applications for "engineering/technology courses fell from 17.5% in 2000 to 14.4% in 2006[25].

  - Within the broad area of "engineering/technology", there has been a significant shift in disciplinary interest towards courses in civil engineering and construction studies, although there is some evidence that this is now moderating in the face of reduced construction industry confidence.

  - In contrast, within the broad SET (science, engineering, technology) domain, overall demand for places in "science/applied science" courses has held up well, virtually the same in 2007 (9.4% of non-nursing applicants) as it was in 2000 (9.5%). Thus, the burden of declining interest in studying SET subjects has fallen mainly on "engineering/technology".

  - Excluding numbers applying for nursing from consideration, applications for human healthcare courses have increased sharply since 2000, from 6.7% of applications in 2000 to 10.7% in 2007[26].

  - Interest in courses in "arts/social science", and "art/design" has increased sharply since 2000 from 24.6% of non-nursing applications to 31.4% of non-nursing applications.

- Some of these shifts can be explained, at least in part, as a response to rapidly growing employment opportunities and significant increases in real pay in healthcare and construction.

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24 See in Figures 2.4 and 2.5.

25 There appears to have been a further fall in 2007, but the statistical picture is complicated by the creation of a new "built environment" subject category by CAO. Numbers applying for nursing are excluded from both numerator and denominator in calculating these percentages.

26 This 10.7% rises to 18.8% if nursing is included. Numbers applying for nursing are excluded from both numerator and denominator in calculating the 10.7% figure.

- The shift towards "arts/social science" and "art/design" seems to have occurred primarily at the expense of "administration/business". It may be related to the emergence of more applied, business oriented, courses in these areas. Other factors such as near full employment among graduates, growth in public service employment of generalists and improved career opportunities for designers and artists may also have had an impact.
- Changes at second-level may also have had an influence. While there have been positive changes in the way in which physical sciences are taught, the Chief Examiners Report on the Leaving Certificate Higher-level mathematics paper of 2005 reported a significant fall in performance over a short period of time. As mathematics is important in the study of both computing and electronic engineering, this may have contributed to undermining interest in these disciplines.

Figure 6.9: Situation of 2004 Level 8 Graduates in Computing and Electronic Engineering when Surveyed in 2005

Situation	Electronic Engineering	Computing
Employed	58.6%	66.3%
Further Study	26.8%	22.5%
Seeking Employment	5.0%	4.0%
Not Available for Employment or Study	9.5%	7.3%

Source: From HEA First Destination data.

Figure 6.10: Occupations of 2004 Level 8 Grads in Computing and Electronic Engineering

Occupation	Electronic Engineering	Computing	Occupation	Electronic Engineering	Computing
Managers, Administrators and Executives (general purpose)	1.1%	2.0%	Non Scientific Research, Technical Workers, Translators etc.	0.8%	0.0%
Managers, Administrators in the Public Service (including Local Authorities)	0.0%	0.1%	Other Professionals	0.4%	0.3%
Managers, Executives etc. in Sales, Marketing, Advertising, etc.	0.8%	1.0%	Engineering Technicians	3.4%	0.1%
Managers in Personnel, Human Resource Development, Training etc.	0.4%	0.6%	Electrical and Electronic Technicians	5.0%	0.0%
Other Managers, Executives, exercising specific functions	0.8%	4.8%	Building and Civil Engineering Technicians	0.4%	0.0%
Officers in Defence Forces, Gardai	0.4%	0.1%	Surveyors/Support	0.4%	0.0%

Occupation	Electronic Engineering	Computing	Occupation	Electronic Engineering	Computing
Proprietors in Distribution and Services	0.0%	0.1%	Social Care, Community and Youth Workers	0.4%	0.3%
Managers/Admin/ Execs Not Further Specified	0.8%	0.1%	Software Maintenance and Support	1.9%	6.9%
Industrial Academic Research Scientists	0.4%	0.3%	Technical Writing	0.4%	0.3%
Quality Control/ Analytical Work	1.5%	1.4%	Other Computer Support Staff incl Computer Training	2.3%	9.9%
Scientific and Technical Advisors/ Consultants	0.4%	0.1%	Accounts Assistants/ Technicians	0.0%	0.3%
Other Professional Scientific and Technical activities	0.8%	0.3%	Authors, Writers, Journalists	0.0%	0.4%
Industrial Academic Research Engineers	0.4%	0.0%	Artists, Commercial Artists, Graphic Designers	0.0%	0.7%
Design and Development Engineers (excl. software development)	12.6%	0.3%	Actors, Broadcasters, Musicians, Sports Professionals	0.4%	0.1%
Engineering Advisors/ Consultants	6.9%	0.1%	Photographers, Sound and Video Equipment Operators etc.	0.4%	0.0%
Manufacturing, Production, Process Engineers	7.7%	0.8%	Other Literary, Artistic and Sports	0.4%	0.1%
Other Engineering Professionals	19.9%	3.0%	Aircraft and Ships Officers, Air Traffic Controllers	0.0%	0.1%
Civil and Structural Engineers	1.9%	0.0%	Clerical assistants/clerical officers/bookkeepers (except Bank Officials)	0.4%	2.4%
Quantity etc. Surveyors	0.4%	0.0%	Receptionists/telephonists/ clerk-typists/secretaries	0.4%	0.8%
Software Design and Development	6.9%	20.2%	Bank Officials	0.0%	2.5%
Systems Analysts	0.8%	4.2%	Computer Operators, Data processors	0.4%	0.6%
Computer Programming Professionals	4.2%	10.2%	Skilled electrical, electronic workers	0.4%	0.0%
Accountants	1.1%	3.1%	Other Skilled manual occupations	0.8%	0.3%
Actuaries, Statisticians	0.0%	0.7%	Industrial and other operatives	0.8%	0.6%

Occupation	Electronic Engineering	Computing	Occupation	Electronic Engineering	Computing
Management Consultants, Business Analysts	2.7%	2.1%	Defence Forces and Gardai (non-commissioned)	0.4%	0.3%
Stockbrokers	0.0%	0.3%	Security guards and related activities	0.4%	0.1%
Other Business etc. Professionals	0.4%	4.0%	Sales representatives, manufacturers agents, import/export	0.4%	1.0%
Barristers – Other	0.0%	0.8%	Sales assistants, check-out operators	0.4%	1.1%
Medical Practitioners	0.0%	0.1%	Telephone salespersons (incl customer support)	0.8%	2.7%
Primary Teachers (incl. Nursery)	0.0%	0.1%	Other sales occupations	0.4%	0.1%
Second-level	0.0%	0.1%	Waiters, Waitresses, etc.	0.0%	0.4%
Third-level (Lecturers)	0.0%	0.3%	Bar Staff, etc.	0.4%	0.3%
Third-level (Assistants, Demonstrators)	0.0%	0.3%	Other Service Occupations	0.0%	0.4%
Other Teachers (eg. language, special etc. schools)	0.4%	0.3%	Other Unskilled Manual, Other Occupations	0.8%	1.3%
Librarians, Archivists, Curators, etc.	0.0%	0.1%	Occupation Unstated	3.1%	3.0%
			Total	**100%**	**100%**

Source: From HEA First Destination data.

Some additional factors appear to have been at work among female school leavers.

- Based on interviews with students undertaken in the course of past studies for the Expert Group on Future Skill Needs, the consultants think that the sense of attachment female students considering careers in technology feel to computing and engineering is much weaker than that felt by male students. Where most male engineering students consulted felt that they had been on an almost inevitable track into engineering or an allied discipline, because of their interests, aptitudes and subject choices at second-level, most female engineering students felt that they could have gone in any of a number of directions. This openness to different directions may have allowed female students to be more sensitive than males to changes in the relative prospects perceived to be offered by different fields of study in higher education.
- The shift in interest towards healthcare has had a particularly strong female component to it. For example, females made up 59.3% of new entrants into medicine in 2005/06, up from close to 50% in the late 1990s.

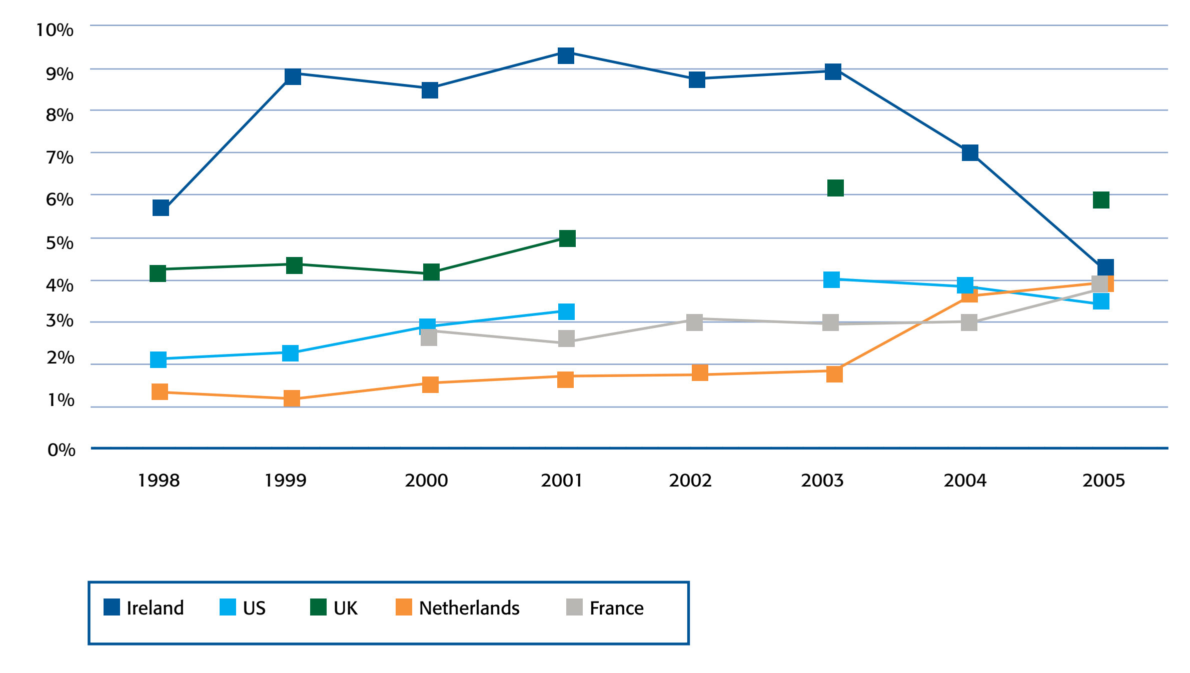
It seems likely that these two factors contributed to the especially steep fall in female student numbers in computing.

Social factors are often quoted as discouraging females from applying to study technology subjects, such as a "geek" image, association of computing with violent computer games, and a risk of being somewhat isolated in a mainly male class. None of these is new, but their effect may possibly have increased after the share of females in classes started to fall for other reasons.

A number of interviewees noted that Ireland's output of graduates in computing was exceptionally high around 2000/01, by reference to the share of all graduates accounted for by computing in other developed countries. They suggested that the fall in graduate output represented a shift to a more normal pattern of graduate output, and that it would be difficult to reverse this.

OECD data, presented in Figure 6.11, confirm that Ireland's output of graduates in computing was exceptionally high, at around 9% of all graduates, between 1999 and 2003, but fell steeply in 2004 and 2005. The supply analysis in this report points towards a further fall of 35% at Honours Bachelor Degree level between 2005 and 2008.

Figure 6.11: "Tertiary A" Graduates in Computing as % of All "Tertiary A" Graduates for Various Countries, 1998 to 2005*



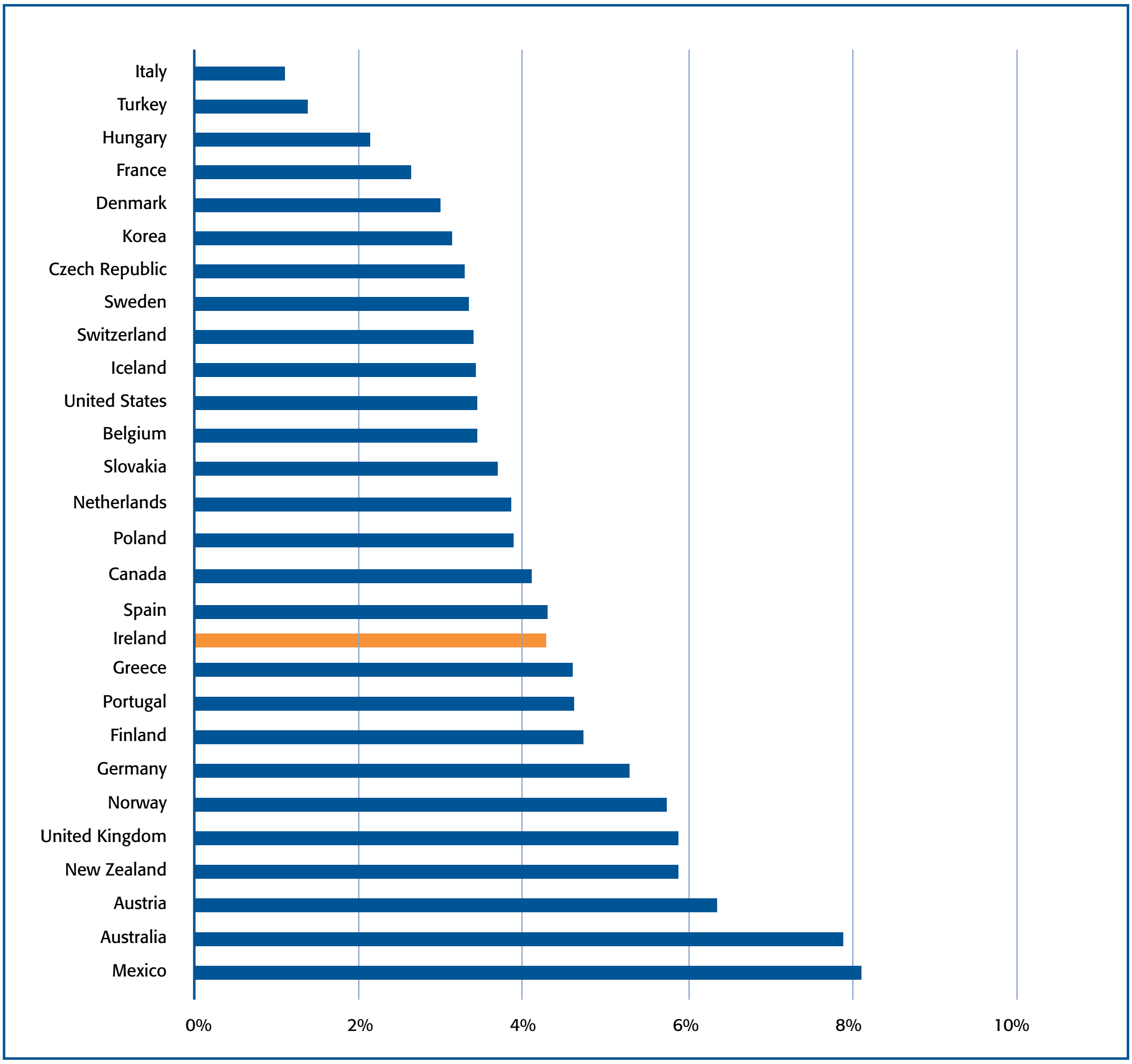
**Some gaps in trend lines due to missing data.*

Source: OECD Education Database.

Figure 6.12 shows that, as of 2005, Ireland's output of graduates in computing was mid-ranking at about 4.3% of all graduates. A further possible fall of about a third between 2005 and 2008 could leave Ireland lower in the rankings in terms of share of all graduates accounted for by computing if proactive actions to reverse this are not implemented.

On the positive side, this means that there is considerable scope for recovery in numbers taking computing before Ireland comes back into line even with mid-ranking OECD countries like the Netherlands, and that there is further scope for recovery before Ireland comes into line with other English-speaking countries such as the UK, New Zealand or Australia, or with countries such as Finland, Germany or Austria.

Figure 6.12: "Tertiary A" Graduates in Computing as % of All "Tertiary A" Graduates for Various Countries, 2005



Source: OECD Education Database.

6.7 Increasing Interest in SET Disciplines – Ireland and Overseas

Concerns about a shift in interest among students away from SET disciplines are common in developed countries. Worries about declining interest in mathematics and about insufficient graduate numbers in various engineering disciplines are common across much of Europe and in North America. The shift in student interest away from computing and electronic engineering experienced in Ireland also reflects events in many other countries in recent years.

Many countries are responding to these concerns with initiatives to promote the study of disciplines relevant to SET at all levels of education, often branded as "STEM" (Science, Technology, Engineering and Mathematics) initiatives. Examples include the UK's STEM Cross-cutting Programme and a wide array of federal and state level STEM interventions in the US.

The main features of such programmes tend to be:

- Measures to improve teaching and learning of STEM subjects, in terms of content, methodologies and capacity;
- Measures to persuade students to study STEM subjects; and
- Provision of information about STEM subjects, typically focused mainly on careers.

In some cases, direct economic incentives are given to promote the study of SET subjects at higher education level. These include, among others:

- Various STEM scholarship programmes in the US; and
- "direct bursaries and inducements in shortage subject areas" in the UK[27].

In Ireland, to date, the focus has been on improving teaching and learning, on persuasion and of provision of information.

A sample of key initiatives includes the following:

- Discover Science and Engineering promotes interest in Science and Engineering among students at primary and secondary levels. 3,300 primary teachers are involved in the Discover Primary Science (DPS) programme. A Discover Sensors scheme targeted at Junior Certificate students will be extended to 150 schools. Various other initiatives, including teacher training courses and web sites were undertaken, and a wide range of other initiatives is in development. Discover Science and Engineering had a budget of €5m for 2007.
- A science curriculum has been introduced at primary level and the Junior Certificate (15-16 year olds) awards points for practical work in science.
- Many initiatives have been undertaken to improve teaching and learning, and improve the relevance of courses, in SET-related courses at junior and senior cycle, including the recent introduction of a new Leaving Certificate subject(s) entitled "technology".
- The Engineers Ireland STEPS to engineering (Science, Technology and Engineering Programme for Schools) programme[28] undertakes promotional activities such as the "STEPS to engineering K'NEX Challenge" for primary students, the "STEPS Magical Science Show", "Engineering as a Career" student seminars, "Engineer to School" visits and an "Explore Engineering Summer Camp".

27 See "The Science, Technology, Engineering and Mathematics (STEM) Programme Report", Department of Education & Skills and Department of Trade and Industry, page 20.

28 STEPS is supported by Discover Science and Engineering.

- ICT Ireland has an education working group that involves a range of other organisations. Its initiatives include:
  - A Champions campaign, under which volunteers from industry visit schools to promote ICT careers in a coordinated programme; and
  - ICT Ireland and the HEA promote an internship programme for higher education students studying ICT-related subjects. It is hoped that the commitment for work experience will clarify the career opportunities, in particular to parents. The HEA is providing funding of €450,000 per annum from the Information Technology Investment Fund for this programme.
- Among its other activities, Women in Technology and Science (WITS) has a "role model" project aimed at female second-level students.
- The Irish Computer Society (ICS) has a promotional campaign called Choose IT. It has developed a web site, www.chooseit.ie, targeted on school students, as a way of interesting them in careers in computing. ICS distributed an information pack on computing careers to over 400 schools promoting the web site, and included a copy of a promotional DVD from the Higher Education Authority.
- A group comprising Fórfas, Discover Science and Engineering, Engineers Ireland, ICT Ireland and the HEA have cooperated on a PR campaign for ICT careers. This campaign called 'Areyouupforit' used a combination of radio and web advertising to a web site where a prize competition was held to attract interest in ICT from participants.

6.8 Resourcing ICT-Related Disciplines

From 1997 to 2004 recurrent funding for the creation and expansion of courses to meet identified ICT skills shortages was provided to universities on a per capita basis by the Higher Education Authority, with earmarked annual funding for each additional student admitted. As enrolments on a number of these targeted courses declined, the HEA moved to support the retention of the academic infrastructure in these key areas. From 2003/04 onwards, additional funding was provided to prevent the dismantling of capacity built up by the earlier investment. Parallel measures were taken to build capacity in the Institutes of Technology.

The HEA, through the Information Technology Investment Fund, has provided each third-level institution with an average of €60,000 per annum to improve retention on ICT skills courses since 2002. Many are using this funding for both retention and recruitment programmes.

The HEA is promoting the development of new bundled courses to Third-level Institutions, in areas such as business and computing, partly in the hope of attracting students with broad interests, particularly female students.

The HEA responded to projections of shortages in the Fourth Report of the Expert Group on Future Skills Needs published in October 2003 by agreeing to provide funding from the Information Technology Investment Fund for a promotional campaign to address declining enrolments. In 2003, €120,000 was allocated to the PR campaign to address the declining enrolments in Computer Science. Of this €20,000 was used to develop marketing material including a promotional DVD. The balance was distributed to 20 Third-level Computer Science departments for the promotion of their courses and careers in information technology.

6.9 System of Incentives Seen by Students

Since 2000, there has been a decline in the numbers of students entering college to study computing and electronic engineering. Despite a modest net improvement for computing in 2006, the number of entrants into both disciplines is now far below peak, and their average qualifications prior to entry have disimproved significantly.

The need to redress this shift has been a staple of skills reports and commentary.

Problems with mathematics, physics and chemistry at second-level, and the need to address science education at primary level form a part of the same field of discussion. It is presumed that students who like these subjects, and perform well in them, are more likely to choose to study science, engineering and technology (SET) subjects at third-level, and are more likely to perform well when they do so.

Much is already being done to promote the study of computing and electronic engineering, to develop the study of mathematics, physics and chemistry at second-level and to develop the study of science at primary level. A sample of key initiatives has been described above.

Unfortunately, all this work has not yet succeeded in producing a significant recovery in the number and quality of applications to study computing and electronic engineering, although it may have served to prevent the extent of the fall from being even more severe than would otherwise have been the case, and may also have helped to maintain, or in some cases increase, student interest in other areas of science and engineering.

A modest 2006 improvement in numbers studying computing has been driven mainly by the introduction of new courses in development of computer games, which appear to have caught the imagination of some school leavers. These courses are general degrees in computing, with a games specialisation, so their graduates are likely to become suitable for employment in other areas too.

The main "new" issue that has arisen is that the Chief Examiners Report on the Leaving Certificate Higher-level mathematics paper of 2005 reported a significant fall in performance over a short period of time. This is in the context of a long history of concern among third-level academics in engineering and computing about declining standards in mathematics among school leavers. The Review of Mathematics in Post-Primary Education, undertaken by the NCCA, has recommended a range of reforms.

Reflecting on the policy initiatives that have been recommended, and those that have been implemented, going back to the early 1990s, it is apparent that:

- The initiatives implemented have mainly been a mix of encouragement for students, provision of information and pedagogical reforms; while
- The main credible initiatives not implemented in any form are about changing the system of incentives that students see[29, 30].

29 One significant change fell into both categories. A change in the Higher-level mathematics curriculum implemented in the early 1990s appears to have cut the workload in Higher-level Leaving Certificate mathematics, with the explicit intention of raising participation at Higher-level to 25%. It was followed by a significant rise in uptake of Higher-level mathematics, to around 18%, along with a sharp reduction in the difference in uptake rates between males and females. However, there was a perception among third-level academics in engineering and computing that the standard of mathematics among school leavers declined significantly in the period following the new curriculum's introduction. It thus increased the number of school leavers well qualified to study engineering and computing, while raising the barriers to success faced by those who chose to study the subjects.

30 A notable exception is the ICT Ireland Graduate Placement Programme, which cushioned the impact of the industry downturn on graduates in computing and electronic engineering in recent years, and which continues to operate.

This is despite the fact that the changes that have most obviously driven the fall in student numbers have been more about changed perceptions of prospects, rather than lack of information or problems with teaching and learning.

Based on this experience, it seems unlikely that policies based only on encouragement, provision of information and pedagogical reforms will produce the changes in student behaviour that the ICT sector needs. There is, in addition, a need to change incentives seen by students. As seen earlier, there are precedents in other countries for initiatives to tackle student incentives, with STEM scholarships being common in the US, and with bursaries and inducements in skill shortage areas in the UK.

Additional policy interventions which could change the system of incentives here are:

- **Establishing a better value proposition for computing and electronic engineering as subjects to be taken at college.** A range of approaches could be taken, again including but not limited to the following:
    - Scholarships and bursaries in significant numbers, targeted on high achievers. An argument for providing bursaries as an additional incentive to students to enter specific subject areas for which there are skill shortages, is made in a recent paper commissioned by the Education and Training Policy Division, OECD (*Tertiary Education Systems and Labour Markets*, January 2007). There are many examples of bursaries schemes introduced in different countries to attract students to STEM subjects. For example East Midlands Development Agency in the UK is injecting more than £600,000 into a bursary scheme to encourage more students to study science-based courses at university. The bursaries and will be available at the region's nine universities. Up to 200 students will be eligible for £3,000 bursaries (£1,000 a year for three years) to enable them to study STEM courses. Queens University Belfast is now offering an automatic £1,000 scholarship to any student attaining a minimum of three A levels enrolling in a Science, Technology, Engineering and Mathematics subject. The School of Informatics, City University, London offers a number of scholarships of £2,000 for both home and overseas well-qualified postgraduate students on their full-time master's courses.
    - Funding some, or even all, courses in computing and electronic engineering, at Level 8 and above, at a much higher-level, possibly sufficient to provide an educational experience comparable to a leading US school.
- **Tackling the perverse incentives that students face when choosing at which level to study mathematics, and how much attention to give it.** Because the workload for Higher-level mathematics is perceived to be much greater than for other subjects, while the rewards in college entry points are no different (or worse, see next point), an able student seeking to maximise points may plan to use mathematics as a spare subject, to be taken at Ordinary Level or barely passed at Higher-level, rather than seeking to excel at Higher-level. Similar incentives may also encourage a less able student to use mathematics as a spare subject. The most commonly canvassed solution to this is to apply something similar to the bonus points system used in the University of Limerick across the higher education system. This gives a very large[31] bonus (40 points) for an A1 at Higher-level, with decreasing bonuses down to 5 points for a C3. However, other strategies are also possible, which might have less impact on the wider operation of the points system. One option would be to award a more modest flat bonus (perhaps 10 to 15 points) for mathematics, rewarding all of those who derive college entry points from mathematics – not just high performers. In principle, this bonus could be extended to Ordinary Level as well as Higher-level.

31 *It is very large in the sense of its impact on the wider working of the college entry points system. For example, it would have the effect of making a high grade in Higher-level mathematics effectively a requirement for entry into undergraduate courses in medicine.*

Any approach to resolving the issue by significantly reducing the workload would be counterproductive. It could leave even high performing students ill prepared to study electronic engineering and computing to Honours Bachelor Degree level, as well as affecting preparation to study many other numerate disciplines. A major revision to the Higher-level mathematics curriculum in the early 1990s, designed to make the course more accessible, was followed by complaints about standards of preparation from higher education academics that have still not dissipated.

- **Tackling the grading penalty that students face in Higher-level Leaving Certificate Mathematics, Physics and Chemistry.** Data quoted in the Report of the Task Force on the Physical Sciences, and reproduced in Figure 6.13, showed that, on average, students taking Higher-level mathematics, physics and chemistry obtained higher grades on their other Higher-level papers, suggesting that they face an effective grading penalty in these three subjects. The gaps were big enough to most likely pose a significant disincentive to taking these subjects, but small enough so that they could, in principle, be addressed by a one-off recalibration of grading in these subjects without making it difficult to distinguish in the revised grading scheme between different levels of performance.

Figure 6.13: Differences Between the Mean Score of Students in Higher-level Mathematics, Physics and Chemistry and the Mean for the Same Students in Other Leaving Certificate Higher-level Subjects*

	2000	2001
Mathematics	-1.4	-0.7
Physics	-1.1	-1.7
Chemistry	-1.5	-1.3

** For example, in 2000, students taking Higher-level mathematics were on average graded 1.4 grades lower in mathematics than in other Higher-level papers they took.*

Source: Report of the Task Force on the Physical Sciences. Also, Grading in the Leaving Certificate Examination: a Discussion Paper, Kellaghan & Millar, ERC, 2003.

Figure 6.14 shows that the grading penalties suffered by students taking mathematics, physics and chemistry at Higher-level are also present at Ordinary Level, and indeed appear to be greater at Ordinary Level than at Higher-level.

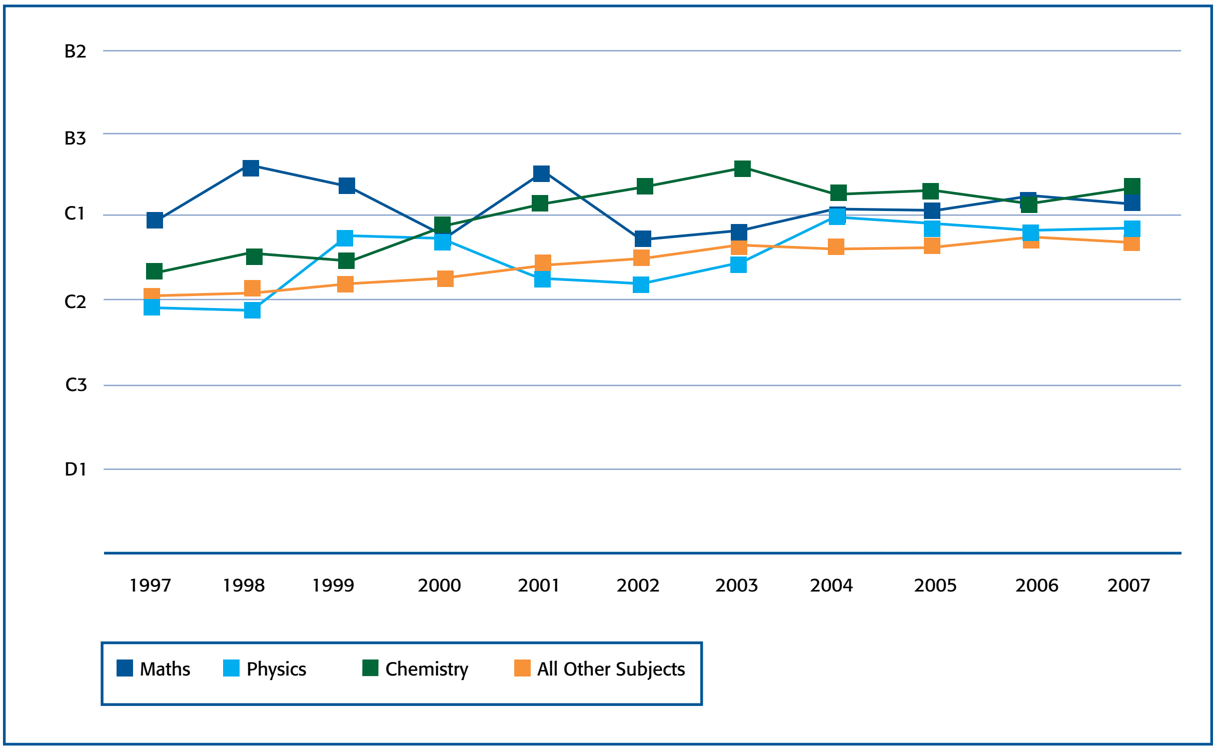
Figure 6.14: Differences Between the Mean Score of Students in Ordinary Level Mathematics, Physics and Chemistry and the Mean for the Same Students in Other Leaving Certificate Ordinary Level Subjects

	2000	2001
Mathematics	-1.9	-2.3
Physics	-1.6	-1.8
Chemistry	-1.2	-1.5

Source: Grading in the Leaving Certificate Examination: a Discussion Paper, Kellaghan & Millar, ERC, 2003.

Figure 6.15 shows how average grades[32] in Higher-level mathematics, physics and chemistry have varied since 1997. It presents averages for all students that took a subject. The figure shows that average grades in subjects other than mathematics have risen by about 0.5 of a grade since 2000. Meanwhile grades in mathematics remain close to their 2000 level. This suggests that the grading penalties seen around 2000 have most likely persisted.

Figure 6.15: Average Grades in Higher-level Leaving Certificate Examinations 1997 to 2007



Source: Based on analysis of data from State Examinations Commission and Department of Education & Science (2007 data via Irish Times 15/8/07).

32 *Average calculated by assigning a score of 14 to an A1, 13 to an A2, 12 to a B1 etc.*

6.10 Bologna-related Changes in Engineering

Engineers Ireland has decided that the education standard for the grade of MIEI and the professional title of Chartered Engineer should be raised to Master Degree in engineering, awarded on successful completion of a programme recognised by Engineers Ireland, with effect from programmes completed in 2013[33]. It is understood that most or all engineering schools currently operating Engineers Ireland recognised Honours Bachelor Degree courses in engineering envisage responding to this by replacing Honours Bachelor Degree courses with masters courses. This would increase the usual duration of study from four years to five.

The decision has been taken in the context of the EU Bologna process, which aims to create a European Higher Education Area, with qualifications that are more comparable and compatible across Europe. In many cases, courses responding to the Bologna process award an undergraduate degree after three years, and a masters degree after a further two years of study, although other configurations are possible. It is understood that at least some of the courses planned by engineering schools would follow this 3+2 year model.

These plans are likely to initially affect the ICT sector mainly through electronic engineering. They will primarily be relevant to students starting college in 2009 or later. Issues as to how the postgraduate elements of course provision will be funded remain open – the Free Fees Scheme applies only to undergraduate study.

If most colleges were to make the change in the same year, with the 2009 intake, there would be a very sharp one-off dip in graduate output in 2013, with most 2008 entrants graduating in 2012, and most 2009 entrants not graduating until 2014.

It is not clear what the broader impact of this planned change would be on ICT sector skills supply – whether the package of changes involved would make electronic engineering more or less attractive to college applicants.

It is also not clear how much more value the ICT sector will derive from a greater duration of study by electronic engineering students. While there will be undoubted benefits in terms of the greater content that can be covered, and in terms of possibly freeing up more time for internships in industry, it was not clear from interviews undertaken for this study that employers had a consistent preference for masters degrees over Honours Bachelor Degrees.

These issues deserve further study.

33 *Accreditation Criteria for Engineering Education Programmes, Engineers Ireland, 2007.*

6.11 Conclusions

This chapter outlines how Honour Bachelor Degree graduate numbers in computing and electronic engineering have fallen steeply from a peak around 2002. Intake into courses appears to have roughly bottomed out. There was a modest increase in numbers entering computing in 2006, which should be reflected in a small increase in graduate numbers in 2010. The performance of those taking up places on Honours Bachelor Degree courses in computing, as measured by CAO points, have disimproved.

The number of PhD graduates in computing and electronic engineering available for recruitment by industry will be increasing steeply over the next few years.

The projected domestic supply of graduates alone will not be sufficient to meet demand under the two more positive demand scenarios, and is only just about enough under the scenario where the sector loses competitiveness. However, each of the scenarios is based on ICT market demand remaining moderately strong (the lowest demand scenario is based on a progressive loss of competitiveness), so transient periods of lower demand remain possible.

The chapter reviews the reasons for the downturn in interest in studying computing and electronic engineering. It suggests that interest remains relatively weak because of factors such as continuing feelings of insecurity in the sector, slow growth in pay, competition from other sectors and changes in performance in mathematics at second-level. It briefly reviews measures taken to boost interest in studying SET subjects in Ireland and overseas. It suggests that there is scope to improve the system of incentives perceived by students, as well as continuing to provide encouragement and information, and seeking to improve how SET subjects are taught and learned.

Chapter 7: Comparison of Domestic Supply with Demand

7.1 Introduction

This chapter addresses interactions between labour demand, labour supply, finding that these interact in complex way. It compares projected trends in graduate demand projections from Chapter 5 with trends in graduate supply in Chapter 6 under each of the three scenarios for future trends in employment in the sector and whether any likely gap will arise in terms of quantity and quality. The chapter also considers the interaction between demand, supply and labour costs.

7. 2 Summary of Demand

Computing

Demand projections in 2007, from the ICT sector, for high-level skills in computing span a range from 1,900 to 2,800 under all three scenarios.

For 2013, demand projections under the two scenarios where the sector remains competitive range from 2,400 to 4,500. Under the scenario where the sector loses competitiveness, demand projection for 2013 remains substantial at over 600.

Demand from other sectors of the economy will also be significant and could amount to 800 per annum around 2013.

Demand is overwhelmingly for graduates with an Honours Bachelor Degree or Masters in computing.

Electronic Engineering

Demand projections, from the ICT sector, for high-level skills in electronic engineering span a range from around 300 to 360 in 2007, increasing to 400 to 550 in 2013 under the scenarios where the sector remains competitive. There will also be significant demand from other sectors, including telecommunications services and engineering consultancy companies. The financial services sector also has a record of recruiting electronic engineers to meet its need for highly numerate graduates.

Demand is overwhelmingly for graduates with an Honours Bachelor Degree or Masters. In both computing and electronic engineering, demand will be particularly strong for graduates with high grades.

Jobs in the ICT sector for electronic engineers are less diverse in character than for computing. Graduates who are unsuited to electronics design work may have more difficulty than others in finding employment within the ICT sector, even in the context of an overall shortage of graduates. In some cases, employers are likely to seek honours grades, narrowing the effective supply of graduates available.

Research

While a substantial part of the demand for graduates in computing and electronic engineering can be characterised as relating to research, this requirement is primarily for graduates at Honours Bachelor Degree and Masters level. There are few roles that specifically require a PhD level qualification; indeed employers may not always be interested in substituting PhDs for graduates with lower qualifications.

In addition to ICT sector demand, there will also be demand from other sectors of the economy. Quantifying this additional demand was outside the scope of this study.

7.3 Summary of Domestic Supply

Projections of graduate numbers are for an Honours Bachelor Degree output averaging 1,128 in computing and 414 in electronic engineering between 2007 and 2010. Not all of these will be available for employment; some will leave the country, and some will switch career direction. Many, also, will progress to studying for higher qualifications, although this delays their availability for work rather than ending it.

Graduates from higher diploma and graduate diploma courses in computing can also be considered to be relevant to the supply, although the total amounted to just 168 in 2004. For comparison, numbers peaked over 1,000 around 1999/2000. While graduates from these courses generally do not meet the general criterion of holding an Honours Bachelor Degree in computing or electronic engineering, the combination of a year's study of computing with an Honours Bachelor Degree in another discipline frequently makes them suitable for roles requiring a combination of business and technology skills. Moreover, a proportion of graduates from these courses continue on to obtain a Masters in computing, deepening their technical skills.

An inflow of students from overseas to study at PhD level adds to the total supply, but at best the total numbers involved will be modest – of the order of 50 in computing and 30 in electronic engineering. While the demand is primarily at Honours Bachelor Degree and Masters level, some roles are specifically suited to PhDs, and many roles have potential to benefit from being filled by PhD graduates qualified above the minimum level required.

These supply figures exclude inward migration.

7.4 Comparison of Domestic Supply with Demand

Under the two demand scenarios where the sector remains competitive, a significant gap is apparent between ICT sector demand and the supply of computing and electronic engineering graduates from Irish higher education institutions when demand from outside the ICT sector is taken into account.

While projected gaps between graduate numbers and demand vary between scenarios, the shortages projected range up to some hundreds per annum for electronic engineers qualified to Honours Bachelor Degree level or above, and up to an average of about 2,000-3,000 per annum for computing graduates qualified to this level. Inward migration will be required to bridge the gaps for the foreseeable future.

Even under the "Loss of Competitiveness" scenario, demand for graduates remains comparable to current graduate output, when account is taken both of ICT sector demand and demand from other sectors of the economy.

Even in the event of a rapid ramp up in student numbers, the mismatch would be likely to persist under the two scenarios under which the sector remains competitive.

Key issues that arise include the following:

- Under the two positive scenarios, there is scope for the ICT sector and other employers to absorb the graduates from any expansion in student numbers at undergraduate (and probably higher/graduate diploma) level *to the limits allowed by student interest in studying computing*. The same is true to a lesser extent for electronic engineering;
- As far as can be foreseen, there will continue to be scope for significant levels of immigration, and, under some scenarios, for high-levels of immigration; and
- The extent of the gap between supply and demand under some scenarios is so big that it is unlikely that it can be bridged, even with substantial levels of immigration.

It should be remembered that all three scenarios reflect a future of modestly positive global ICT market conditions, and it is plausible that that actual outcome could reflect stronger demand in the event of more positive market conditions, or weaker demand in the event of weaker market conditions. Transient industry downturns are inevitable, in the future as in the past, with temporary negative implications for labour demand.

It should also be remembered that the quantity of ICT staff available is not the only issue. The quality of staff is also a key issue, which was raised by many of those interviewed for the study. A resurgence of interest in computing and electronic engineering among the highest performing school leavers could significantly increase the number of very high performing graduates in these disciplines. This would greatly strengthen the pull that Ireland exerts on ICT employers, potentially boosting business and employment growth significantly beyond the levels set out in the three scenarios.

The availability of a range of important types of skill is also important.

7.5 Interaction between Demand, Supply and Labour Cost

While demand for high-level ICT skills and the supply of skills have been modelled independently of each other, to illustrate the likely gap between demand and supply of high-level ICT skills, demand and supply are not actually independent.

When demand is strong, as it is now, some combination of the following is likely to occur:

- Retention of high-level ICT staff within the industry (as opposed to moving to user organisation or non-technology work) is likely to rise, so there will be less need to replace skills;
- Immigration by people with high-level ICT skills may increase, which has happened over the last two years; and
- Recruitment into relevant courses may increase, and the qualifications of entrants may increase. This has only happened to a very limited extent since the downturn in interest in ICT courses bottomed out.

Conversely, when demand is weak:

- Retention within the industry is likely to fall, increasing the need for replacement workers (which explains why significant recruitment continued as employment of people with high-level ICT skills fell through the downturn);
- Immigration by people with high-level ICT skills is likely to fall, and indeed the number of existing immigrants returning home may rise, which appears to have happened during the market downturn; and
- Recruitment into relevant courses, and the qualifications of recruits, may fall, despite the likelihood that labour market conditions will be different at the time of graduation. Again, this happened during the downturn.

This interaction between demand and supply factors will affect the cost of labour. Changes in the cost of labour, in either direction, have both positive and negative implications.

The immediate effect of lower labour costs is to boost industry competitiveness, as labour is the single biggest component of cost for the parts of the ICT sector that employ most high-level ICT staff. Over a somewhat longer period, however, low labour costs may make pay levels unattractive for high skilled immigrants. They may also make it unattractive for Irish students to enter ICT courses, reducing recruitment immediately and reducing graduate Honours Bachelor graduate numbers four to five years into the future.

Conversely, higher labour costs (without improvements in productivity) will hurt industry competitiveness immediately, but are likely to boost the labour supply over the medium and long-term, in terms both of quantity and quality.

These interactions are impacted upon by trends in competitor countries, elsewhere in the Irish economy and in currency exchange rates.

- The rising costs of employing people with high-level ICT skills in India and China, and also in developed economies such as the US, may increase the level of pay increase that is possible in Ireland without loss of competitiveness, even given the gains in capability occurring in India and China.
- Within Ireland, the ICT sector is competing with other sectors for students to enter relevant courses. While graduates in computing and electronic engineering are still well paid, they have fallen behind some disciplines that they once led. If the trend continues, it will become more difficult to attract good students in significant numbers.
- While significant levels of immigration by people with strong ICT skills have benefited the sector, they may reduce the incentives for companies to recruit new graduates, who often take some time to become fully productive. It is important for Irish graduates to gain the experience they need to build good careers and contribute to the sector's future development.
- Migration alone is not a sustainable long-term solution to *skills shortages*. The primary policy objective should be the upskilling of the resident population at all levels.
- Exchange rates are significant as a factor. The euro's rise of more than 45% against the US dollar since the turn of the millennium has put competitive pressure on the industry, adding to the pressure on labour costs.

The available indicators show that real pay in the software sector, and most likely among high-level ICT staff employed in many other ICT sectors, was near static between 2001 and 2006. While it was constrained initially by weak demand for labour, improved labour supply arising from immigration may have prolonged the period over which real pay remained static. The anecdotal evidence is that real pay is now rising again, however. Employers in both overseas-owned and Irish-owned companies are aware of competition from countries with lower labour costs, and are conscious that pay increases need to be accompanied by increases in productivity in order to maintain cost competitiveness.

Increases in pay can only be supportable through business success rooted in increased productivity and innovation, underpinned in turn by better skills.

Factors outside the Irish sector's control will also have an influence, including:

- ICT market growth;
- Developments in pay and skills in India, China and other developing countries, as well as in competitor developed countries;
- Exchange rate movements; and
- Pay in other sectors of the Irish economy.

7.6 Conclusion

Under the two demand scenarios where the sector remains competitive, a significant gap is apparent between ICT sector demand and the domestic supply of computing and electronic engineering graduates from Irish higher education institutions when demand from outside the ICT sector is taken into account.

While projected gaps between graduate numbers and demand vary between scenarios, the shortages projected range up to some hundreds per annum for electronic engineers qualified to Honours Bachelor Degree level or above, and up to an average of about 2,000-3,000 per annum for computing graduates qualified to this level. Inward migration will be required to bridge the gaps for the foreseeable future.

Even under the "Loss of Competitiveness" scenario, demand for graduates remains comparable to current graduate output, when account is taken both of ICT sector demand and demand from other sectors of the economy.

It should also be remembered that the quantity of ICT staff available is not the only issue. The quality of staff is also a key issue, which was raised by a significant number of those interviewed for the study.

Chapter 8: Conclusions and Recommendations

8.1 Introduction

The conclusions and recommendations set out below correspond to three major strands of issues identified by this report, i.e:

- Providing a sufficient quantity of skills;
- Providing skills of sufficient quality; and
- Providing a sufficient diversity of skills to reflect the complexity and diversity of ICT businesses.

A main conclusion of the report is that the projected domestic supply of high-skilled computing and electronic engineering graduates will not be sufficient to meet future demand. Inward migration (which currently meets a substantial part of total demand) will continue to be required for the foreseeable future. Ireland is seen as a good location to attract experienced talent from all over Europe. This is against the background that the ICT sector here has largely recovered from the global downturn in market demand experienced in 2000/01 and is now growing again – with both productivity and profitability rising. Labour market demand for high-level ICT skills is tightening and employers are becoming more demanding about the type of skills they require. At the same time the flow of computing and electronic engineering graduates here has fallen. This is against the background of a global-wide shortage of high-skilled ICT people.

The quality of ICT staff here is also a key issue and is likely to remain so as long as the number of highly performing students choosing to study higher degree courses in computing and electronic engineering remains modest – even though there are good career opportunities in these occupations.

However, the primary policy objective should be on boosting the supply of high-level computing and electronic engineering skills.

Based on these findings, the EGFSN are recommending radical measures designed to increase the supply of high-skilled personnel (both in terms of quantity, quality and diversity of skills) to meet the future needs of the ICT sector. The successful implementation of these recommendations will require a collaborative approach between the many stakeholders involved. While the recommendations are designed to support the ICT sector, and specifically to address its high-level skills needs, some undoubtedly will have a positive impact on adjacent sectors, and support the wider agenda on skills for enterprise.

Companies consulted have identified a significant need for more people possessing business expertise relevant to the sectors in which their employers' products and services are deployed, as well as technical skills.

There are learning benefits to students in ICT-related disciplines arising from practical work experience via the use of internships programmes and other initiatives designed to expose students and graduates to the workplace in a structured manner.

The domestic supply of high-level skills into the ICT sector is dependent on what happens at all levels of education from primary onwards. The mathematical and scientific ability of students, coupled with their preference to study ICT or related subjects at college will influence heavily the quantity and quality of the graduate pipeline into the sector.

8.2 Communicating Career Opportunities and Skill Needs

A strategic approach towards influencing the numbers and calibre of students applying for computing and electronic engineering courses should be adopted by (i) communicating in concrete terms the rewarding job and career opportunities that exist in computing, software and electronic engineering and (ii) ensuring, through a deepening level of engagement between industry and third-level institutions, the ongoing development of attractive education and career pathways.

Recommendation 1: Communicating Career Opportunities that Exist in Computing, Software and Electronic Engineering

A major new initiative should be launched to communicate the rewarding and interesting career opportunities that exist in the fields of computing, software and electronic engineering in line with the CAO application process. The vital strategic role that the ICT sector plays in ensuring Ireland's long-term prosperity should be highlighted. It should seek to address concerns (real or perceived) about job security in the ICT sector which influence students' choices. All stakeholders, including employers, their representative bodies, HEA, should work together to develop a coherent message, containing hard facts, aimed at three specific audiences.

- Students at secondary level;
- Parents; and
- Teachers/Career Guidance Counsellors.

A gender dimension to this communication is needed, aimed at addressing the relative decline in the number of women taking high-level ICT courses.

This new initiative, (which would include revitalised actions already underway), should be led and coordinated by Discover Science and Engineering given their experience in this area.

The recommendations of the Expert Group on Future Skills Needs *Careers and Labour Market Information Dissemination* report should be implemented expeditiously. In summary, these are about:

- Development of a careers and labour market portal;
- Promotion of existing careers web sites;
- Improving access to useful labour market information; and
- Improving existing career guidance and information resources.

The Expert Group encourages guidance practitioners to be aware of the current positive outlook for the ICT sector both worldwide and in Ireland, and to regularly update their information on the sector.

Recommendation 2: Communicating Future Skill Needs

The Expert Group on Future Skills Needs, the HEA and ICT Ireland should facilitate discussions between industry and third-level institutions on an annual basis with a view to deepening engagement between employers, third-level institutions around ideas to improve:

- Recruitment onto third-level computing and electronic engineering programmes;
- The development of careers paths in the industry; and
- The relevancy of industry programmes.

8.3 Broadening Base of Recruits for Higher-level ICT Courses

Mathematics is fundamentally important to the fields of science and technology and in the context of this report, to supporting the further development of the ICT sector (addressing science, engineering and technology education form a part of the same field of discussion). The attainment of school students in mathematics is a key factor influencing the supply of graduates in computing and electronic engineering. A main concern is that the future stock of mathematical capability is in sharp decline, with the proportion of candidates taking higher-level mathematics in the Leaving Certificate dropping from 25% of the overall cohort in 2001 to 18% in 2005[34]. Given its importance to the educational and economic well-being of the country, a strategic approach to the development of mathematics is essential. The following recommendations are made in relation to improving proficiency in mathematics at primary and second-level thereby broadening the base of the potential supply into third-level level ICT courses.

Primary Level

The initial building block for the development of mathematics proficiency is at primary school level. Primary teacher training and in-service professional development is a key foundation for the development of mathematics proficiency. In recent years the DES has invested significantly in the in-career development of teachers. According to the DES Inspectorate report, *Beginning to Teach* (2005), 28% of new primary teachers felt themselves to be “poorly prepared” to teach mathematics. In the ERC/DES report, *Counting on Success – Mathematics Achievement in Irish Primary Schools*, (2006), 70% of school inspectors described teacher’s knowledge of methods for teaching mathematics as “somewhat limited”.

Recommendation 3: Enhancing the Professional Development of Primary Teachers

- The professional development of primary teachers would be enhanced by including further development in mathematics through Professional Master Courses and opportunities to enhance ‘academic mathematics’;
- Improve the allocation of time and resources to be given to the development of mathematics competence in teacher training courses; and
- The Primary Curriculum Review indicates that children are enjoying the active engagement with mathematics and the methodologies being employed in class. This should be continued and reinforced at second-level.

34 EGFSN (2007), *Tomorrows Skills Towards a National Skills Strategy*, EGFSN, Dublin.

Second-level

Findings from the OECD PISA mathematics assessment for 15 year olds[35], concluded that fewer students in Ireland (11%) achieved the highest mathematics proficiency levels, compared to the OECD average (15%). It should also be noted that fewer students in Ireland achieved at the lowest proficiency level – indicating a relatively narrower spread of achievement compared to other countries. In the most recent PISA 2006 ranking of countries on the mathematics scale, Ireland was 16th out of 30 OECD countries[36].

Improving performance in mathematics at upper secondary level will increase the potential supply of recruits for computing and electronic engineering degree courses from secondary Level. The attainment of school students in mathematics is an important factor influencing the supply of graduates in computing and electronic engineering. Many Level 8 courses (particularly in electronic engineering) have minimum requirements for attainment in Higher-level Leaving Certificate mathematics, most commonly a C3. More generally, academics in computing and engineering say that students with strong mathematical skills tend to perform better than others, and are the most likely to develop strong technical skills. Courses in computing and electronic engineering may also be more attractive to students who have developed a real interest in mathematics at second-level although other factors will also affect their choice of higher education discipline.

For these reasons, performance in mathematics at second-level and the uptake of Higher-level mathematics in the Leaving Certificate are matters of great concern to the ICT sector. The Chief Examiners Report on the Leaving Certificate Higher-level mathematics paper of 2005 reported a significant fall in performance over a short period of time. This came in the context of a long history of concern among third-level academics in engineering and computing about declining standards in mathematics among school leavers.

The Review of Mathematics in Post-Primary Education, undertaken by the NCCA, has since addressed the need for change in the curriculum, in teaching and learning and in assessment[37]. The Expert Group welcomes the work of the NCCA and the Department of Education and Science on mathematics at post-primary level, and agrees strongly that reforms to the teaching of mathematics at this level are necessary.

However, reflecting on the policy initiatives that have been recommended by various interested parties in relation to mathematics at second-level, and those that have been implemented, going back to the early 1990s, it is apparent that:

- The initiatives implemented, and those now envisaged in the Review, have mainly been a mix of encouragement, provision of information and pedagogical reforms; while
- The main credible initiatives not implemented have been about changing the system of incentives that students see[38].

35 Educational Research Centre, (2007), PISA Mathematics Teachers Guide, DES, Dublin.

36 OECD (2007), PISA 2006 Science Competencies For Tomorrows World, OECD.

37 Most recently, Review of Mathematics in Post-Primary Education – Report on the Consultation, NCCA, April 2006.

38 See main body of report for some specific exceptions.

Two specific factors appear to incentivise students to avoid higher-level mathematics, so as to obtain a better overall college entry points return on their work.

- There is a very widespread belief and understanding that Higher-level mathematics requires much more work than other Higher-level Leaving Certificate subjects.
- On average, students perform less well in Higher-level mathematics than in other Leaving Certificate subjects that the same students take at Higher-level. In effect, they appear to suffer a grading penalty for choosing mathematics over another subject. The penalty appears to be of the order of one grade – the difference between, for example a B3 and a C1[39].

With most Leaving Certificate students studying seven or more subjects, only six of which will count towards points for college entry, an able student can respond to these incentives by treating mathematics as a spare subject, to be taken at Ordinary Level or barely passed at Higher-level, rather than seeking to excel at Higher-level. There is considerable anecdotal evidence that students are doing this in significant numbers.

To address these factors, it is necessary to shift the effort/reward balance. Academics in computing and electronic engineering involved in undergraduate teaching are clear that there is no scope to further cut the content of Higher-level Leaving Certificate mathematics[40] without seriously undermining preparation for college. If the balance between effort and points awarded is to be rectified, it will be necessary to reinstitute a system of bonus college entry points for mathematics. There are various options available, ranging from a system similar to that employed in the past, and currently employed by the University of Limerick, awarding a high bonus for high grades and no bonus for low grades, to a system based on a modest flat bonus for every student presenting mathematics as one of their six subjects for college entry points.

There appears to be scope to recalibrate grading in Higher-level mathematics to bring it into line with the average for other subjects, without compromising the capability of the grading scale to differentiate between different levels of performance.

Recommendation 4: Tackle the Incentives for Studying Leaving Certificate Mathematics at Higher-level

The Department of Education and Science should work with Higher Education Institutions to address the disincentives to studying Leaving Certificate mathematics at Higher-level. In doing so, it should:

- Promote the development and introduction of a system of bonus college entry points for Higher-level Leaving Certificate maths to compensate students for the greater effort widely considered to be required for success in this subject; and
- Ask the State Examinations Commission to propose and implement a response to the grading penalty that appears to be suffered by students taking Higher-level mathematics in the Leaving Certificate.

These initiatives should be seen in the context of a levelling of the 'playing pitch' in the choice open to students between taking higher-level maths and other subjects.

39 As indicated in the body of the report, similar penalties exist for Higher-level Physics and Chemistry, and for Ordinary Level Mathematics, Physics and Chemistry, all of which are important to the broader supply of people with SET qualifications.

40 The curriculum underwent significant reform in the early 1990s, designed to make it more accessible, so as to increase the share of Leaving Certificate students taking mathematics at Higher-level.

Recommendation 5: Enhancing the Professional Development of Second-level Mathematics Teachers

The quality of second-level mathematics teachers is central to driving up interest and mathematics proficiency levels. The Department of Education and Science should continue their support for initiatives aimed at enhancing the quality of mathematics teaching in secondary schools. This should comprise professional development opportunities for second-level mathematics teachers including a Professional Masters Degree (taking account of professional experience) and a part-time Higher Diploma in Mathematical Education. Consideration should also be given to the introduction of a 4 year Honours Degree in Mathematical Education to provide another source of mathematics teachers. Industry and higher education institutions should improve feed back to teachers about the vital practical applications of mathematics. A more interactive, imaginative approach to teaching mathematics as being developed by the NCCA within "Project Maths", should be supported in which students are engaged in discussing real-life situations and how the mathematics involved can be applied to them – so that students can see its relevance to themselves and the world around them.

8.4 Improving Intake of Highly Qualified Students into Honours Bachelor Degree Level Computing and Electronic Engineering Courses

Given the strategic importance of the ICT sector here in terms of jobs and exports – and the significant shortages being faced – there is a strong rationale for measures which could boost the recruitment of highly qualified students into Level 8 computing and electronic engineering courses[41]. The following recommendation is made in this regard.

Recommendation 6: Consider the Introduction of Bursaries to Boost the Recruitment of Highly Qualified Students into Honours Level Computing and Electronic Engineering Bachelor Degree Courses, as a Matter of Urgency

In order to boost the recruitment of high qualified students into Level 8 computing and electronic engineering courses bursaries could be introduced for students entering such courses who achieve a demanding CAO point's threshold of 500 points[42] and a minimum requirement in higher-level maths[43]. The introduction of bursaries, on a pilot basis in the first instance, should be urgently assessed by the relevant Departments as an integral part of the package of measures being proposed. The private and public sectors should pursue the funding for any such pilot scheme from the ICT Sector and the National Training Fund. The involvement of HEA, DETE and Business would be required in the management of the process[44].

Bursaries could be valued at up to €4,000 per annum, and would be conditional on students maintaining acceptable grade averages and undertaking relevant industrial experience (which may be undertaken during the summer break). It is envisaged that between 150 and 180 new graduates per annum may become eligible for this initiative[45] (with an outer limit of 300 on review of uptake).

Similar STEM course incentives exist in several countries such as the UK, USA, Australia and learning from these could be drawn upon.

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41 *There will also be a positive impact upon adjacent sectors i.e. Medical Devices Sector.*

42 *In 2006, this was achieved by 10% of acceptors (19 students) for Honours Bachelor Degree Courses in Electronic Engineering and 4% of acceptors (42 students) for Honours Bachelor Degree Courses in Computing.*

43 *To be decided in consultation with Third-level Institutions – suggested that it should be between C3 to B3.*

44 *The pilot process could be reviewed annually and its outcomes evaluated at the end of year three, following which a decision would be made either to modify, expand and/or terminate.*

45 *An eligible student would receive the bursary for each of the four years of their study, (conditional on meeting criteria). Therefore, the envisaged total number of students benefiting from the bursary could be 180 in the first year of its introduction, 360 in its second year, 540 in its third year and 720 in its fourth year – thereafter the total would remain at 720 as students exit following their graduation. The estimated cost of the initiative could be €0.72m in the first year rising to an €2.88m (constant prices) in year four and for subsequent years.*

Recommendation 7: Proactively Encourage High-skilled Overseas ICT Students to Come, Study and Work in Ireland

Recent figures indicate a 170% increase in the number of full-time undergraduate and postgraduate enrolments of overseas students at Irish Universities and Colleges over the past decade – from 4,425 (4.5% of enrolments) in 1996/97 to 11,934 (8.7% of enrolments) in 2006/07[46]. In 2006, 8% of full-time overseas students were taking ICT related subjects (1167 students-of which 72% are non-European)[47]. This was an increase of 332 over 2005. This trend should be capitalised upon by launching a major new initiative aimed at:

- Attracting a greater number of overseas computing and electronic students to come and study here; and
- Seeking to retain such overseas students here, to work in the ICT sector following their graduation.

Employers, HEA, Universities and Colleges, IDA, Enterprise Ireland and the International Education Board Ireland[48] should collaborate on the development of a major new initiative focused on attracting overseas computing and electronic engineering students that markets Ireland as "*the place to come, study and work*". This should include offering such students an attractive package including the certainty of internships during their study period and graduate placement opportunities following (and subject to) their graduation[49] (The *Third-level Graduate Scheme (2007)* under the new economic migration regulations enables a non-EEA student who has acquired a primary, masters or doctorate degree from an Irish third-level educational institution to apply for one non-renewable extension to their current student permission for a six-month period[50] to seek employment in relation to a job offer of more than two years duration). This overall package is necessary to compete with other English speaking countries that currently offer such incentives such as the USA, Australia, Canada and New Zealand.

46 HEA Release, November 2007.

47 The International Education Board Ireland (2006), International Students in Higher Education in Ireland 2006, IEBI.

48 The International Education Board Ireland will be incorporated into Education Ireland when established by the Department of Education and Science.

49 This package would be promoted through Enterprise Ireland and IDA offices abroad and offered directly to prospective students at forthcoming graduate fairs in 2008 being held in the USA, Norway, Mexico, India, Malaya, Singapore etc. which International Education Board Ireland will attend.

50 During this six-month period they are allowed to work for up to 40 hours per week.

8.5 Ensuring that Third-level Courses Reflect the Skill Needs of the ICT Business

As well as ensuring a sufficient quantity of skills it is also important that there be the right skill mix and a sufficient diversity of skills to reflect the complexity and diversity of ICT business. The following recommendations are made in this regard.

Recommendation 8: Produce More Graduates with Strong Engineering Skills

Several ICT companies consulted for the study identified problems in recruiting enough people with very high-levels of technical capability, whether at graduate or experienced level. Those finding difficulties at graduate level tended to identify the need for more technically challenging project work on undergraduate programmes as an issue, and drew comparisons with 'strong engineering schools' in the US, and with challenging degree programmes in countries in Central Europe. More generally, the reduced numbers of students entering college with high Leaving Certificate grades were seen as an issue.

As a majority of companies said they were happy with the capabilities of the graduates they see, the current requirement for change is not across-the-board. As with the US, courses that are highly intensive technically can co-exist well with courses whose differentiating strengths lie in other areas. Thus there is a need not only to boost the number of students with high grades choosing to study computing and electronic engineering at Level 8; but also to strengthen the most technically intensive programmes at this level, and even introduce new technically intensive courses if sufficient demand can be established.

The Higher Education Authority should continue to provide funding to Higher Education Institutions to further develop and improve the attractiveness of the most technically intensive Level 8 programmes in computing and electronic engineering and subject to demonstrating a viable level of student interest, to enable institutions to develop new programmes focused on developing strong engineering skills. A small number of such programmes are required. The graduates of these programmes will provide skills for the most technically challenging work in the ICT sector in areas such as systems software, electronics design and development of complex networked applications.

Recommendation 9: Produce More Graduates with Domain-specific Knowledge[51]

One of the major needs identified by software companies is for more people with expertise both in computing and in business. People with these skills are required for roles in areas such as business analysis, product management, product development, sales and provision of services to customers. While a broad knowledge of business is useful, what companies want most are people who are expert in the application domain in which their products and services are used (e.g. banking).

In order to develop domain specific knowledge (deep knowledge of sectors in which applications will be used) and business competencies, Higher Education Institutions should consider further developments in the following areas, whether through modifying existing programmes or establishing new ones should a sufficient demand from students exists.

- Specialist taught masters programmes combining technology and business, each focused on the specifics of an application sector in which the Irish ICT sector has a strong presence, such as banking or telecommunications, and made available full-time and/or part-time, and targeted on both existing high-level ICT professionals and new Level 8 ICT graduates;

51 *This recommendation gives examples for purposes of illustration. The examples are not intended to be prescriptive.*

- Undergraduate Honours Bachelor Degree programmes combining technical and domain-specific business skills (such as a BSc in Banking Industry Technology or a BSc in Telecommunications Industry Technology);
- Industry-focused training programmes for working technologists, focused on industry domains that are important to a significant number of Irish technology companies (e.g. financial services); and
- Higher diploma/graduate diploma conversion courses, designed to introduce graduates in any discipline to computing. Where possible these conversion courses should feed masters programmes designed to deepen the technology skills learned.

Recommendation 10: Boosting Postgraduate Training

Postgraduate education has important functions in:

- Upgrading skills – giving students and professionals opportunities to improve and deepen their existing skills in areas such as software engineering; and
- Specialisation – providing opportunities to graduates who already have a strong general foundation of skills from an undergraduate degree in an ICT-related discipline to specialise in a particular technology or industry area.

While some specialisation can be accommodated at undergraduate level, much of the requirement for specialised courses can only realistically be accommodated at postgraduate level.

The HEA should be supported in continuing its strategy of promoting and supporting study on master courses (both part-time and full-time) in order to:

- Boost skill levels;
- Develop industry-relevant skills specialisations; and
- Providing lifelong learning opportunities.

8.6 Improving Intake of High-skilled Computing and Electronic Engineering Graduates from Third-level into ICT Sector

There is anecdotal evidence of a disconnect between employers perceived skills shortages and the experience of some graduates in accessing employment in the sector (although this may now be historical).

Recommendation 11: Strengthen Graduate Internship and Placement Programmes

Industry regards internships as an invaluable means of preparing students for work. It is recommended that they should become an integral part of both undergraduate and postgraduate courses. Graduate placement programmes have been useful in providing young people with temporary work experience after graduation and helping them get a job. They should be continued where they remain helpful to students and companies.

8.7 Supporting Educational Capacity

Many academic departments in higher education institutions that provide higher education courses in computing and electronic engineering face challenges in retaining the resources they need in the context of reduced undergraduate student numbers. Institutions have responded to the loss of income that has arisen from reduced undergraduate numbers by cutting the resources devoted to these departments for undergraduate teaching. While the Higher Education Authority has provided support for the retention of academic infrastructure, and while departments have been able to compensate in part by attracting research funding, and by expanding postgraduate education, if the loss of resources that has occurred since 2001 were to continue there is a risk that the system as a whole might be unable to respond effectively to a recovery in undergraduate applications. It is essential that this strategically important infrastructure is preserved. The support given by the HEA for retention of the academic infrastructure in computing and electronic engineering departments and for the improvement of retention and recruitment for ICT courses should continue. Departments should continue to innovate in their provision, to improve the educational experience, to better serve the needs of industry and research, and to enhance their status and reputation among school students and other groups of potential applicants.

Recommendation 12: Support Computing and Electronic Engineering Educational Capacity

The Higher Education Authority should continue their support for Higher Education Institutions computing and electronic engineering departments while undergraduate enrolments continue to be depressed. It should also continue to underpin measures aimed at improving retention and recruitment on ICT programmes.

The Higher Education Authority should continue to fund Higher Education Institutions to innovate within their current Level 8 course portfolios in computing and electronic engineering, in order to increase the marketability and relevance of such programmes.

8.8 Adopting Proactive Labour Market Strategies

The existing workforce in the ICT sector forms a valuable skill resource that requires investment to ensure that productivity levels remain high. Industry itself has a vital role to play in demonstrating the attractiveness of careers in their sector. Overseas labour markets form a potential source of recruitment of high-skilled personnel. The following recommendations are made in this regard.

Recommendation 13: Demonstrate the Attractiveness of Careers in ICT Sector

It is important that industry is competitive and able to attract the level of high-skilled graduate recruits it requires to meet its future skill needs. Industry must demonstrate that rewarding and attractive career paths are available for young people taking up employment in their sector. This is something which ICT firms, working together with their representative bodies could best achieve.

Recommendation 14: Continuing Professional Development

Third-level institutions, while having improved in recent years, should do more to engage with enterprises to provide flexible, accredited training course options responsive to the needs of enterprises and individuals.

Computing and electronic engineering are professions in which constant learning is required, both in technology and in related business skills. Continuing professional development should be supported by ICT companies as the main way that high – qualified computer and electronic engineering staff (at Level 8) can upskill and reskill to Level 9 (possibly Level 10). This can be done through part-time master courses, internal training in companies, self-learning etc. Shorter courses in generic skill areas such as communications, team working, problem solving, report writing, innovation and creativity skills would also be valuable.

The establishment of technology focused networks of high-level ICT staff is important (both within companies and beyond) as such networks play an important role in improving company performance and driving innovation[52]. Industry representative bodies should support the development of such networks.

Recommendation 15: Attract Skills through Foreign Recruitment

Recognising that the domestic supply of high-skilled ICT graduates will not meet the immediate high-level needs of the ICT sector and against a background of a world-wide shortage of high-skilled ICT people another source of supply is through foreign recruitment. In addition, mobility between Ireland and other major centres of ICT industry is also important to the cross-fertilisation of ideas and practices, which underpins innovation.

Ireland has a strong international reputation in IT and high-skilled people in other European countries would be positively disposed to careers here. To attract high-level ICT recruits from within the EEA, employers and their representative organisations should work closely with the EURES programme (operated in Ireland by FÁS). EURES Ireland's good knowledge of labour market conditions across EEA countries and their entrée into European Employment Placement Services can facilitate ICT company recruitment drives. While there is an upturn here in the ICT sector, this is also the case in several other European countries such as Sweden, Finland, Norway and the Netherlands who are also sourcing high-skilled professionals abroad.

High-level ICT staff from outside the EU form an important part of the supply available to ICT companies in Ireland. Where the skills required reside outside the EEA, the Department of Enterprise, Trade and Employment should ensure that applications for non-EEA migrants are processed quickly and efficiently within the boundaries of the economic migration regulations introduced in January 2007, and that the regulations are interpreted consistently and predictably.

The occupations within the ICT sector deemed to have skills shortages should continue to be reviewed by the Expert Group on Future Skills Needs, and advised to the Department of Enterprise, Trade and Employment.

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52 *Publica Consulting, (2006), Changing Nature of Skills in Selected Occupations: A Report to the EGFSN & Forfás.*

8.9 Overview of Recommendations

Recommendations	Timescale for Implementation	Timescale for Impact
Communicating Career Opportunities and Skill Needs		
1: Communicating Career Opportunities that Exist in Computing, Software and Electronic Engineering	S/T-M/T	S/T-M/T
2: Communicating Future Skill Needs	S/T-M/T	S/T-M/T
Broadening Base of Recruits for High-level ICT Courses		
3: Professional Development of Primary Teachers	S/T-M/T	L/T
4: Tackle the Incentives for Studying Leaving Certificate Mathematics at Higher-level	S/T	M/T
5: Professional Development of 2nd Level Maths Teachers	S/T-M/T	L/T
Improving Intake into Computing and Electronic Engineering Courses at Undergraduate Level		
6: Consider the introduction of Bursaries for high qualified students entering Level 8 computing and electronic engineering degree courses	S/T	M/T
7: Encourage high-skilled overseas ICT Students to come, study and work in Ireland	S/T	M/T-L/T
Changing Course Mix		
8: Produce more graduates with strong engineering skills	S/T M/T	M/T-L/T
9: Produce more Graduates with Domain-Specific Knowledge (in computing and business)	S/T-M/T	M/T-L/T
10: Ensuring the relevance of postgraduate training	S/T-M/T	M/T-L/T
Improving Intake of High-skilled Graduates into ICT		
11: Strengthen Graduate Internship and Placement Programmes	S/T-M/T	M/T
Supporting Educational Capacity		
12: Support Educational Computing and Electronic Engineering Capacity	S/T-L/T	M/T-L/T
Adopting Proactive Labour Market Strategies		
13: Demonstrate the attractiveness of Careers in ICT Sector	S/T-M/T	M/T
14: Continuing Professional Development	S/T-M/T	M/T
15: Attract Skills through Foreign Recruitment	S/T	M/T

Note: Short-term S/T 1-2 years *Medium-term M/T 2-4 years* *Long-term L/T 5+ years*

Appendix A:
Steering Group Members

Representative	Organisation
Ms. Anne Heraty*	CEO CPL Resources Plc.
Mr. Fearghal Hannaway	Duolog Technologies
Prof. Tom Brazil	UCD
Dr. Brendan Murphy	Cork IT
Mr. David Hedigan	Enterprise Ireland
Mr. Pat Howlin	IDA Ireland
Mr. Pat O'Connor	HEA
Ms. Joan McNaboe	FÁS
Ms. Kathryn Raleigh	ICT Ireland
Mr. Jim Friars	Irish Computer Society
Ms. Úna Parsons	Engineers Ireland
Mr. Martin Shanahan	Forfás
Mr. Gerard Walker	Forfás

* Ms. Úna Halligan chaired this Steering Group in 2007.

Appendix B: EGFSN Members

Representative	Organisation
Ms. Anne Heraty (Chairperson)	CEO, CPL Resources PLC
Ms. Ruth Carmody	Assistant Secretary, Department of Education and Science
Ms. Liz Carroll	Training and Development Manager, ISME
Mr. Enda Connolly	Divisional Manager, IDA Ireland
Mr. Fergal Costello	Head of IoT Designation, Higher Education Authority
Mr. Ned Costello	Chief Executive, Irish Universities Association
Mr. Brendan Ellison	Principal Officer, Department of Finance
Ms. Anne Forde	Principal Officer, Department of Education and Science
Mr. Roger Fox	Director of Planning and Research, FÁS
Mr. David Hedigan	Manager, Sectoral Enterprise Development Policy, Enterprise Ireland
Mr. Gary Keegan	Director, Acumen
Mr. John Martin	Director for Employment Labour and Social Affairs, OECD
Mr. Dermot Mulligan	Assistant Secretary, Department of Enterprise, Trade & Employment
Mr. Pat Hayden	Principal Officer, Department of Enterprise, Trade & Employment
Mr. Frank Mulvihill	President, Institute of Guidance Counsellors
Dr. Brendan Murphy	Director, Cork Institute of Technology
Mr. Alan Nuzum	CEO, Skillnets
Ms. Aileen O'Donoghue	Director of Financial Services Ireland, IBEC
Mr. Peter Rigney	Industrial Officer, ICTU
Ms. Jacinta Stewart	Chief Executive, City of Dublin VEC
Mr. Martin Shanahan	Head of Human Capital and Labour Market Policy Forfás, and Head of Secretariat

Appendix C: Publications by the Expert Group on Future Skills Needs

Report	Date of publication
Future Skill Needs of the Irish Medical Devices Sector	February 2008
The Future Skills and Research Needs of the International Financial Services Industry	December 2007
National Skills Bulletin 2007	October 2007
Monitoring Ireland's Skills Supply: Trends in Educational/Training Outputs	June 2007
Tomorrow's Skills: Towards a National Skills Strategy	March 2007
National Skills Bulletin 2006	December 2006
Future Skills Requirements of the International Digital Media Industry: Implications for Ireland	July 2006
Careers and Labour Market Information in Ireland	July 2006
Skills at Regional Level in Ireland	May 2006
SME Management Development in Ireland	May 2006
Monitoring Ireland's Skills Supply: Trends in Educational/Training Outputs	January 2006
Data Analysis of In-Employment Education and Training in Ireland	January 2006
National Skills Bulletin 2005	October 2005
Skills Needs in the Irish Economy: The Role of Migration	October 2005
Languages and Enterprise	May 2005
Skills Requirements of the Digital Content Industry in Ireland Phase I	February 2005
Innovate Market Sell	November 2004
The Supply and Demand for Researchers and Research Personnel	September 2004
Literature Review on Aspects of Training of those at Work in Ireland	June 2004
Financial Skills Monitoring Report	November 2003
Responding to Ireland's Growing Skills Needs – The Fourth Report of the Expert Group on Future Skills Needs	October 2003
The Demand and Supply of Skills in the Biotechnology Sector	September 2003
Skills Monitoring Report – Construction Industry 2003/10	July 2003
Benchmarking Education and Training for Economic Development in Ireland	July 2003
The Demand and Supply of Engineers and Engineering Technicians	June 2003
The Demand and Supply of Skills in the Food Processing Sector	April 2003
National Survey of Vacancies in the Private Non-Agricultural Sector 2001/2002	March 2003
National Survey of Vacancies in the Public Sector 2001/2002	March 2003
The Irish Labour Market: Prospects for 2002 and Beyond	January 2002
Labour Participation Rates of the over 55s in Ireland	December 2001

The Third Report of the Expert Group on Future Skills Needs – Responding to Ireland's Growing Skills Needs	August 2001
Benchmarking Mechanisms and Strategies to Attract Researchers to Ireland	July 2001
Report on E-Business Skills	August 2000
Report on In-Company Training	August 2000
The Second Report of the Expert Group on Future Skills Needs – Responding to Ireland's Growing Skills Needs	March 2000
Business Education and Training Partnership 2nd Forum, Dublin	March 2000
Business Education and Training Partnership Report on the Inaugural Forum, Royal Hospital Kilmainham	March 1999
The First Report of the Expert Group on Future Skills Needs – Responding to Ireland's Growing Skills Needs	December 1998

Appendix D: Glossary of Acronyms

CAO	Central Applications Office
CIP	Census of Industrial Production
CSO	Central Statistics Office
BPO	Business Process Outsourcing
EGFSN	Expert Group on Future Skill Needs
FÁS	National Training & Employment Authority
EI	Enterprise Ireland
EU	European Union
EURES	European Employment Services
FDA	US Food and Drug Administration
FETEC	Further Education and Training Awards Council
GDP	Gross Domestic Product
GLB	Good Laboratory Practice
GMP	Good Manufacturing Practice
HEA	Higher Education Authority
IEI	Engineers Ireland
ICS	Irish Computer Society
ICT	Information Communication Technology
IDA	Industrial Development Agency Ireland
IMDA	Irish Medical Devices Association
IC	Integrated Circuits
IP	Intellectual Property
IRCSET	Irish Research Council for Science, Engineering and Technology
NACE	General Industrial Classification of Economic activities in the European Communities
NAICS	North American Industry Classification System
NASSCOM	Indian IT Industry Organisation
NCCA	National Council for Curriculum Assessment
QC	Quality Control

QNHS	Quarterly National Household Survey
R&D	Research and Development
SET	Science, Engineering and Technology
SLMRU	Skills and Labour Market Research Unit (FÁS)
SME	Small Medium Enterprise
SSTI	Strategy for Science, Technology and Innovation
STEM	Science, Technology, Engineering and Mathematics
US	United States
VC	Venture Capital
WITS	Women in Technology and Science

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