A Study of the Electronics and Software Industry in Ireland
1960-2010

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Department of Management and Enterprise, Cork Institute of Technology, Cork, Ireland.

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A Study of the Electronics and Software Industry in Ireland 1960 - 2010

SARAH DAVIS
A Study of the Electronics and Software Industry in Ireland 1960-2010

Sarah Davis, B.E. (Electrical)

Thesis
Presented to the Department of Management and Enterprise of Cork Institute of Technology
Supervisor: Doctor Breda Kenny
in Fulfilment of the Requirements for the Degree of Master of Business

Submitted to Cork Institute of Technology, June 2015
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Abstract

A Study of the Electronics and Software Industry in Ireland 1960-2010

Sarah Davis

This study explores the origins of the Electronics/Software industrial sector in the Republic of Ireland and its subsequent development from 1960 to 2010 inclusive. A key focus of the study is to identify and explore the sectoral drivers/inhibitors. The influence of government policy and technical education on this development is explored. This research study was sponsored by the Irish American Partnership.

A critical realist philosophical approach is chosen to deal with the time-frame and the subject area breadth. An evolutionary research design process is used. An ongoing literature review and access to historical documentation provides other contextual data. Road-mapping is the chosen framework to deal with the complexity of the inter-related time-series for government policy, education and the industrial sector development. Empirical evidence in the form of fifteen semi-structured interviews was gathered, spanning the areas of government policy, technical education and the industrial sector itself.

Empirical findings are reviewed in light of the theoretical framework as well as the historical and archival sources. In addition to the industrial sector exploration, this research identifies management/social trends with implications for the sector - currently called the ICT sector. Conclusions and recommendations for government policy, technical education and the ICT sector are provided. This research is unique in tackling the development of a relevant industrial sector over a fifty year time frame and in using road-mapping in an historical study.
Declaration of Originality

No portion of the work referred to in this thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

I declare that the thesis embodies the results of my own work. Following normal academic conventions, I have made due acknowledgement of the work of others.

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Signed:  
Sarah Davis  
Date:  28-09-2015

Signed:  
Dr Breda Kenny  
Date:  28-09-2015
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<td>AnCO</td>
<td>An Chomhairle Oiliúna</td>
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<tr>
<td>AVT</td>
<td>Accelerated Vocational Training</td>
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<tr>
<td>BBC</td>
<td>British Broadcasting Company</td>
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<tr>
<td>BERD</td>
<td>Business Expenditure on Research &amp; Development</td>
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<td>BIC</td>
<td>Business Innovation Centre</td>
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<tr>
<td>BPO</td>
<td>Business Process Outsourcing</td>
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<td>BPSE</td>
<td>Business Process Services Export</td>
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<tr>
<td>BT</td>
<td>British Telecom</td>
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<tr>
<td>C.I.O.</td>
<td>Committee for Industrial Organisation</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
<td>CAO</td>
<td>Central Applications Office</td>
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<td>CAQDAS</td>
<td>Computer Assisted Qualitative Data Analysis</td>
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<td>CDM</td>
<td>Contract and Design Manufacturing</td>
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<td>CEB</td>
<td>County Enterprise Board</td>
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<td>CEIA</td>
<td>Cork Electronics Industry Association</td>
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<tr>
<td>CEO</td>
<td>Chief executive officer</td>
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<td>CIM</td>
<td>Computer Integrated Manufacturing</td>
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<td>CIP</td>
<td>Census for Industrial Production</td>
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<td>CIT</td>
<td>Cork Institute of Technology</td>
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<tr>
<td>CM</td>
<td>Contract Manufacturing</td>
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<td>CMOS</td>
<td>Complementary Metal Oxide Semiconductor</td>
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<td>CPD</td>
<td>Continuous Professional Development</td>
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<td>CR</td>
<td>Critical Realism</td>
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<td>CSO</td>
<td>Central Statistics Office</td>
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<td>CSR</td>
<td>Country Specific Resources</td>
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<tr>
<td>DEC</td>
<td>Digital Equipment Corporation</td>
</tr>
<tr>
<td>DES</td>
<td>Department of Education and Science</td>
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<td>DETE</td>
<td>Department of Enterprise Trade and Employment</td>
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<td>EEC</td>
<td>European Economic Community</td>
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<tr>
<td>IQ</td>
<td>Intelligence Quotient</td>
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<td>IRCHSS</td>
<td>Irish Research Council for</td>
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<td>Enterprise Ireland</td>
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<td>EMEAE</td>
<td>Europe, Middle East and Africa</td>
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<td>European Regional Development Fund</td>
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<td>Electricity Supply Board</td>
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<td>Economic and Social Research Institute</td>
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<td>EU</td>
<td>European Union</td>
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<td>FAS</td>
<td>Foras Áiseanna Saoghal</td>
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<td>FDI</td>
<td>Foreign Direct Investment</td>
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<td>FETAC</td>
<td>Further Education and Training Awards Council</td>
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<td>FSR</td>
<td>Firm Specific Resources</td>
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<td>GDP</td>
<td>Gross Domestic Product</td>
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<td>GPN</td>
<td>Global Production Network</td>
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<tr>
<td>GPS</td>
<td>Global Positioning System</td>
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<td>Global Value Chains</td>
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<td>HEA</td>
<td>Higher Education Authority</td>
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<td>HETAC</td>
<td>Higher Education and Training Awards Council</td>
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<td>HPSU</td>
<td>High Potential Start Up</td>
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<td>HR</td>
<td>Human Resources</td>
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<td>IBEC</td>
<td>Irish Business and Employers Confederation</td>
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<td>IC</td>
<td>Integrated Circuit</td>
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<td>ICSTI</td>
<td>Irish Council for Science, Technology and Innovation</td>
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<tr>
<td>ICT</td>
<td>Information and communications technology</td>
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<tr>
<td>IDA</td>
<td>Industrial Development Authority or Industrial Development Agency</td>
</tr>
<tr>
<td>IIRS</td>
<td>Institute for Industrial Research and Standards</td>
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<tr>
<td>IMI</td>
<td>Irish Management Institute</td>
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<tr>
<td>IoT</td>
<td>Institute of Technology</td>
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<td>IP</td>
<td>Intellectual Property</td>
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<td>NSD</td>
<td>National Software Directorate</td>
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<td>NUI</td>
<td>National University of Ireland</td>
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<tr>
<td>Acronym</td>
<td>Full Form</td>
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<tr>
<td>IRSET</td>
<td>Irish Research Council for Science, Engineering and Technology</td>
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<td>NQAI</td>
<td>National Qualifications Authority of Ireland</td>
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<tr>
<td>OE</td>
<td>Operational Effectiveness</td>
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<td>OECD</td>
<td>Organisation for Economic Co-operation and Development</td>
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<td>OEM</td>
<td>Original Equipment Manufacturer</td>
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<tr>
<td>P&amp;T</td>
<td>Posts and Telegraphs</td>
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<tr>
<td>PBL</td>
<td>Problem based learning</td>
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<tr>
<td>PC</td>
<td>Personal Computer</td>
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<tr>
<td>PESP</td>
<td>Programme for Economic and Social Progress</td>
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<tr>
<td>PEST(I)</td>
<td>Political Economic Socio-Cultural and Technological (and International)</td>
</tr>
<tr>
<td>PhD</td>
<td>Doctor of Philosophy</td>
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<tr>
<td>PND</td>
<td>Personal Navigation Device</td>
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<tr>
<td>PNR</td>
<td>Programme for National Recovery</td>
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<td>PRTL1</td>
<td>Programme for Research in Third-level Institutions</td>
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<td>PTT</td>
<td>Post, Telephone, Telegraph</td>
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<td>QDAS</td>
<td>Qualitative Data Analysis Software</td>
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<td>QQI</td>
<td>Quality and Qualifications Ireland</td>
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<td>R&amp;D</td>
<td>Research and Development</td>
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<td>RBV</td>
<td>Resource Based View</td>
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<td>RF</td>
<td>Radio Frequency</td>
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<td>RISC</td>
<td>Reduced Instruction Set Computer</td>
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<td>RTC</td>
<td>Regional Technical College</td>
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<td>NSC</td>
<td>National Software Centre</td>
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<tr>
<td>ODM</td>
<td>Original Design Manufacturer</td>
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<td>RTÉ</td>
<td>Radio Telefís Éireann</td>
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<td>SaaS</td>
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<td>SCA</td>
<td>Strategic Competitive Advantage</td>
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<td>SFADCO</td>
<td>Shannon Free Area Development Company</td>
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<tr>
<td>SME</td>
<td>Small to Medium Enterprise</td>
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<tr>
<td>SOE</td>
<td>Small Open Economy</td>
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<tr>
<td>STEM</td>
<td>Science Technology Engineering and Mathematics</td>
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<tr>
<td>SWOT</td>
<td>Strengths, weaknesses, opportunities and threats</td>
</tr>
<tr>
<td>TCD</td>
<td>Trinity College Dublin</td>
</tr>
<tr>
<td>TCP/IP</td>
<td>Transmission Control Protocol/Internet Protocol</td>
</tr>
<tr>
<td>TNC</td>
<td>Transnational Corporation</td>
</tr>
<tr>
<td>TRM</td>
<td>Technology Road Mapping</td>
</tr>
<tr>
<td>U.S. [A.]</td>
<td>United States [of America]</td>
</tr>
<tr>
<td>UCC</td>
<td>University College Cork</td>
</tr>
<tr>
<td>UCD</td>
<td>University College Dublin</td>
</tr>
<tr>
<td>UCG</td>
<td>University College Galway</td>
</tr>
<tr>
<td>VB</td>
<td>Visual Basic</td>
</tr>
<tr>
<td>VC</td>
<td>Venture Capitalist</td>
</tr>
<tr>
<td>VCR</td>
<td>Video Cassette Recorder</td>
</tr>
<tr>
<td>VEC</td>
<td>Vocational Education Committee</td>
</tr>
</tbody>
</table>
Chapter 1 Introduction

This chapter begins with a brief overview of the research study. It then proceeds to outline the research questions and objectives of the research. Next a working definition is sought for the industrial sector and finally, an overview of the structure of this thesis is given.

1.1 Overview of the Study

The Irish American Partnership, in conjunction with Cork Institute of Technology, offered an 18 month sponsored research study. They proposed a study into the development of the Electronics Sector in Ireland, from its beginnings. The advertisement for the scholarship is included, for reference, as Appendix A. The electronics industrial sector, in the Republic of Ireland, has grown and changed considerably since its beginnings. It is the focus of this study, which takes 1960 as its starting point. The electronics industrial base was very small at that stage. The industrial sector developed over the five decades and became the ICT sector. It was, and is, an important and complex industrial sector.

1.2 The Research Questions

This aim of this study is to examine the beginnings and, to explore the subsequent development of the electronics and software industry, in the Republic of Ireland, in the time period 1960 – 2010.

Within the stated time frame, further goals of this research are to identify key developments in technical education and to review how government policy affected the electronics and software (now called the Information and Communication Technology or ICT) sector in Ireland. Also, the effect of technology developments on the emerging industrial sector is explored.

Throughout this sectoral exploration, another goal of the research is to identify relevant determinants in the form of drivers and inhibitors for the sector over the study time frame. Identification of trends which occurred as the industry developed will also be sought.
Then this study looks to see what, if any, critical realist (CR) mechanisms can be identified from the above?

The next section describes the search for understanding of the sector through the development of a working definition of the industrial sector.

1.3 **Definition of the Industrial Sector**

For the purposes of this study, the Irish electronic and software industry, currently called the Information and Communications Technology (ICT) sector, is defined as the foreign-owned and indigenous firms actively involved in the production and/or servicing of hardware and software electronic products within the Republic of Ireland. This broad definition is a modified version of the definition used by Collins and Grimes (2008). Maintaining a broad definition of the sector allows the exploration of its emergence and development from its beginnings in the early 1960s.

Development of the Internet and Internet infrastructures, as well as advances in ICT related technology, promoted and continue to promote the development of e-business. However, e-business is not considered to be relevant to this study except that it is used by ICT firms in addition to the production/support of electronic or software products or services, per the above definition.

The term “Information Technology” was coined by Leavitt and Whisler in 1958 to identify new technology which had appeared after the Second World War and which they suspected would have major implications for management, particularly middle and top management in medium and large enterprises (Leavitt and Whisler 1958). Information technology (IT) involved the use of computers to process large amounts of information. The Organisation for Economic Co-operation and Development (OECD) indicated that the term IT was narrower than the term ICT and was used to denote computer, software and related technologies that did not include communications and network technologies. ICT referred to the family of related technologies that process, store and transmit information by electronic means (OECD 2003).
There was much variety in the definitions of the industry sector in reviewing the Irish context. The following quotation illustrates this:

"So many areas of Science and Technology contribute to the broad field of information systems that it is difficult to define the boundaries of the computer industry. Electronics, telecommunications and information sciences all play essential roles and, inevitably, any historical account of the industry in Ireland will encompass some developments from other related disciplines"

(Cox 2006).

In a study of the electronics industry in the Cork and Limerick/Shannon regions, Delaney (1987) examined five sub-sectors of the electronics industry. These were classified as:
1) Components, 2) Computer, peripheral and office equipment, 3) Instrumentation and industrial control, 4) Telecommunications and 5) Software.

Tiernan et al. (2006) defined the ICT sector as comprising the following sub-sectors: 1) computers, 2) components, 3) contract manufacturing, 4) semiconductors, 5) telecommunications and 6) data communication services. They reported exports of €21 billion from the sector in 2003. They listed our modern digital telecommunications system and the founding of the National Microelectronics Research Centre (NMRC) in Cork as drivers for success. The sector included both foreign multinationals and indigenous companies. Foreign companies, such as Apple, Verbatim, Amdahl, Sun Microsystems, Motorola and Intel were examples of large multinationals that had set up in Ireland. On the indigenous front, many small, successful Irish companies, such as Iona Technologies, Trintech and WBT were operating in the high tech sector (Tiernan et al. 2006).

O’Gorman et al. (1997) used National Software Directorate (NSD) data to define the Irish software sector. In their study, they applied Porter’s diamond model to analyse the indigenous Irish software sector. Their software sectoral definition is presented as an inclusion/exclusion list which is listed in Table 1.1.

In 1998, the Forfás breakdown of the ICT sector included 12 sub-divisions (Görg and Ruane 1998). These were broken down as 1) Computers, 2) Consumer Electronics, 3) Electronic components, 4) Instrumentation, 5) Networking & Data Communication, 6) PC Board Assembly, 7) Peripherals and Media, 8) Semiconductors, 9) Software Development,
10) Software Production, 11) Telecommunications and 12) Services – IT related services not included in other sub-sectors e.g. IT training and education. Görg and Ruane (1998) reported that 800 electronics firms were in operation in Ireland in 1995, 458 Irish-owned and 342 foreign-owned. Their data were based on the Forfás Employment Survey. They also accessed data from the Irish Economy Expenditure Survey for the years, 1982-1995 but found that only five firms were included in the sample each year throughout that period (Görg and Ruane 1998). Because of this variability in definition of the sector, an international perspective was also reviewed.

Table 1.1 Definition of the Software Sector

<table>
<thead>
<tr>
<th>Included are companies</th>
<th>Excluded are</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Developing software products/systems for subsequent sale to end users.</td>
<td>• Personnel of Irish companies who are based in overseas offices.</td>
</tr>
<tr>
<td>• Developing systems software and/or software development tools for sale to hardware/software vendors.</td>
<td>• Companies providing data entry or processing or bureau services for either local or overseas organisations.</td>
</tr>
<tr>
<td>• Providing services directly related to the design and/or development of software systems.</td>
<td>• Companies providing training services for standard software packages.</td>
</tr>
<tr>
<td>• Involved in the localisation of either their own organisation’s products or third-party products.</td>
<td>• The software development function of in-house IT departments.</td>
</tr>
<tr>
<td>• Involved in the development of programmes or systems for subsequent incorporation into dedicated hardware devices.</td>
<td>• Companies involved in the sale of hardware and/or third-party software packages, except where they have a separate software development function.</td>
</tr>
<tr>
<td>• Providing technical training in the areas of systems analysis, design and programming.</td>
<td></td>
</tr>
<tr>
<td>• Providing “hot-site”/disaster recovery facilities.</td>
<td></td>
</tr>
</tbody>
</table>

Definition by the National Software Directorate in a database of the Irish Software industry (O’Gorman et al. 1997)

The OECD member countries first agreed on a definition of the ICT sector in 1998 (OECD 2011). This defined the ICT sector as “a combination of manufacturing and service industries whose products capture, transmit or display data and information electronically” (OECD 2011, p.58). The OECD definition included hardware, packaged software and services as well as semiconductor technologies (OECD 2002). The ICT industry included
the sub-sectors of manufacturing, office, computing and accounting equipment as well as radio, television and communication equipment. Services in the ICT sector included post, wire or radio communication services offered to the public as well as services for the exchange/recording of messages (OECD 2002). The ICT sectoral definition was reviewed again in 2006. In 2007, an OECD agreed revised definition was based on ISIC Rev. 4 (International Standard Industrial Classification). This definition stated:

"The production (goods and services) of a candidate industry must primarily be intended to fulfil or enable the function of information processing and communication by electronic means, including transmission and display"

(OECD 2011, p.59).

In analysing the electronics global value chain, Sturgeon and Kawakami (2010) use the following Table 1.2 to break down the (hardware) electronics industry into nine main market segments.

Electronic Components is not included as a sector in Table 1.2 and Intel is considered to be a platform company and also not included. Many of the companies listed in Table 1.2 have subsidiaries in Ireland.
Table 1.2  Main Electronics Markets, Products and Lead Firms

<table>
<thead>
<tr>
<th>Main Market Segments</th>
<th>Product Examples</th>
<th>Lead firm Examples</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Computers</td>
<td>PCs (incl. desktop, notebook, netbook), enterprise computing systems, embedded computers</td>
<td>IBM, Dell, Apple, Fujitsu, Siemens, Hewlett-Packard, Acer, Lenovo</td>
</tr>
<tr>
<td>2. Computer peripherals and other office equipment</td>
<td>Printers, fax machines, copiers and scanners</td>
<td>Hewlett-Packard, Xerox, Epson, Kodak, Cannon, Lexmark, Acer, Fujitsu, Sharp</td>
</tr>
<tr>
<td>3. Consumer electronics</td>
<td>Games consoles, televisions, home audio and video, portable audio and video, mobile phone handsets, musical equipment, toys</td>
<td>Toshiba, NEC, Vizio, Sony, Sharp, Apple, Nintendo, Microsoft, Samsung, LG, NEC, Matsushita, Hitachi, Microsoft, HTC, Philips</td>
</tr>
<tr>
<td>4. Server and storage devices</td>
<td>Portable, internal, external, backup systems, storage devices</td>
<td>EMC, Toshiba, Western digital, NetApp, Hewlett-Packard, Hitachi, Seagate, Maxtor, LeCie, Quantum</td>
</tr>
<tr>
<td>6. Automotive electronics</td>
<td>Entertainment, communication, vehicle control, (braking, acceleration, traction, suspension), vehicle navigation</td>
<td>TomTom, Garmin, Clarion, Toyota, General Motors, Renault, Bosch, Siemens</td>
</tr>
<tr>
<td>7. Medical electronics</td>
<td>Consumer medical, diagnostics and testing, imaging, telemedicine, meters and monitoring, implants, fitness</td>
<td>General Electric, Philips, Medtronic, Varian</td>
</tr>
<tr>
<td>8. Industrial electronics</td>
<td>Security and surveillance, factory automation, building automation, military systems, aircraft, aerospace, banking and ATM, transportation</td>
<td>Diebold, Siemens, Rockwell, Philips, Omron, Dover</td>
</tr>
<tr>
<td>9. Military and aerospace electronics</td>
<td>Ground combat systems, aircraft, sea-based systems, eavesdropping and surveillance, satellites, missile guidance and intercept.</td>
<td>L-3 Communications, Lockheed Martin, Boeing, BAE systems, Northrop Grumman, General Dynamics, EADS, L-3 Communications, Finmeccanica, United Technologies.</td>
</tr>
</tbody>
</table>

Source: Sturgeon and Kawakami (2010)

The NACE code system is the European standard for industry classifications and it was introduced in 1970. NACE is an acronym of the French “Nomenclature générale des Activités économiques dans les Communautés Européennes”. A brief look at the Central Statistics Office (CSO) office listings of NACE codes, on-line, indicated that there are over 22 sub-sectors identifiable by searching for words like electronic, hardware, software, IT etc. Breakdown of the sector is still expanding and becoming more complicated. Currently,
however, in transmission of data to Eurostat, the CSO office follows an ICT definition as per that shown in Table 1.3 below.

Table 1.3  ICT NACE Codes used by the CSO office to Report to Eurostat.

<table>
<thead>
<tr>
<th></th>
<th>NACE codes per NACE Rev 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICT Manufacturing</td>
<td>26.1, 26.2, 26.3, 26.4, 26.8 (Data on Census of Industrial Production)</td>
</tr>
<tr>
<td>ICT Services</td>
<td>95.14, 46.5, 58.2, 61, 62, 63.1 (Data on Annual Services)</td>
</tr>
</tbody>
</table>

Source: E-mail from CSO dated 27/11/2014

Appendix B shows the development milestones in the evolution of the NACE codes. Restructuring in The International Standard Industrial Classification of All Economic Activities (ISIC Rev 4) affected some of the industries that are included in the ICT sector definition. The OECD expected that this would make it “very difficult to produce consistent time series when ISIC Rev. 4 was implemented” (OECD 2011, p.156). These changes to the NACE codes have implications for this research, making statistical tracking of the subsectors of the ICT sector difficult.

The industry definition was perhaps easier for the early 1960s, where fewer firms were operating in the country. These firms had clearly defined products and related services, mostly hardware, marketed to clearly defined sectors. Irish and international definitions of the ICT sector have evolved with time. Convergence has led to combinations of functions in telecommunications, computer and information products. The sector is continually adapting and changing. A broad definition allows the development of the sector in Ireland to be explored.

1.4  THESIS PLAN AND FORMAT

This Thesis is structured as illustrated in Figure 1.1 below. This chapter has outlined the research project, defined the questions to be answered by the study and defined the sector for the purposes of this study.
Chapter Two reviews the literature in the area of industry development and analysis. Frameworks are reviewed and a suitable framework is identified to match the research goals. Chapters Three reviews the literature in the areas of government industrial policy and of technical education. Chapter Four examines the literature to set the context of technological developments in the electronics industry in general and then examines the development of the electronics sector as it transitions into the current ICT sector. Four sets of time series, one for each area of government industrial policy, technical education, technological development and the Irish ICT sector result. Chapter Five then describes the methodology for this research study and describes the methods and methodological choices in detail. The empirical data collected is described in Chapter Six and the findings are tied to the research questions. Conclusions of the study are presented in Chapter Seven. The limitations, as well as, recommendations are outlined, along with areas for further research identified at the end of the research process.
Chapter 2  Literature Review Part I

2.1  INTRODUCTION

This section focuses on the areas of relevance to industrial emergence and development and examines possible tools, or frameworks to analyse industrial development in the ICT sector in Ireland. A framework is then chosen and modified for this study.

The next section reviews the role of the environment and the treatment of time. This is followed by a review of the literature on industry development, leading into to a section which considers frameworks for analysis of industry.

2.2  THE ENVIRONMENT AND THE TREATMENT OF TIME

2.2.1 The External Environment

The external macro environment consists of influences from political/legal, economic, socio-cultural, technological and international contexts (PESTI). Sometimes the environmental analysis is simplified and not all influences are included e.g. PEST or other variations. Such environmental influences tend to affect all organisations within an industry. PEST analysis is useful to identify "long-term drivers of change" (Johnson and Scholes 1993).

Figure 2.1 below illustrates Duncan's (1972) classification of organisational environment. He identifies two variables as being important in determining the nature of the environment. These are environmental complexity which can range from simple to complex. A simple environment indicates only a few determining factors are required to make a decision. The second determining variable is the rate of environmental change leading to either a static/stable environment or, conversely, a dynamic environment where the high rate of change makes decision making more difficult. The computer and telecommunications industries operate in a dynamic and highly complex environment and therefore face high uncertainty. Porter (1991, p.110) indicates that, where there is little exogenous change, strategy can be viewed as a "once-and-for-all game" but where exogenous change is rapid or continuous then choice of strategy is a "series of ever changing games".
2.2.2 The Global Environment

A global environment has three distinguishing features, namely, worldwide scope, increased convergence and interdependencies of an economic, business and political nature (Fahy 2001). Some industries, such as the semiconductor industry, are more subject to global influences than others (Fahy 2001). Strategic choices in global strategy show two different dimensions (Porter 1990). These are 1) configuration i.e. where and how activities are performed and 2) co-ordination of those activities. Based on a literature review, Fahy (2001) finds both exogenous and endogenous drivers affected the development of the global environment. The five exogenous variables are: technology, travel and communications, converging income levels, trade agreements and English language use. The four endogenous variables are strategic intent, shortened product life cycles, economies of scale and the need to amortise high R&D costs (Fahy 2001).

2.2.3 Industry Environment

Porter (1980) indicates that, while the external environment is of consideration in an industry-level analysis, it is the industry environment that has the most effect on the various elements of the five forces. The main dimensions of industry environment are industry concentration, state of industry maturity and exposure to international competition. Five important generic industry environments can be identified (Porter 1980). These are:
1) **Fragmented Industry Environment** characterised by a large number of SME enterprises (Small to Medium Enterprises) without market leaders to shape industry events, for example computer software.

2) **Emerging Industry Environment** characterised by the lack of rules. For example, the word processing industry and the PC industry in the 1970s.

3) **Transition Environment** from rapid growth to maturity, characterised by fundamental changes in the industry’s competitive environment.

4) **Declining Industry Environment** characterised by a decline in unit sales over a sustained period. Electronics and computers and such areas of technological change have contributed to a higher prevalence of this industrial environment (Porter 1980).

5) **Global Industry Environment** characterised by the need to compete on a worldwide co-ordinated basis to achieve a strategic advantage.

An industry boundary is often difficult to define precisely. No matter how loosely the boundary is drawn, technological change has an ability to broaden or to narrow the industry boundary (Porter 2004). Broadening can be by the geographic scope of the market, by globalisation, by adding new customers to the market through the introduction of better product performance, and it can increase the inter-relationships among industries.

Technological change can also narrow the industry boundary by segmentation, allowing segments of an industry to become industries themselves. The electronics and software industries in Ireland showed both the broadening of industry boundaries with product convergence and also the narrowing in the identification and specialisation in niche technical areas or segments.

2.2.4 The National Environment

"In most industries, a nation succeeds because it combines some broadly applicable advantages with advantages that are specific to a particular industry or small group of industries" (Porter 1990).

According to Porter (1990), one of three determinants normally triggers the formation of a local industry, namely (i) factors of production, (ii) related and supporting industries and
(iii) demand conditions. Table 2.1 lists the macro indicators Lasserre (2012) uses in assessing attractiveness of countries in international markets.

**Table 2.1 Macro-economic indicators of country attractiveness**

<table>
<thead>
<tr>
<th>Economic</th>
<th>GDP measures, income distribution, disposable income, saving rate, exports/imports, investment rates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sociological</td>
<td>Urbanisation, socio-economic distribution-by-income, socio-economic distribution by region, education</td>
</tr>
<tr>
<td>Demographic</td>
<td>Population, population growth, age distribution</td>
</tr>
<tr>
<td>Institutional</td>
<td>Government spending, infrastructure (power, telecoms, internet, roads etc.), education levels, number of scientists, R&amp;D expenditure</td>
</tr>
</tbody>
</table>

(Source: Lasserre 2012)

Porter (1990) claims that the source of competitive advantage can be the local environment.

"A nation provides a better environment for competing in some industries than others" (Porter 1990, p.546).

Successful firms tend to concentrate geographically within nations. According to Porter (1990), there is a dynamic development in the national and local environment for competing in a particular industry. The starting place is in history and in an inheritance from other industries. Figure 2.2 below shows a general trend of national development. Every country can upgrade its economic prosperity (Porter 1990). Countries tend to start with provision of factors and they graduate to investment based growth. Further evolution leads to innovation-led development. In the final stage of development, wealth drives national development and there is a tendency for decline.

![Figure 2.2 Stages of National Development](Source: Porter1991)

The local environment is further discussed in Porter’s diamond model. The next section reviews the treatment of time.
2.2.4 Treatment of Time

As this study explores the development of an industrial sector over a five decade period, the consideration of time and how change can be determined was reviewed in the literature.

"Time itself, sets a frame of reference which directly affects our perceptions of change" (VanDeVen 1992).

All change and development processes theories have three common elements. These are 1) a set of starting conditions; 2) a functional end-point and; 3) an emergent process of change (VanDeVen 1992). The starting conditions are those found in the early 1960s and the functional end-point is chosen as 2010. The electronic and software sector, as it went through an emergent process of change (developing into the ICT sector), is the subject of this study.

Farjoun (2002) divides strategy into an earlier, mechanistic view and a more recent, organic view which includes the importance of strategy processes. Inherent in this is a change in the perception of time. It requires a change in time perception from a discrete/synchronic to a diachronic/incessant time concept. A move from the three “D”s of discrete, directional and differentiated, to the three “I”s of incessant, interactive and integrated (Farjoun 2002).

The development of an industry is key to the research questions and, therefore, change and the dynamics of change need to be considered. According to Smith (2006, p.522), sensitivity to both the temporal dimension and the spatial dimension is required. This requires the consideration of a variety of policy areas that may themselves be undergoing changes as well as staying true to the temporal dimension by the mapping of the change processes over time (Smith 2006).

This mapping of the change processes over time is consistent with the road-mapping technique which will be discussed further in the framework section. The Technology Roadmap (TRM) can be seen as a flexible time-based chart and will be discussed later in more detail under the framework section. The next section reviews how an industry develops and examines determinants for industry, in the form of drivers and inhibitors.
2.3 Industry Development

Every industry begins with an initial structure and is configured by 'evolutionary processes' (deWit and Meyer 2010). Some general evolutionary processes are: long-run changes in growth, changes in buyer segments served, buyer's learning, reduction of uncertainty, diffusion of proprietary knowledge, accumulation of experience, expansion (or contraction) of scale, changes in input and currency costs, product innovation, process innovation, structural change in adjacent industries, government policy change and entries and exits. These processes operate "even if there are no important distinct events to signal this" (Porter 1980, p.184). Industry boundaries can shift with industry evolution. Innovation also acts as a driver which can affect industry boundaries as well as the relative positions of the five forces. This sometimes results in suppliers becoming direct competitors.

2.3.1 Dimensions of Industry Development

Development in an industry means a change to its structure (deWit and Meyer 2010). This industry development is illustrated in Figure 2.3 below. Some of the key dimensions along which industry can change are:

- **Convergence-divergence** i.e. the degree to which firms adopt/develop new business models.

- **Concentration-fragmentation** i.e. less companies in the industry with an increasing share of the market through M&As or company exits / average market share of the largest companies begins to decrease through new entrants.

- **Vertical integration-fragmentation** i.e. firms involved in more value-added activities / firms withdrawing from various value-added activities. Porter (1980, p.300) defined vertical integration as the "combination of technologically distinct production, distribution, selling, and/or other economic processes within the confines of a single firm".

- **Horizontal integration-fragmentation** - where the boundaries between different industries lose distinction or firms strictly confine themselves to their core business.

- **International integration-fragmentation** i.e. the lowering of the importance of geographical boundaries between different segments of an industry versus regionalisation of competitive interactions.
• **Expansion-contraction** i.e. increasing versus decreasing demand for products and/or services of a particular industry. Where periods of expansion and contraction follow each other the industry is said to be cyclical.

2.3.2 **Paths of Industry Development**

Industry development can follow four main generic patterns (deWit and Meyer 2010):

- **Gradual development** – a dominant business model is slowly replaced by slightly improved versions in a gradual development process.

- **Continuous development** – continuous changes to the dominant business model were frequent but relatively modest in size.

- **Discontinuous development** – sudden replacement of the long-term dominant business model with a radically better one.

- **Hypercompetitive development** – occurs in industries where the business models are often overtaken by radically better ones.

Development of an industry involves changes and the determinants of change can be classified as either drivers or inhibitors.

2.3.3 **Determinants of Industry Development**

While competitive advantage emerges from a firm’s activities, this does not explain why some firms are able to perform some activities at a lower cost or how firms can create more
value than others. Porter (1991) indicates that drivers are the answer. "Only by moving to the level of underlying drivers can the true sources of competitive advantage be identified" (Porter 1991). Determinants for industry development can be divided into drivers and inhibitors. Drivers push industry to change in a certain direction and inhibitors resist changes in the industry.

Porter (1991) lists the following as industry drivers: scale, cumulative learning in an activity, linkages, the ability to share the activity with other business units, capacity utilisation patterns over the relevant cycle, location of the activity, investment timing choices, extent of vertical integration, institutional factors such as government regulation and firm’s choices in configuration of activities.

Change drivers are external or internal to the industry. Drivers that are found in the contextual environment can be broken into PEST (Political, Economic, Socio-cultural and Technology) forces. These were already discussed in the Environment Section above. Porter (1991) states that industry forces can be broken down into the five forces comprising groups of buyers, suppliers, existing rivals, new entrants and substitutes. Change drivers can be found in each of these areas. Change in one area of the system can cause changes elsewhere in the system but this change is not guaranteed to occur. Sometimes industry changes are triggered by a single firm, usually an industry leader firm.

Changes within an industry are usually due to interactions of many drivers and inhibitors and industry dynamics, itself, can act as a driver. Phaal et al. (2011) find that enablers and barriers to industrial development are contextual, industry-specific and depend on the phase of industrial emergence of the industry under review. They identify a co-evolutionary process between the demand side, or market forces and the supply side, or technological forces, as a key driver.

In analysing evolution of an industry, Porter (1980, p.162) indicates that identification of the underlying drivers is more useful than a simple description of industry evolution. He points to evolutionary processes as the forces that create the incentives or pressures for change. Evolutionary processes push industry from its initial structure towards one of many
potential structures. At firm level, Porter (2004) finds that drivers are based on cost leadership and differentiation strategies and these are summarised in Table 2.2.

Table 2.2  Cost and Differentiation firm level drivers

<table>
<thead>
<tr>
<th>Cost Driver</th>
<th>Uniqueness Driver</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Economies of scale</td>
<td>Policy choices</td>
</tr>
<tr>
<td>2 Learning and spill-overs</td>
<td>Linkages</td>
</tr>
<tr>
<td>3 Pattern of capacity utilisation</td>
<td>Timing</td>
</tr>
<tr>
<td>4 Linkages</td>
<td>Location</td>
</tr>
<tr>
<td>5 Interrelationships</td>
<td>Interrelationships</td>
</tr>
<tr>
<td>6 Integration</td>
<td>Learning and spill-overs</td>
</tr>
<tr>
<td>7 Timing</td>
<td>Integration</td>
</tr>
<tr>
<td>8 Discretionary Policies independent of other drivers</td>
<td>Scale</td>
</tr>
<tr>
<td>9 Location</td>
<td>Institutional factors</td>
</tr>
<tr>
<td>10 Institutional factors</td>
<td></td>
</tr>
</tbody>
</table>

(source: Porter, 2004)

Cost drivers can vary over time independent of strategy and lead to changes in industry structure. Porter (2004) calls this ‘cost dynamics’. He identifies the most common sources of cost dynamics as industry’s real growth, differential scale sensitivity, different learning rates, differential technological change, relative inflation costs, ageing capital base or workforce, and market adjustment. Under differential scale sensitivity, Porter (2004, p.95) gives the example of software costs rising in comparison with hardware costs in many electronics related industries such as computers and telecommunications. This is due to hardware being more sensitive to scale and learning. Also uniqueness does not lead to differentiation unless it is perceived as valuable to the buyer (Porter 2004).

2.3.5 Inhibitors of Industry Development

Some forces act to oppose change. These inhibitors can lead to industry rigidity. Examples of factors which act as inhibitors are:

- **Underlying conditions** – economies of scale required/not required, buyer fragmentation/concentration, product differentiation/price etc.
- **Industry integration** – “locked in” nature of some industries to specific structures/standards.
• **Power structures** – powerful industry incumbents versus "rule breakers".
• **Risk averseness** – more risk averse usually means more rigidity.
• **Industry recipes** – cognitive map of industry structure and demands held by industry incumbents.
• **Institutional pressure** – pressure from government, professional associations, trade unions etc., limiting what is acceptable strategy and behaviour (deWit and Meyer 2010).

Technological change plays a major role in industry structural change and is a key competition driver (Porter 2004, p.164). It can even create new industries. Technological evolution in an industry results from interactions such as scale changes, learning, uncertainty reduction and imitation, technology diffusion and diminishing returns to technological innovation in value activities (Porter 2004). Value activities are further explained in the Value Chain section. Not only is technology a driver in and of itself but it can also affect the other cost or uniqueness drivers (Porter 2004).

Technological change can also act as an inhibitor, in that it can erode competitive advantage in well-established firms and propel new firms to leading positions by changing the industry structure. Despite technological change being an important driver, many high-technology companies can be less profitable than some low-technology companies (Porter 2004, p.165). It is the capacity to deploy technology and not mere access or use of technology that leads to competitive advantage (Porter 1990).

Porter (2004) describes four circumstances where technological change can lead to competitive advantage. These are

- Where technological change itself lowers cost or enhanced differentiation where the firm's technological lead was sustainable.
- Where technological change shifts cost of uniqueness drivers in a firm's favour.
- Where first-mover advantages can be achieved from pioneering the technical change (other than those inherent in the technology itself).
- Where the technological change improves the overall industry structure.
If a technological change fails the above four tests, it will be unlikely to improve the competitive condition of the firms in an industry. Therefore technological change can act as either a driver or an inhibitor, depending on circumstance.

The time period for measurement is another challenge for strategic theory, where both exogenous and endogenous variables, as well as environmental factors, were and are subject to change over time. Porter (1991) indicates that when examining strategy over long periods, it is more appropriate to seek determinants earlier in the causality chain. This is compatible with the aims of this study which seeks to establish the development of an industrial sector over a long time period and establish drivers and inhibitors for the electronics and software industry.

The following section reviews some industry analysis frameworks. A summary of the frameworks is then given and one is selected as a best fit and modified for use in this study.

2.4 Frameworks for Industry Analysis

"Frameworks identify the relevant variables and the questions which the user must answer in order to develop conclusions tailored to a particular industry and company"  

Frameworks can be viewed as tools to a better understanding of the competitive environment. The firm, the industry and the broader environment need to be addressed in attempting to find a dynamic theory of strategy (Porter 1991).

2.4.1 Review of Frameworks Considered

A review of available frameworks, both firm-specific and industry-related, was undertaken to choose a framework for this industry analysis. The firm specific frameworks were examined to see if they would allow broadening to an industrial analysis. Then the frameworks for industry analysis were reviewed. A summary of all of the frameworks considered is shown in Table 2.3.
Table 2.3 Evaluation of Frameworks for Applicability to this Study

<table>
<thead>
<tr>
<th>Framework</th>
<th>Features</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
<tbody>
<tr>
<td>SWOT (Strengths, weaknesses, opportunities and threats)</td>
<td>General Planning - 1) identify current strategy position 2) PEST analysis 3) Resource profile</td>
<td>Well used and understood</td>
<td>Static Mainly applied at firm level Would need to be done numerous times at industry level to cover time frame</td>
</tr>
<tr>
<td>Mintzberg's Framework</td>
<td>Looks for fit between environment and organisational structure Five structural types</td>
<td>Covers organisational types and their environments Could cover government, industry firms and educational establishments</td>
<td>Static Mainly applied at organisational level Doesn’t cover industry evolution</td>
</tr>
<tr>
<td>Dunning’s Eclectic Theory for international production</td>
<td>OLI advantages General Theory of internationalisation -</td>
<td>Won’t cover historic indigenous firms and only covers internationalisation Doesn’t fit to 50 year analysis</td>
<td>X</td>
</tr>
<tr>
<td>The Product Life-cycle</td>
<td>Four phases of development 1) Innovation 2) Growth 3) Maturity 4) Decline</td>
<td>Intuitive, well used well recognised, crosses both technology and industry</td>
<td>Doesn’t account for global networks Debate as to whether it can be used for industry Duration of each stage not defined. Sequence not always followed</td>
</tr>
<tr>
<td>RBV (Resource Based View)</td>
<td>Based on both country specific resources and firm specific resources</td>
<td>Widely used general strategy framework</td>
<td>More suited to positivist study where resources can be identified and quantified. Mostly used at firm level.</td>
</tr>
<tr>
<td>PEST (Political, Economic, Socio-cultural and Technology)</td>
<td>Broad environmental</td>
<td>Can be applied to analyse industry environment and firm environments Can be used to identify exogenous drivers</td>
<td>Needs to be used in conjunction with other models i.e. industry model +PEST</td>
</tr>
<tr>
<td>Porter’s Five forces</td>
<td>Five Forces of 1) Potential new entrants 2) Threat of substitutes 3) Bargaining power of suppliers 4) Bargaining power of buyers 5) Rivalry among existing firms</td>
<td>Well known and used Industry structure framework</td>
<td>Static Not typically used to show industry development</td>
</tr>
<tr>
<td>Porter’s Diamond Model</td>
<td>Four Determinants of national competitive advantage 1) Factor conditions 2) Demand conditions</td>
<td>Well known and used framework,</td>
<td>Static Identified as not suitable for small open economies</td>
</tr>
</tbody>
</table>
### Framework Features

<table>
<thead>
<tr>
<th>Framework</th>
<th>Features</th>
<th>Advantages</th>
<th>Disadvantages</th>
</tr>
</thead>
</table>
| 3) Related and supporting industries  
4) Firm strategy, structure and rivalry | | | Doesn’t consider the importance of FDI, which is considerable in the case of Ireland  
Meant to be used with a narrow industry definition |

| Global Value System | Activities. Focus on organisation’s activities, on configuration and inter-relationships. Based on Value System and Value Chain | Activities can be viewed across the three areas of industry, education and government policy  
Is widely associated with the ICT sector in Ireland | Not particularly suitable for past indigenous firms but may have more relevance in future business models |

| Road-mapping Framework | Three elements of  
1) Technology based industrial emergence  
2) Key themes and demand and supply-side drivers  
3) Significant events and milestones | Used to understand dynamics and characteristics of emergence of industry  
Matches a critical realist perspective  
Flexible framework  
Views industry as a complex system  
Suitable for qualitative case study method  
Suitable for use with long time frame | Forward looking strategic mapping but can be adapted to include history.  
Full framework too large to achieve in scope of this research |

In the next section, the value system is reviewed because it has particular relevance for the ICT sector. Then Porter’s industry analysis models and technology roadmapping (TRM) are explored. Finally, a justification for the choice of TRM is presented.

#### 2.4.2 The Value system

Industry structure shapes the value chains of the firms operating in an industry and is a reflection of the competitors’ collective value chains (Porter 2004). The concept of the value chain is rooted in industrial economics. Porter (1991) claims that discrete activities create buyer value and differentiation and he illustrates the various activities in terms of the value chain and the value system, shown below in Figure 2.4. Under these representations, the firm’s value chain is embedded within the larger value system. Upstream, means closer to the raw material end and downstream is closer to the final customer (Porter 1991). The
value system and value chain is considered in detail here as it has particular relevance to Irish electronic and software development.

In generic value chains, as shown in Figure 2.4, the activities are either primary activities, such as logistics, operations, service, sales and marketing or, support activities, such as infrastructure, technology, procurement and HR (human resource) management.

**Figure 2.4  Value System and Value Chain**

Electronics firms can use the twin strategies of outsourcing and off-shoring quite easily (Sturgeon and Kawakami 2010). This is because there is less need for the engineers to co-locate than with other high technology sectors. Sourcing is often done globally and it is relatively easy to move and adapt electronics factories. This has resulted in the electronics industry being more geographically extended and more dynamic than any other sector producing goods. Sturgeon and Kawakami (2010) identify flexibility, resiliency, speed and economies of scale (which accrue at the industry level rather than the firm level) as the characteristics of value chain modularity. This is possible due to the standardised or "formalised" exchange of information between the links or value chain firms. They support these claims with figures from the intermediate goods trade. Out of the top 50 products,
24.4 per cent were electronic in 1988 and this grew to 43.3 per cent in 2006 (Sturgeon and Kawakami 2010).

Greenstein (2005) indicates that the value chain is a core concept of manufacturing electronics. He reports confusion in using the concept in relation to global outsourcing in electronic equipment manufacturing. The supply chain includes all the steps from raw material to final products. The value chain puts a monetary value on each step in the supply chain. Per Greenstein (2005), while the difference is subtle it has implications for strategy and gives a means of judging which plants have valuable operations. Value added is the difference between the market value of the inputs and the market value of the final goods. Value activities are related within the value chain by linkages. Linkages can lead to competitive advantage by either a process of optimisation or a process of co-ordination (Porter 2004).

Sturgeon and Kawakami (2010) examine the importance of electronics global value chains (GVCs) to the global economy. They identify three main firm-level actors in GVCs. These are: lead firms, contract manufacturers and platform leaders.

**Lead Firms**
Lead firms sell branded products and/or systems to end-users. They are called lead firms as they initiate GVC activities by placing orders with suppliers. Most electronics lead firms are located in industrialised countries, particularly in the United States, Japan and Western Europe and, more recently, in the Republic of Korea. Many of the lead firms in the electronics markets have subsidiary operations in Ireland. Developing countries have generated only a few important lead firms and this is also true in Ireland. Electronics manufacturers tend to be 'trapped' in the low value-add parts of the GVC (Sturgeon and Kawakami 2010). For example, branded lead firms, such as HP and Dell, tend to capture most of the profits, although it is often platform leaders, such as Microsoft and Intel, who successfully capture the most significant value.

**Contract Manufacturers**
Contract manufacturers (CMs make products for lead firms and sometimes they also provide design services (CDMs). While some lead-firms manufacture their products in house, Sturgeon and Kawakami (2010) indicate that the use of contract manufacturers has
been a strong trend since the 1980s. Sturgeon and Kawakami (2010) characterise electronics CM as high growth but with low-profitability. CM is prone to intense competition and consolidation.

Sturgeon and Kawakami (2010, p.15) indicate that consolidation amongst electronics suppliers has led to larger supplier firms who provide a one-stop shop solution to lead firms for their global supply needs.

Langlois (2003) indicates that these CMs are not only specialists, but also generalists. They have a high specialisation in function but a generalisation in capabilities. Langlois (2003) identifies a trend toward general-specialists who are not tied to any particular brand or product but can diversify by the range of customers who supply them with work. This aids in achieving high-volume production.

The company PCH was founded in Cork, in 1996, by Liam Casey. PCH opened an operational centre in Shenzen, China in 2002. They have expanded since then and added engineering and design functions. They currently provide solutions to both lead firms and technology start-ups.

**Platform Leaders**
Platform leaders are companies that have been successful in implanting their technology (as hardware, software or a combination of both) in the products of other companies. Intel is a good example of a platform leader in the PC industry. Mobile phone handsets are a second area where platform leaders have dominated over lead firms. Platform leaders have both technological capabilities and market power to position the points on the value chain where open standards can start (Sturgeon and Kawakami 2010). Apple is unusual in that it is both a lead firm and a platform leader. It has created an ‘ecosystem’ of suppliers of software applications and hardware add-on products by the limits it has put on the scope of such products and also by limiting the specification that they publish (Sturgeon and Kawakami 2010).

Sturgeon and Kawakami (2010) ask why global value chains (GVCs) are more extensive and dynamic in the electronics industry than in other industries. They point to the high value-to-weight ratio (assisted by miniaturisation and Moore’s Law) of most electronics
parts and final goods which make long-distance transport cost effective and mean companies can operate based on optimum geographic operating costs. Also, due to the rate of technological development, import substitution policies are unlikely to succeed and, indeed, incentives are often given for industry to invest, perhaps due to the "propulsive" nature of the industry.

Sturgeon and Kawakami (2010) identify US outsourcing as a key driver for GVC expansion. Low rates of unionisation in the US electronics industry and the holding of design and innovation functional capabilities meant that there was low political or general public resistance to the moves. Outsourcing and off-shoring strategies are popular after recessions due to a reluctance to risk expanding internal capacities.

Sturgeon and Kawakami (2010) used intermediate-goods trade figures to support the notion that the electronics industry was subject to the "bullwhip" effects of recession and recovery. Components and parts are more subject to slowdowns and downturns than final goods because, in uncertain times, producers work to reduce inventory and delay reordering. Also intermediate goods tend to grow again after recessions and after sectoral bubbles (1985 PC bubble, 2001 dot.com bubble, East Asian financial crisis, oil shocks 1972 and 1979).

A further reason for the global nature of electronics is down to the nature of the products and the value-chain architecture. Sturgeon and Kawakami (2010, p.10) characterise both of these as highly "modular". Electronic products and customer applications initially were non-standardised and exhibited wide variety. The industry developed "de facto and de jure" standards for components, systems and production processes. The development of Computer Aided Design (CAD) and the shift from analogue to digital systems simplified the codification of electronic systems and components.

Digitisation also led the way to the development of the internet and information technology. Digitisation served to enhance the modularity of electronics and led to higher interoperability, where system elements could be combined or removed, without requiring a complete product/system redesign. The fact that the internet was not tied to any particular computer platform, facilitated global sharing of data, and added to the attractiveness and monitoring of GVCs. Similarly, the modularity of electronics production, whereby key
business processes such as CAD, production planning, inventory control, logistics and the production processes of assembly, test, quality inspection, existed independently of the other processes.

Sturgeon and Kawakami (2010) identify complexity, codifiability and supplier competence as being the three GVC governance variables that determine competitive outcomes. Increased complexity leads to alterations in positioning of the codified links in the GVC which can force local firms to bundle (supply products or components with increased functionality) new technologies. An example of this is, the addition of colour LCD (Liquid Crystal Display) displays, MP3 music playing and full cameras features becoming available on mobile phones (Sturgeon and Kawakami 2010).

Digital content is identified as a recent driver for all areas of the ICT industry (OECD 2006). Improvements in networking, software and hardware allow more advanced digital content. Development of digital content is posing a challenge for non-digital value chains. Digital value chains are very complex and diverse and dis-intermediation and re-intermediation are occurring within them. This adds new participants to the value chain and leads to new business models such as pay-per-use, subscriptions and others (OECD 2006).

There are impacts to the value chains and business models outside of the ICT sector also (OECD 2008). Cross-industry collaboration and new business partnerships are developing. Broadband has enabled the development of new e-business value chains and business models in a similar way to the earlier general purpose technologies such as the development of electricity (OECD 2008).

Firms look to increase their plants' added value and endeavour to do this by climbing the value chain. They can do this in two different ways by either process climbing or by product position climbing (Greenstein 2005). These processes are not mutually exclusive. For example, when looking to reposition a product, companies might well use contract design and manufacturing houses. Apple, after designing the iPod product, sourced much of the hardware from CM services. Greenstein (2005) points to tension between high-end branded firms who look to outsource CM services and Contract and Design manufacturing (CDM) houses who are seeking to become original design manufacturers (ODMs).
Process climbing requires a plant to take control of more processes in the value chain which is the more familiar method of climbing the value chain. Greenstein (2005) indicates that moving from CM to CDM and from there to ODM was one way to climb the value chain. The second route to climbing the value chain is related to product position climbing. Many firms start with a low cost commodity product to develop a brand reputation and build up distribution channels. When successful, they expand into other product lines and segments. Greenstein (2005) cites the example of Sony who began in the electronics business in transistor radios and recording devices. Over time Sony expanded into a broad range of consumer electronic products. The success rate in this type of repositioning is not high and strategically involves many tough decisions.

Barrientos et al. (2011) identify four types of upgrading. These four types of economic upgrading are: 1) Process upgrading, e.g. higher productivity through automation; 2) Product upgrading, e.g. manufacture of more advanced product types requiring higher skilled jobs; 3) Functional upgrading, e.g. a shift to higher value in the mix of activities performed and; 4) Chain upgrading, e.g. a shift to higher technologically advanced production chains e.g. in new industries or product markets.

Barrientos et al. (2011) examine the economic and social upgrading associated with global production networks (GPNs). GPN analysis focuses on the complete range of actors (governments, trade unions, NGOs, various organisations) who influence or shape the global production network. Each type of upgrading has both a capital and a labour dimension (Barrientos et al. 2011). While the five different types of work are required in each GPN, the proportion at each level differs across the different sectors. The capital dimension involves more advanced technology or new machinery and the labour dimension improves skills development or productivity.

In electronics, in the global value chain, functional upgrading occurs when firms upgrade from simple assembly to CM or to ODM, both of which require new skills in the workforce to match expanded firm capabilities.

The GVC framework, illustrated in Figure 2.5, views how value is created and captured within the global supply chains. The GVC approach can be taken as a top-down approach
consistent with the ‘governance’ of the GVC or alternatively a bottom-up approach or an ‘up-grading’ perspective. Figure 2.5 shows the five different types of global value chain governance (Gereffi and Lee 2012; Gereffi 2011). The five types of structure are Market, Modular, Relational, Captive and Hierarchy. Gereffi and Lee (2012) indicate that Markets and Hierarchy (i.e. vertically integrated) are the extremes and, in between, are the network forms of GVC governance, i.e. modular, relational and captive structures.

*Market governance* describes a situation where suppliers make their products with little coordination with buyers and price is the governing mechanism. With *modular governance*, suppliers and customers exchange information (standards) and suppliers make their product to customer specification.

*Relational governance* occurs where there is a requirement for sharing of complex information between supplier and customer leading to knowledge sharing and mutual trust. *Captive governance* typically occurs where a supplier (or group of suppliers) is dependent on one or a few dominant buyers. *Hierarchical governance* is recognisable by vertically integrated chains under managerial control of lead firms who develop and manufacture products in-house (Gereffi and Lee 2012).
In GPNs, the economic and social upgrading that can occur is illustrated in tabular form in Table 2.4.

**Table 2.4  Key Drivers of Economic and Social Upgrading and Downgrading**

<table>
<thead>
<tr>
<th>Economic Upgrading/Downgrading</th>
<th>Social Upgrading/Downgrading</th>
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<tbody>
<tr>
<td>(+) Allows poor workers to engage in GPNs</td>
<td>(+) High quantity of jobs, especially for female workers</td>
</tr>
<tr>
<td>(+) Provides access to niche products and labour skills, such as high plateau teas</td>
<td>(+) Women can balance productive and reproductive work</td>
</tr>
<tr>
<td>(+) High dependence on intermediaries who can support or exploit</td>
<td>(+/-) Long or insecure working hours and poor conditions</td>
</tr>
<tr>
<td>(+/-) Difficulty meeting standards, hence exclusion from GPNs</td>
<td>(-) Lack of social protection and rights</td>
</tr>
<tr>
<td>(+) Often low value-capture within chain</td>
<td>(+/-) High quantity of jobs (especially for female workers)</td>
</tr>
<tr>
<td></td>
<td>(+) Low quality, low wages; &quot;footloose&quot; jobs</td>
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<tr>
<td></td>
<td>(-) Operation of labour relations predominantly on a flexible, casual basis</td>
</tr>
<tr>
<td></td>
<td>(-) Absence of fixed working hours</td>
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<tr>
<td></td>
<td>(-) Lack of employment security and other benefits</td>
</tr>
<tr>
<td></td>
<td>(-) No skill improvement (repetitive, scrappy work)</td>
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Source (Barrientos et al. 2011, p. 311)
According to Haugh (2013), the high level of FDI in Ireland is responsible for Ireland’s involvement in GVCs. Begley et al. (2005) indicate that the nature of the multinational business in Ireland has changed over time from low-cost manufacturing/assembly to more ‘leading edge, knowledge-intensive’ activity. Ireland has gained an advantage and competence in manufacturing. A move up the value chain to incorporate other high-value activities was seen as a way to offset some of the negative effects of Ireland’s no longer being a low cost base. Backward participation was higher than forward participation, i.e. Irish-produced inputs were being used in third country exports (Haugh 2013).

2.4.3 The Value Chain in the ICT sector in Ireland

Collins and Grimes (2008) identify two significant trends in the evolutionary path of Irish subsidiaries. These are firstly, the shift up or down the value chain to product, fleet, logistics and control of the supply chain functions and, secondly, to increasing subsidiary value to the organisation by servicing customers within the EMEA (Europe, Middle East and Africa) region. A level of competence in the original subsidiary mandate and profitability are listed as key drivers for these moves along the value chain of the organisation. Similarly, Begley et al. (2005, p.203) find that Ireland’s “business proposition has relied on activities in the value chain where it could deliver comparative advantage” and that this advantage over the fifty years was mostly in manufacturing.

The value chain is also mentioned by Sterne (2004, p.108) in relation to the Irish software industry. In reviewing the Irish software industry, he reports that “The value chain began with software development, evolved through independent service providers and has now led to a cluster of ‘language-ware’ expertise”. This was accomplished in only two decades. The University of Limerick was home to a respected Localisation Research Centre since 1999.

Barry and vanEgeraat (2005) review employment trends in EU data. They use industry codes NACE30 (manufacturing of office machinery and computers) and NACE3210 (manufacturing of electronic components) and find a downward trend noticeable from around the year 2000. They consider that the decline was significant enough to indicate that the global high-tech downturn alone was not sufficient to account for it. Also, they note that the component subsector had been growing relative to the computer assembly subsector. As
these provide higher wage jobs, they point to higher positioning on the value chain as a likely explanation but they point out that about a third of the component sector employment is in the platform leader, Intel (Barry and vanEgeraat 2005).

In the late 1990s, with rising costs in Ireland, many manufacturing subsidiaries had already departed or were in danger of having to shut down. Molloy and Delaney (1998) stated that surviving subsidiaries couldn’t afford to rest on their laurels and remain happy with the status quo. Being good or even excellent at fulfilling their original mandate (“Boy-scout”) was no longer sufficient, they needed to be proactive in pushing the boundaries (“Subversive”) to obtain optimum possible positioning of their subsidiary and thus become a vital part of the corporate value chain.

The government had taken a two prong approach to move the commercial base significantly up the value chain (Begley et al. 2005). The first prong was in seeking to attract companies in knowledge-intensive industries and the second was to encourage companies already in Ireland to increase their activities in the higher value-add functions (Begley et al. 2005). Achievement of these twofold functions required the skills of the IDA as well as desire within the subsidiary management to upgrade and an ability to advocate within their organisations for higher functions (Begley et al. 2005).

Standardisation (through technology, automation and commoditisation) acted as a negative driver for the manufacturing industry in this country. It resulted in many manufacturing functions moving to low cost locations. Molloy and Delaney (1998) recommended that subsidiaries should consider moving their position on the value chain. According to them, there were options for moving to the left (R&D and Sourcing) or to the right (Logistics or Sales &Marketing) or for extension of corporate support activity (e.g. HR, Training, Finance, Strategic planning, Regulatory work). This would help to avoid the collapse of the middle (Operations) in the Value Chain. These moves were to more knowledge intensive areas requiring higher educational levels and where activities were much less dependent on geographic location. Increase in scope, by these strategic moves, would be better in the long run than just an increase in scale (Molloy and Delaney 1998, p.16). They quoted one General Manager as saying “You don’t want to take on responsibility for work that has ‘destined for Taiwan’ written all over it”.

31
2.4.3.1 Stages of Strategic Development

Table 2.5 lists eight stages in increasing and extending subsidiary mandates to become more strategically involved and add value to the parent organisation, as recommended by Molloy and Delaney (1998).

Stages 1-4 comprise a basic mandate which applies to operations, marketing satellites and miniature replicas. These are at the domain consolidation phase. From stages 4 upwards, domain development begins to take place. Throughout the process, defending and maintaining credibility are critically important. Achievement of Stages 4, 5 and 6 give enhanced mandates. Advanced mandate sites are in stages 6, 7 and 8. Movement in both directions is possible. Constant vigilance by management of the subsidiary is necessary to ensure backward movement does not occur (Molloy and Delaney 1998).

While seeking for ways to move up the value chain, Molloy and Delaney (1998) recommend having the vision to stretch for capabilities higher on the value chain internally within the subsidiary. A further recommendation is the strategic leveraging of external resources. Examples of potential resources are local universities/technical centres with existing competency in research, potential partnering with suppliers, advice from local and international experts and support from IDA for funds or tax incentives. They also point out that this move up the value chain must benefit the parent company. Politics and relationship building are critical to negotiating and influencing decisions of the parent. This relationship management is a necessary requirement alongside the preserving of the credibility and good performance of the subsidiary.

The parent company is responsible for positioning of the corporation within the industry and within the marketplace. The subsidiary needs to understand this overall corporate position and to improve its own strategic position within the corporation. Understanding this means that the subsidiary will be better able to fend off competition from ‘sister sites’, green-field start-ups in other countries and outsourcing. Influence is different from autonomy. Autonomy of a marginal area for the corporation is not a strong position (Molloy and Delaney 1998). Significant influence, up or down the value chain, is key to strategic positioning of a subsidiary to ensure long-term survival.
Table 2.5  Stages of Development of Subsidiary Plants

<table>
<thead>
<tr>
<th>Stages</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Establishing Start-up-Technology Transfer</td>
<td>expatriate managers, spoon-feeding, copy exactly</td>
</tr>
<tr>
<td>2 Carrying out Basic Mandate Satisfactorily</td>
<td>up and running according to plan, parent quite pleased</td>
</tr>
<tr>
<td>3 Performing Basic Mandate in 'Superior' Way</td>
<td>stretch targets set by subsidiary and achieved, verifiably superior to 'sister sites' or other benchmarks</td>
</tr>
<tr>
<td>4 Extending Basic Mandate - Low Risk Moves (typically within existing budget)</td>
<td>involved in active, low key pursuits of initiatives, seeking opportunities in 'corridors of indifference', taking on corporate projects, 'toe in the water' development of services/field activity</td>
</tr>
<tr>
<td>5 Extending Basic Mandate - Strategic Development</td>
<td>mandate extended to other value chain activities, openly with parent agreement and budget</td>
</tr>
<tr>
<td>6 Becoming Strategic Centre for M.N.C.</td>
<td>world or regional mandate for some activity (e.g. product, major channel, technology), responsibility for key functions with the corporation</td>
</tr>
<tr>
<td>7 Becoming Strategic Pivot for M.N.C.</td>
<td>high level of autonomy and standalone strategy-making unit, full-line business with significant multi-country linkages and control</td>
</tr>
<tr>
<td>8 Becoming Strategic APEX for M.N.C.</td>
<td>effectively, the corporate centre for all activities</td>
</tr>
</tbody>
</table>

(source: Molloy and Delaney 1998, p.18)

However, Collins and Grimes (2008) are critical of this value chain model as being too simplistic and linear in its logic and questioned the sustainability of it in the longer term. Under this model, Irish operations would require constant reinvention. They question the 'value' of the services being substituted. They indicate that the shift had been primarily toward second-level services and give one example where moving up the value chain involved simply retraining operators who were moved from machines to telephones and data-entry after a short course in 'cold calling', a move from manufacturing to telesales. They admit that not all the transitions were to low value. Some very successful transitions had taken place where manufacturing dominated industry moved to a mix of manufacturing
and services. Many of the moves along the value chain were in line with the IDA three-fold policy of World Class Innovation and Development, Superior Performance and Business Integration and Service and Support.

At a global level, China, India and some developing Eastern European countries had joined Ireland and Korea as top ICT exporters and producers (OECD 2006). A change in the trend of FDI was noticeable as ICT manufacturing and, to an increasing extent, services, shifted to countries outside the OECD. More and higher-value activities were moving off-shore, outside of the OECD areas. This was due to large markets opening up in these developing countries and also the fact that a shortage of workers was unlikely to be an issue in these developing areas (OECD 2006). It is in this expanding global context that the Irish ICT sector seeks competitive advantage. The following section explores Porter's industry analysis models.

2.4.4 Porter’s Industry Analysis Models

To Porter (1980, p.5) "the group of firms producing products that are close substitutes for each other" was "the working definition of an industry". An industry exists independently of an individual's or an organisation's perception of it (Frishammar 2006). This is in line with a critical realist view of reality.

The structure of the industrial sector has a large influence in setting the rules for the companies that operate within it. Industry structure also has implications for the structures and strategies that firms within that industry adopt (Porter 1980). All organisations pursue strategy, whether this is done implicitly or explicitly. The competitive forces framework seeks to encompass many variables and to capture the complexity of competition in an industry. The state of competition within an industry depends on five competitive forces. The collective strength of these forces determines the overall profit potential in the industry (profit potential measured as long run return on invested capital).

Porter indicates that the reason why firms succeed or fail is traditionally attributed to "largely implicit but crucial assumptions" about the nature of the firm and its operating environment (Porter 1991). These assumptions lead to challenges and trade-offs both for theory and for empirical testing. Porter defines firm success as "attaining a competitive
position or series of competitive positions that lead to superior and sustainable financial performance” (Porter 1991). This search for competitive advantage developed to encompass research into interlinked industries or sectors and how industrial clusters benefitted industrial development (O’Gorman et al. 1997).

Table 2.6 lists the key structural features of each of Porter’s five forces that in combination, determine the strength of the industry forces.

**Table 2.6 Porter’s Five Forces Framework (Elements of Industry Structure)**

<table>
<thead>
<tr>
<th>Entry Barriers</th>
<th>Rivalry Determinants</th>
<th>Determinants of Buyer Power</th>
<th>Determinants of Supplier Power</th>
<th>Determinants of Substitution Threat</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economies of scale</td>
<td>Industry Growth</td>
<td>Buyer concentration versus firm concentration</td>
<td>Differentiation of inputs</td>
<td>Relative price performance of substitutes</td>
</tr>
<tr>
<td>Proprietary product differences</td>
<td>Fixed (or storage) costs</td>
<td>Buyer Volume</td>
<td>Switching costs of suppliers and firms in the industry</td>
<td>Switching costs</td>
</tr>
<tr>
<td>Brand identity</td>
<td>Intermittent overcapacity</td>
<td>Buyer switching costs relative to firm switching costs</td>
<td>Presence of substitute inputs</td>
<td>Buyer propensity to substitute</td>
</tr>
<tr>
<td>Switching Costs</td>
<td>Product Differences</td>
<td>Buyer information</td>
<td>Supplier concentration</td>
<td></td>
</tr>
<tr>
<td>Capital requirements</td>
<td>Brand identity</td>
<td>Ability to backward integrate</td>
<td>Importance of volume to supplier</td>
<td></td>
</tr>
<tr>
<td>Access to Distribution</td>
<td>Switching costs</td>
<td>Substitute products</td>
<td>Cost relative to total purchases in the industry</td>
<td></td>
</tr>
<tr>
<td>Government Policy</td>
<td>Concentration and balance</td>
<td>Pull-through</td>
<td>Impact of inputs on cost or differentiation</td>
<td></td>
</tr>
<tr>
<td>Expected Retaliation</td>
<td>Informational complexity</td>
<td>Price Sensitivity - Price/total purchases - Product differences - Brand identity - Impact of quality/performance -Buyer Profits -Decision maker’s incentives</td>
<td>Threat of forward integration relative to threat of backward integration by firms in the industry</td>
<td></td>
</tr>
<tr>
<td>Absolute cost advantages - Proprietary learning curve -Access to necessary inputs -Proprietary low-cost product design</td>
<td>Diversity of competitors</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Exit Barriers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Porter (1980, p.109) gives an example of electronic component distribution. The cost of servicing buyers who ordered components in small quantities is higher than servicing buyers of an organisation ordering in higher volumes. This is because the cost of processing an order is relatively fixed and therefore, buyer selection, in this case, can have a large influence on strategy. Porter (1980) points out that as industries mature, buyers who had not been price sensitive can become so.

Porter (1980) lists three generic strategic approaches used by companies in dealing with the competitive forces within an industry. These are: 1) Overall Cost Leadership, 2) Differentiation and 3) Focus. Technology is also important as an overall determinant of industry structure and can potentially affect each of the five forces (Porter 2004).

New entrants to an industry can face six major sources of barriers to entry. Porter (1980) identifies these as economies of scale, product differentiation, capital requirements, switching costs, access to distribution channels and cost disadvantages independent of scale. Government policy can also be considered an entry barrier with use of regulation, standards and licensing requirements.

Porter (1980, p.7) cites the example of scale economies as responsible for the lack of success for Xerox and General Electric in breaking into the mainframe computer industry. Chandler (2005) attributes lack of success to failure to develop an integrated learning base and indicates that in technological industries, early movers have mostly prevailed. Emerson Electric and Texas Instruments were examples of the successful application of cost leadership strategies.

"Texas Instruments, Black and Decker, Emerson Electric and others have built successful strategies based on the experience curve through aggressive investments to build cumulative volume early in the development of industries, often by pricing in anticipation of future cost declines" (Porter 1980), p.13).

Differentiation of a product or service involves creation of something that is unique throughout the industry. Costs for differentiated products, while still important, are not the primary strategic target. By building brand loyalty, customer price sensitivity reduces. This
allows higher margin, but comes at the cost of a reduction in market share. Focus is the third generic strategy and here a particular target customer base is developed.

Leadership is required to develop and maintain clear strategy requiring strong leaders who can make the tough trade off choices, define and communicate the company’s unique position and fit the individual company functions and activities within the industry.

Porter (1996) points to the difficulty in strategy development experienced by businesses where uncertainty is caused by the rapid rate of technological progress. This leads to imitation and hedging by companies. Porter (1996) considered that, in high tech industries, this imitation period had often lasted longer than it should. High tech companies, instead of focussing strategically, often strove for growth to satisfy market pressures. Companies added more features to products and slashed prices leading to “a rat race no one can win”.

**Porter's Diamond Model**

Porter (1991) claims that the diamond model does not negate the importance of the five forces but rather highlights new issues for strategy. It is the most comprehensive framework for considering a country’s physical, economic and institutional capacities and the firm and country specific resources (Fahy 2001). In Ireland, Porter’s work in this area influenced the Culliton Report (Culliton 1992) which recommended encouraging the development of clustering in niche areas.

Understanding of how nations achieve a competitive advantage should focus on particular competitive industries within that nation. Porter finds that successful industrial development requires the development of clusters of interlinked industries. This linking can be through vertical, buyer and supplier relationships or horizontal, with common customers, technologies, skills, distribution channels etc. (Porter 1990).

The diamond illustrates the ability of the nation to attract factors of production and points to the ever increasing importance of highly mobile but highly skilled individuals as a source of competitive advantage. "The same features that make a nation an attractive home base also help it attract mobile factors" (Porter 1991, p.113). Where only modest levels of technology and skill are required, factor advantages (cheap labour or material) alone can
yield an advantage. Porter (1991) indicates that this type of advantage is extremely unstable, particularly when faced with modern challenges of globalisation, rapid substitution and technological change. Sustained competitive advantage in more sophisticated industries usually requires favourable interaction in several determinants.

D'Aveni et al. (2010) indicate that competitive advantages do not always seem to be sustainable. They list technological change, globalisation, industry convergence, aggressive competitive behaviour, deregulation, privatisation (stimulated by governments and hedge funds), government subsidies, the rise of China and other emerging countries, increase in the availability of venture capital, terrorism, global political instability and pressure for short-term incentives for senior executives to produce results etc. as potential contributors to the temporary nature of advantages. Also, they point out that the “duration of the advantage” is more appropriate. The durations of the advantages achieved by firms were different, at the time the models of competition were created, to the rate of duration of a competitive advantage now and they suggest new theoretical models may need to be developed.

Clusters

Clusters are now a feature of all advanced economies (Porter 1991). Conditions which result in clustering (development of vertical and horizontal linkages) evolve out of the determinants of competitive advantage and these determinants act in a systemic manner. Porter (1990 p.2) defines a cluster as “groups of interconnected firms, suppliers, related industries, and specialized institutions in particular fields that are present in particular locations”. Overlapping clusters are often sources for new business formation. Spin off firms and diversification upstream and downstream all assist in the growth and transformation of clustering.

As clusters develop, resources in the economy tend to flow towards them (Porter 1990). This is consistent with the view expressed by (Sterne 2004) that the indigenous Irish software sector developed a considerable mass before it came to government notice and resources were allocated to further development. O’Gorman et al. (1997) reviewed clustering in the indigenous software industry using Porter's diamond model. They found that the indigenous software industry was not quite a cluster in the Porterian sense, despite
being internationally competitive (O’Gorman et al. 1997). Much of the current research in the ICT sector is focused on this area of clusters and development of successful clusters (Ryan and Giblin 2012; O’Malley and vanEgeraat 2000; Green 2000; O’Gorman et al. 1997).

The competitiveness of a nation lies as much in the level of clustering as in the individual industries themselves (Porter 1990). Porter lists some mechanisms that lead to interchanges within clusters. Both information flow and commonality of goals are important for linkages (horizontal or vertical) between firms (Porter 1990). The mechanisms for facilitating information flow are: personal relationships, links to scientific and professional associations, community ties due to close geographic proximity, active trade associations and behavioural norms. Samples of goal congruence listed by Porter (1990) are family/quasi-familial ties, common ownership within an industrial group, ownership of partial equity stakes, interlocking directors and national patriotism (Porter 1990).

**Limitations of Porter’s frameworks**

Critics of Porter’s positioning approach point to the lack of any stable definition of the industry or market to be analysed. In fact, McKiernan (2006) states that modern trends of industry convergence, globalisation, hyper-competition, and developments in information and communication technologies mean that codifying individual sectors is difficult if not impossible. When conditions are changing quickly, industry boundaries are hard to define (D’Aveni et al. 2010). This makes assessment of the forces of rivalry, as well as buyer and supplier powers, difficult. He asks what industry structure means when all leading firms are changing their business models?

Grundy (2006, p.213) states that developments of Porter’s five forces model are rare and it appears to be “frozen in time” and to be little used by mainstream managers. While in favour of the model as a “vitally important concept” he lists the limitations as: 1) an overemphasis on macro or industry level analysis at the expense of the micro level, 2) oversimplification of the value chains, 3) failure to link to management action, 4) fixed industry boundaries which may not apply in a fluid environment, 5) self-contained and not linked to “PEST” or dynamic factors and 6) the economic terminology is potentially off-putting for management (Grundy 2006).
O’Gorman et al. (1997) indicate that Porter’s diamond model has been criticised under five headings. These are:

1) That it is lacking in theoretical specification.
2) The importance it places on geographic proximity which may only be partial and industry specific. It also ignores transnational linkages and industries which show a trend for dispersal with development.
3) Co-operation and competition (lacks in descriptions of networks or how relationships operate).
4) Suitability for small open economies (SOEs) and the role of domestic demand as a determinant and also the nature of rivalry where the number of firms is limited by country size.
5) The role of multinational enterprises – Porter views FDI and subsidiary development as not being sources of competitive advantage.
6) Resource based industries – the model is criticised as not applying to resource intensive industries.

Criticisms four and five are the areas of particular concern for this study as Ireland is an Small Open Economy (SOE) with a large multinational presence. O’Gorman et al. (1997) used the model as a framework for analysing the indigenous Irish software industry, but they point out that the model was used with an informed awareness of the critiques and they included an analysis of the influence of the multinational sector. They did not offer an updated model.

O’Malley and vanEgeraat (2000) concluded there was only limited evidence of Porter-like clusters in Irish indigenous industry. They looked at modifications of Porter’s diamond to see if these would bring the model better into line for a SOE with a high dependence on FDI and multinational enterprises. Porter’s model excludes contributions of subsidiaries as lacking in key managerial and R&D functions. Porter (1991) also indicates that cultural differences have the potential to lead to blockages in information transfers. He does, however, state that foreign multinational enterprises could “seed” a cluster in indigenous industries.
A modified “double diamond” or “multiple diamond” model was suggested as being more applicable to small peripheral economies. The idea of the double diamond model is that a smaller economy (e.g. Canada) can be considered to be so closely linked to a neighbouring economy (USA) that the two can be considered in one framework. The multiple diamond model extends this notion to more than one other country. O’Malley and vanEgeraat (2000) question whether the double diamond model fits the case of Irish industry.

“We must isolate the influence of the national on the firm’s ability to compete in specific industries and industry segments, and with particular strategies, rather than in broad sectors”, (Porter 1990, p.69). Based on this, Porter (1990) intends a narrow sectoral definition for application of the diamond model to industry and a narrow definition does not match to the broad sectoral definition chosen for this study.

The search for a framework concludes with an evaluation of Technology Roadmapping.

2.4.5 Technology Roadmapping Framework

Technology Roadmapping (TRM) is a flexible and structured approach that has been used in recent years by industries, companies and governments in attempting to align strategic objectives and technology management (Carvalho et al. 2013). In reviewing the roadmapping literature, they find that a roadmapping approach has two main components. These are:

1) The application or roadmapping process.
2) The result of the application or the roadmap produced.

They also note that it has been mostly used in qualitative studies due to the exploratory nature of the theme. The number and variation of definitions support both an emergent theme and also the flexibility of the approach (Carvahlo et al. 2013 Appendix II). The main levels of analysis are roughly equally split between strategy/business level and the innovation/new product development level of analyses. At a methodological level, 53 out of the 79 papers reviewed by Carvahlo et al. (2013) are case studies, indicating that this framework is suitable to apply with case study methods.
Phaal et al. (2011) propose a framework for mapping technology-based industry development. They used technology roadmapping (TRM) concepts to produce a map of industrial emergence. The framework proposed has a three-dimensional approach:

1. Establishment of industrial dynamic patterns which use time-based models with phases and transitions marked on the horizontal axis of the map.
2. Focus on the principles of emergence and evolution in complex systems using key themes which provide the supply and demand side drivers.
3. Mapping of industrial emergence with the technology roadmapping approach using significant events and milestones from R&D to industrial application and then to market.

Technology roadmapping has already been applied at both individual firm level and at sector level in the areas of innovation, policy development and strategy (Phaal et al. 2011). Motorola, Lucent Technologies, Samsung, LG and Philips were a few of the leading ICT companies that have used TRM in planning innovation at firm level (Lee et al. 2012).

As the scope of the roadmap is broad, it is suitable for covering a number of complex conceptual interactions (Phaal et al. 2004). While most TRM research has been used for forward planning, Phaal et al. (2011) point to the possibility of including and extending this type of mapping into the past, to map historical activities. Figure 2.16 below shows a generic technology roadmap (Phaal et al. 2004).

![Figure 2.6 A Generic Technology Roadmap](image-url)
Advantages of the TRM framework as a strategic planning tool are: the ability to align technology and business objectives, flexibility, scalability, the ability to provide high information content in a single figure (Carvalho et al. 2013). The limitations of the TRM are a lack of reliability and objectivity, a lack of focus and clear boundaries, a difficulty in evaluation of business value, difficulty in expression of the business attractiveness of R&D and a difficulty in expressing business system or operational models (Carvalho et al. 2013).

2.5 Summary

Table 2.3 summarises the frameworks reviewed, along with the advantages and disadvantages of each in relation to this study. In reviewing the frameworks, PEST analysis, modifications to Porter's diamond which include internationalisation and the roadmapping framework were considered to be the main options likely to fit to the research questions. Figure 2.6 was selected as the best representative framework to direct answers to the research questions.

**Figure 2.7 Roadmap for the ICT sector in Ireland from 1960-2010.**

This roadmap framework will be filled in using relevant information from Chapter 3 and Chapter 4 and this will then be repeated using the primary data gathered.

This study matches the road-mapping framework in many instances and, in particular, in the development of interlinking time series which allows the spatial areas of 1) government policy, 2) technological changes, 3) technical education developments and 4) the ICT...
sector’s industrial emergence to be viewed alongside one another. Although a full industry roadmap, as described by Phaal et al. (2011), is considered to be outside the scope of this study, a modified framework such as that shown in Figure 2.7 was selected as the best representative framework to direct answers to the research questions.

Mindful of the limitations, TRM was chosen for the following reasons

- It is a flexible strategic approach that matches the complex requirements of viewing the four spatial areas of technology, government policy, technical education and industrial emergence on a long time scale.
- It is an emerging framework suitable to combining technology and business elements.
- It is a model that has been used in firm-level analysis by many electronics companies and is suitable for industry-level analysis and government policy roadmapping.
- While it is customary to use this framework to develop a future-looking roadmap, it is suitable to use for review of the historical development in an industrial sector.

The following chapters, Chapter 3 and 4, provide a means of completing the roadmap for the ICT sector development.
Chapter 3 – Literature Review Part II

Government Industrial Policy and Technical Education

3.1 INTRODUCTION

In this chapter a review is given of the historical developments in government policy on industry and technical education. The following sections develop a time series for education and government policy to give an understanding of how these influenced, or were influenced by the development of the ICT sector. The time series in this section provides contextual data for understanding the industrial sector. It provides a source of events to identify mechanisms for change or drivers for the ICT sector in Ireland, over time using the critical realist methodology outlined in Chapter 5. The areas of development in technology and development of the industrial sector are reviewed in Chapter 4.

3.2 GOVERNMENT POLICY

3.2.1 An Administrative View of Government Policy

"If producing sustained economic growth is one of the major developmental challenges of states undertaking modernisation, and industrial policy one of the principal instruments available to it [sic], then economic development can be tracked through an examination of the state institutions through which these were given effect."

(Hardiman and MacCarthaigh 2010).

Policy changes can be seen in the alterations made to the state organisation and thus public administration can be used as a barometer to point to the political, economic and social life of the state (Hardiman and MacCarthaigh 2010). The number of civil servants employed by the state was approximately 8,000 in 1922, grew to over 30,000 by 1958 and rose sharply over the course of the 1970s to a peak of 50,000 in 1978. The number declined thereafter and held static around 30-35,000 from 1987 to 2007 (Hardiman and MacCarthaigh 2010). They identify a trend for increased creation, and use, of agencies and increased use of external consultancies. The trend in Ireland is for government support agency numbers to continually increase with time. This is does not follow the international trend where agencies are developed and later decline. Similarly, Hardiman and MacCarthaigh (2010) indicate that Ireland differs from other countries in that core civil service numbers have
held static while agency staff numbers have increased, whereas in other countries the civil service numbers tend to decrease as agency numbers increase.

There are three time periods (1959-69, 1969-1989 and 1989-2007) where the number of government departmental mergers or de-mergers of departmental responsibilities increased and where transfers of functionality were high in Irish government. In the first time period 1959-69, the Department of Labour was created. A trend to change name and focus in the department responsible for industry has continued – see Table 3.1 below.

**Table 3.1 Changes of Title to Government Department of Industry**

<table>
<thead>
<tr>
<th>Years</th>
<th>Government Department Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>1922-1977</td>
<td>Department of Industry and Commerce</td>
</tr>
<tr>
<td>1977-1980</td>
<td>Department of Industry, Commerce and Energy</td>
</tr>
<tr>
<td>1980-1981</td>
<td>Department of Industry, Commerce and Tourism</td>
</tr>
<tr>
<td>1981-1983</td>
<td>Department of Trade, Commerce and Tourism</td>
</tr>
<tr>
<td>1983-1986</td>
<td>Department of Industry, Trade, Commerce and Tourism</td>
</tr>
<tr>
<td>1986-1993</td>
<td>Department of Industry, Commerce and Communications</td>
</tr>
<tr>
<td>1993-1997</td>
<td>Department of Enterprise and Employment</td>
</tr>
<tr>
<td>1997-2010</td>
<td>Department of Enterprise, Trade and Employment</td>
</tr>
<tr>
<td>2010-2011</td>
<td>Department of Enterprise, Trade and Innovation</td>
</tr>
<tr>
<td>2011-Present</td>
<td>Department of Jobs, Enterprise and Innovation</td>
</tr>
</tbody>
</table>

From 1969 to 1986, there were four changes to the functionality of the Department of Industry and Commerce. The changes in the departmental titles are indicative of the changes in government focus. In the 1970s, two energy crises loomed large. A focus in the 1980s on tourism and serious unemployment brought industry back to the fore. The shift to focusing on Irish indigenous industry is represented in the selection of the word ‘Enterprise’ and the modern ‘Knowledge Economy’ is driven by ‘Innovation’. The most recent addition is the word ‘Jobs’.

Hardiman and MacCarthaigh (2010) identify that the pattern for change in government organisation began around 1973. While, coincidentally, Ireland joined the EEC in this year, this was also the year when the Fine-Gael/Labour coalition took power. This was the first non-Fianna Fáil government since 1957. Between 1989 and 2009, every major political party had held power at some time and governments were formed by coalition during this period. This coincided with great departmental and organisational changes and this trend
was particularly noticeable in the Department of Industry and Commerce as evidenced by Table 3.1. The three high growth areas of state function assigned to agencies were:

1) Regulatory activities,
2) Adjudication and grievance handling and
3) Advisory / consultative/advocacy/representation.

Education & Training and Enterprise & Economic Development were the two areas that had the highest growth in the number of agencies and these increases occurred from the late 1980s onwards. Over 50% of agencies fell into the category of service delivery agencies in 1958 and this percentage still held in 2008 (Hardiman and MacCarthaigh 2010). They estimate that there were around 50 agencies in 1924, 112 in 1958 and that this trend has continued with over 350 agencies by 2008. EU demands for independent regulation, a requirement for managerial flexibility, stakeholder involvement and a means of embodiment of new policy priorities, were all given as potential reasons for the rapid increase in the use of agencies.

The Industrial Development Authority (IDA) “became the flagship state agency” and developed “a sophisticated capability to target and secure FDI in industrial sectors identified as strategic priorities” (Hardiman and MacCarthaigh 2010, p.384). Continuous changes in the structure of the IDA over time were indicative of continuous government focus on industrial development policy. Table 3.2 illustrates the changes in employment patterns in some of these agencies over the period 1958-2007. Between 1971 and 1978, the IDA staff increased from 237 to 623. This rose to 728 in 1983 and then decreased to 275 by 2007 when the government strove to bring the country’s finances back into control and to reduce the national debt.

By 1991, The Industrial Policy Review Group advised that six government departments were directly involved in industrial development and was critical of the “passive coordinating role” played by the Department responsible for Industry and Commerce. They questioned how responsibilities for industrial policy were distributed between government departments (Hardiman and MacCarthaigh 2010).
### Table 3.2 Personnel Numbers for Industry Related Agencies 1958-2007

<table>
<thead>
<tr>
<th>Agency (and Date of Creation)</th>
<th>Personnel Numbers (1958-2007)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Industrial Development Authority</strong> (created 1949)</td>
<td>20</td>
</tr>
<tr>
<td><strong>An Foras Tionscal</strong> (created in 1952)</td>
<td>6</td>
</tr>
<tr>
<td><strong>Industrial Development Authority</strong> (new statutory agency created in 1970 following merger of IDA with An Foras Tionscal)</td>
<td>237</td>
</tr>
<tr>
<td><strong>IDA Ireland</strong></td>
<td>281</td>
</tr>
<tr>
<td><strong>Institute for Industrial Research and Standards (IIRS)</strong></td>
<td>360</td>
</tr>
<tr>
<td><strong>Eolas created 1987 from merger between IIRS and National Board for Science</strong></td>
<td>543</td>
</tr>
<tr>
<td><strong>Forbairt (created in 1993 &amp; dissolved 1994)</strong></td>
<td>805</td>
</tr>
<tr>
<td><strong>Forfás (created in 1993)</strong></td>
<td>114</td>
</tr>
<tr>
<td><strong>Coras Trachtála (created in 1959; lasted until 1991)</strong></td>
<td>183</td>
</tr>
<tr>
<td><strong>Enterprise Ireland (created out of merger of Forbairt and Irish Trade Board in 1998)</strong></td>
<td>826</td>
</tr>
</tbody>
</table>

Source: (Hardiman and MacCarthaigh 2010)

The Culliton Report, which followed in 1992, recommended that the Department of Industry and Commerce needed to take a stronger role in overall policy development for industry. Subsequently, in 1993 the Department of Industry and Commerce was changed to the Department of Enterprise and Employment and took over some of the Department of Labour functions. The Industrial Development Act 1993, created three new agencies; the IDA to cover foreign industry, Forbairt to support and develop indigenous industry and Forfás for policy advice and co-ordination (Hardiman and MacCarthaigh 2010; McSharry 48
& White, 2000 pp.227-228). Later in 1998, a further Industrial Development Act set up Enterprise Ireland (a merging of Forbairt and An Bord Tráchtála/The Irish Trade Board and some training functions previously covered by the industrial training agency FÁS) to support and to develop indigenous industry with a view to increasing exports. Table 3.2 illustrates some of these agency mergers and de-mergers over time. It also shows the increasing numbers employed by the state industrial development agencies.

3.2.2 Government Policy – Economic Reports
The development of the electronics and software sectors in Ireland occurred within the frame of the country’s overall economic development. Government Policy is also viewed through the milestones of important economic reports and documents. The Second Programme for Economic Expansion, 1964, is the first accessible economic planning document within the study’s timescale of 1960-2010. The Telesis Report, published by the NESC in 1982, was another influential report which informed government policy. A Time for Change: Industrial Policy for the 1990s - also known as ‘The Culliton Report’ (1992) was a later influential document. ‘Ahead of the Curve: Ireland’s Place in the Global Economy’ also known as the ‘O’Driscoll Report’ (Enterprise Strategy Group 2004) was another accessible and influential report. These were important landmarks where a nationwide look was taken at industrial and economic policy.

The First Programme for Economic Expansion began in 1958 and ran until 1963. The Institute for Industrial Research and Standards (IIRS) had been re-organised in 1961 and had increased from a single laboratory to four.

“The Institute encourages manufacturing firms to make greater use of research information facilities to improve manufacturing processes and techniques, to develop new processes and new products, and, generally, to ensure that materials and processes are sufficiently advanced to enable our industries to compete in open markets” (Second Programme for Economic Expansion Part II 1964, p.160).

The Second Programme for Economic Expansion 1963-1967
The Second Programme for Economic Expansion was released in two parts. The first appeared in August 1963 and outlined general objectives, set targets for growth and
specified conditions necessary to achieve the goals set. A consultation process followed the release of Part I. Trade Union, industry, agriculture and outside views were sought. These views informed the second part of the Programme which described the means to achieve the goals and it was laid before the Government in July 1964. The IIRS proposed, at the time, to set up a special division to focus on engineering and science. According to the Programme, “the use made by industry of the standards prepared in the past has been disappointing” and the IIRS proposed to promote improvements in quality and in “promoting the technical uniformity of goods in everyday use by the public” (p. 160).

Displacement of indigenous industry was a major issue, as evidenced by the statement “The Government’s campaign to attract industry from abroad is based on the understanding that such industry will supplement, but not supplant, Irish industry” (Second Programme for Economic Expansion Part II 1964, p.154). The countries targeted were the USA, Britain, Germany, France, Netherlands, Belgium, Denmark, Austria, Switzerland and Italy. During the First Programme for Economic Expansion, 133 new ‘undertakings’ were established with ‘foreign participation’. Also there were 24 factories under construction. In discussing manpower policy, the Programme (p.167) stated:

“While every effort must be made to bring work to the workers, the process of industrial development will be greatly assisted if they can achieve a higher degree of adaptability and of occupational and geographical mobility, and if restrictions on entry to occupations can be eliminated. Official policy will seek to facilitate and encourage the achievement of these aims.”

Two main types of retraining were proposed (i) using accelerated vocational training (AVT) methods and (ii) ‘on the job’ training, with the employer being paid a grant.

The 1970s were a difficult economic time. The first deficit budget was prepared in 1972. Ireland joined the E.E.C in 1973. The development of the sector was described by an Irish entrepreneur.

“Because of the tremendous pace of technological progress in the mid and late 1970s there was an understandable degree of uncertainty and informality in the progression towards a comprehensive national policy on modern technology. This
situation created a hybrid industrial electronics sector comprising largely foreign-owned corporations and some small indigenous enterprises”
(Founder of Lake Electronics, Lynam H., in Gibb 1982).

The Telesis Report - 1982

The NESC undertook a five-part study of policies for industrial development at the beginning of the 1980s. The first part of the study was a survey of changes in Irish industrial policy since the early 1960s. The second was to evaluate infrastructural constraints, with roads, telecommunications and water supply reviewed. The third part was an analysis of the job losses in manufacturing industry. The fourth part was an evaluation of Irish Industrial Policy by a team from the Telesis Consulting Group. This fourth goal resulted in the Telesis report and the fifth part was the NESC response to the Telesis report.

The objective given to Telesis for their study was

“to evaluate existing industrial policies and to make recommendations designed to ensure that the Irish Government’s industrial policy is appropriate to the creation of an internationally competitive industrial base in Ireland which will support increased employment and higher living standards” (NESC 1982, p.10).

As part of the Telesis Report, a survey of the electronics industry was carried out. The NESC (NESC 1982, p.7) evaluated the resulting report as “a major contribution to the formation of Irish industrial policies to meet the challenges of the upcoming decade”. The report summary recommended:

1) A shifting of public expenditure to support internationally trading indigenous industry and development of skilled sub-supply firms.
2) A reduction in the level of grants offered to newly investing foreign firms
3) An improvement in the “control of the process of industrial development” so that Government departments should be more actively involved in “setting of overall strategy and policy direction, monitoring results and reviewing on-going policy”.

The report was confirmed as “deciding the future directions in industrial policy” (White 1982, p.1). The Telesis report was summarised as requiring industrial policy to be “more selective, more directive and more integrative” (The National Archive, Taois/2012/38/15).
The IDA identified a shortage of entrepreneurs and companies willing to expand or start up new companies as the main constraint in the development of indigenous Irish industry. Implementing the second recommendation in reducing grants would run the risk of alienating foreign direct investment, in “increasing intensity of international competition” and also it could have the effect of destroying “Ireland’s reputation for consistency in its policies for attracting foreign investment” (NESC 1982 p.6).

According to Telesis, manufacturing employment in the indigenous sector decreased from 75% in 1973 to 66% in 1980. Few of the 1,262 indigenous companies that had been started since 1973 were serving the sub-supply needs of the foreign firms. The report indicated that only 8% of components and subassemblies used in the Engineering FDI sector were sourced within Ireland. A lack of quality and poor cost competitiveness were the main reasons given for this. Development of skill levels to produce sufficient quality in engineered goods, resources to invest in product design and marketing and distribution to allow the penetration of new markets, were key barriers.

The number of jobs in the foreign-owned sector increased by 22,000 between 1973 and 1980 compared with an increase of 2,000 jobs in the indigenous sector during the same time period. Ireland’s attractiveness was as a “convenient manufacturing satellite for sales in the EEC” and because it provided a tax shelter. Telesis identified the low wage rates as additional attractors in the 1960s and 1970s. By the end of 1980, around 70 multinational firms were operating in Ireland in the electronic and electrical industries. These employed around 10,000 people. Between 1978 and 1980, and based on IDA unpublished data, around 44 electronic projects had been approved with around 15,900 job approvals. This was around 33% of the total job approvals for this period (NESC 1982 Exhibit F).

The Telesis group undertook a survey of 60 companies in the foreign-owned electronics industry and concluded that none had a truly stand-alone operation in Ireland (NESC, 1982). They found that only 3 companies included key competitive elements which would indicate higher functions than the typical “manufacturing satellite” operations. They were critical that skill development and sub-supply linkage were limited. Where linkages and better integration of the electronics sector were taking place, they warned that Scotland had
a longer-established electronics industry but that Scotland had continued to have limited integration of higher-level operations (NESC 1982, p.24). "The competitive economic dictates of the high technology multinational firms" were the main limiting factor and the Telesis Report gave five reasons why electronics companies might not place key activities in Ireland. These were:

1) Marketing and applications engineering were best performed close to large concentrations of customers.

2) A policy of employing locals in large EEC countries to offset EEC government efforts to develop their own indigenous industries.

3) The feeling that R&D was a crucial function that should be kept in the parent organisation to reduce the risk of spin-off companies.

4) Ireland's remoteness and small size.

5) The contradiction that a tax haven is not a good location in which to handle costs of marketing and engineering functions as these subtract from the current profits.

While Telesis (1982) was complimentary about the sophistication and extensiveness of Irish industrial policy, they were critical that:

"high skilled, high technology enterprises are rare; Irish indigenous exports are small and limited in geographic scope; Irish companies are not successfully providing sub-supplies to foreign-owned industry; small firms exist primarily in low-skilled non-traded businesses; foreign-owned industry is often unsophisticated and the evolution of existing companies shows inadequate promise for substantial improvement" (NESC 1982, p.27).

They also pointed to a large discrepancy in job approvals against jobs actually created. They estimated that only 30% of the jobs approved in foreign firms between 1970 and 1978 were actually in operation in 1981. They were not critical that job targets had been set, but that a more complete evaluation was required for evaluation of industrial development agency performance.

"A Time for Change: Industrial Policy for the 1990s"

Chaired by Jim Culliton, this Report looked for a broadening of industrial strategy to include overall macroeconomic and fiscal policy, the level and structure of taxation, the effectiveness of education and training and the provision of adequate infrastructure. Telesis,
by comparison, had indicated that Government needed to take back direction of industrial policy. In his preface to the report, the Chairman, emphasised that 260,000 people were unemployed. There were no ‘quick fixes’ nor any ‘unused cash reservoir’ to address the issues and thus “the search for an adequate response to the unemployment crisis is the most urgent national economic priority” (Culliton 1992, p.25). This was coupled with a crippling level of Government debt. The report made recommendations in the areas of taxation, infrastructure, education, enterprise and technology, direct support for industry, institutional strengthening, and the food industry. Fifty-four recommendations were made in total. The Culliton Report found that many of the recommendations of Telesis a decade earlier still remained as challenges ten years later.

Between 1971 and 1986, the number of auctioneers and lawyers doubled but the number of engineers increased by less than 50% and this attitude of avoidance of industry and engineering was best addressed by new approaches to the system of education and by raising the status and quality of technical education. The low level of entrepreneurship was also mentioned as an inhibitor for the Irish economy. The report was critical of the level of fragmentation and the lack of co-ordination, despite several changes in the institutions. Globalisation of industry would require flexibility in government policy to adapt to an industry which was “mobile – but with Irish involvement in management or other key functions – whose characteristics straddle the traditional categories of foreign and indigenous” (Culliton 1992).

In the area of telecommunications, Ireland was considered to have one of the most advanced networks in Europe in terms of digitalisation and revenue from telecoms in the country was proportionately higher than in any other EU country. Pricing of telecom services was seen as a key point for Ireland’s competitive advantage and the report recommended the introduction of competitive mechanisms to drive down pricing.

“Serious gaps” were found in the Irish system for education and training which was considered to be “a most critical element of policy”. Ten of the recommendations in the report were in this area. Included in this were a “de-emphasis of the bias toward liberal arts and traditional professions” and higher priority given to acquiring “usable and marketable skills” (p.54). The report (p.52) recommended “A high-quality and respected stream of
technical and vocational education with a new curriculum and close involvement by industry" but "the academic subjects should not be neglected in this stream".

The report was critical of the level of training at work and looked for emphasis on areas of enterprise, productive systems and technology application. It called for an institutional re-organisation of FÁS which distinguished between supporting the unemployed and training which was relevant to industry. It was essential that the funds allocated to Science and Technology were used in ways that were relevant to industry. This required involvement by the industrialists to ensure that the Programmes in Advanced Technology and the linkages to third-level institutions continued to be relevant and current to the industrial environment. It also looked for a greater emphasis on technology acquisition in the technology development sphere.

While there had been some shift in policy focus, this change appeared to be larger on paper than in practice (Culliton 1992), giving the example that grant aid of 54% was given to indigenous industry in 1989 while it was 51% in 1985. Telesis had proposed that this shift should reach around 90% by 1990. The Company Development Programme which had begun in 1984 had stagnated. The report attributed the lack of overall progress to "the fact that the State sector has tried to pull so many levers to promote industrial expansion that the net effect of the different instruments is difficult to discern" (Culliton 1992, p.63). This may well equate to a critical realist multi-mechanism effect where the existence of different drivers can cancel each other out. These mechanisms are described in Chapter 5. Irish-owned start-ups grew to maximum employment over about two years and tended to decline thereafter. The cost per job was still an issue and independent ex-post analysis was only just starting within the Department of Industry and Commerce (Culliton 1992).

Culliton found that greater resources were still directed to the attraction and retention of foreign companies than were available for indigenous Irish companies, not only in the area of grants and taxes but also in the education, training and R&D areas. The importance of the foreign-owned sector, with over 90,000 people employed was recognised but critical linkages between these and indigenous firms were weak. The committee concluded that a major shift in IDA policy was required. This shift needed to move away from grants, towards more venture capital activities to grow the indigenous industry pillar.
Culliton recognised the necessity for selectivity but pointed to a requirement to direct this selectivity to the development of clusters in areas where a national competitive advantage could be gained. The work of Porter (1990) influenced the Culliton Report. Ireland should focus on "a limited number of promising niches and segments in which to build industrial clusters". This could then be used as a guide to selecting appropriate interventions. While much foreign investment was in the area of electronics, poor linkages had resulted. This was not surprising as the sector had not built on pre-existing strengths.

Nine of the recommendations were in the area of strengthening the institutions. There were recommendations that the role of the Department of Industry and Commerce should be one of policy determination and that some administrative and regulatory functions should be moved outside the department. The report also recommended splitting the responsibility for foreign-owned investment and indigenous industry. They recommended formation of a new agency to deal with indigenous Irish industrial development which would integrate some of the functions being dealt with by the IDA, An Bord Tráchtála and Eolas. They also called for a Task Force to be set up to ensure that the report recommendations were enacted and progressed. This Task Force should report directly to the Taoiseach.

"Ahead of the Curve" or The O'Driscoll Report 2004

"The transition from a production-driven, investment-based economy to one that is market-led and knowledge-based cannot be achieved by the enterprise sector acting on its own. The Government and state agencies, the education sector and the social partners will need to be mobilised to embrace the change and absorb it into their own structures and operational processes" (Enterprise Strategy Group 2004).

Chaired by Eoin O'Driscoll, the Report indicates that the essential requirements for economic prosperity are (1) Cost competitiveness, (2) Infrastructure, both physical and communications, (3) Innovation and Entrepreneurship and (4) Management Capability.

Figure 3.1 summarises the industrial base requirements for Ireland to build a sustainable competitive advantage as found by the report.
Figure 3.1 Conditions for development of sustainable enterprises in Ireland

These four areas are the essential conditions upon which competitive advantages must be built. Five areas where Ireland could possibly achieve a sustainable competitive advantage are then identified. These comprise the middle layer of the pyramid in Figure 3.1 above.

“We need to develop an expertise in international markets so that business can be more responsive to the needs of customers; we must build a world-class research and innovation capability to support the development of high-quality, high value products and services; we must renew Ireland’s historic commitment to education and training to provide the skills base industry will need; we must maintain a competitive tax environment to drive economic growth and we must provide capable and flexible Government that can quickly identify policies required to facilitate change and implement those policies across a wide spectrum of activities in a cohesive manner”

(Tánaiste Mary Harney, launching the 2004 report).

According to the O’Driscoll Report, the computer/electronics sector accounted for one quarter of export sales in 2002. It pointed to relatively low placement on the value chain for foreign-owned firms. These firms were operating in high-value sectors but essential activities, such as the R&D and marketing activities as well as those activities that require a direct relationship with the customer, were lacking. The activities that underpin the competitive strength of the parent organisations were largely not located
within their Irish operations. Technological innovation depends on R&D and on scientific and technological know-how.

From a low starting point, Ireland had taken a number of measures to improve the research infrastructure and had recognised the importance of R&D. These initiatives included allocating €2.5 billion in the National Development Plan (2000-2006) to R&D and to innovation, as well as the establishment of Science Foundation Ireland (SFI) and the Programme for Research in Third Level Institutions (PRTLI). Knowledge creation and dissemination were at the core of economic activity. The challenge for Ireland lay in ensuring that the country was at the forefront of this transition. Where many considered that the Irish educational system was world-class, a comparison of Ireland’s performance relative to competitor countries showed that there was considerable room for improvement. Also the O’Driscoll Report declared that R&D investment levels, which had increased in recent years, were still well below OECD levels. They estimated that 80% of the global workforce of 2015 was already in the labour force in 2004, but that changes in technology and business processes may have rendered many of their skills obsolete by 2015. This implied a need for continual learning.

This O’Driscoll Report (Enterprise Strategy Group 2004) emphasised that Ireland had come a long way in its development. However, it warns about complacency and stressed that Ireland could no longer rely on the same drivers as had worked in the past. New opportunities would need to be exploited for continuation of success. The report made 52 recommendations in total. Most relate to the sections shown in Figure 3.1 above and some further recommendations related to the role of the development agencies.

Three of the industrial policy reports (The Telesis Report, The Culliton Report and The O’Driscoll Report) are analysed by McCarthy et al. (2010). The recommendations of each report are categorised under the four headings of: (a) those that lower barriers to establishment, (b) those that lower barriers to expansion and growth, (c) those that provide advice, support and finance from public funds and (d) those that address insolvency. McCarthy et al. (2010) conclude that none of these reports from 1982 and 1992 to 2004 had recommended any measures to address business failure and insolvency (acceptance of failure in business being a prerequisite for Schumpeterian entrepreneurial activity (McCarthy et al. 2010). Insolvency was outside of the remit of the present study but the
other three headings were of interest. From 1982 to 2004, economic reports increased the number of recommendations that fell in the category of providing advice, support and finance. This is in line with Hardiman and MacCarthaigh (2010) who found an increase in the number of agencies providing advice.

Another trend identified by McCarthy et al. (2010) is the decline in the number of recommendations to lower barriers to expansion and growth. This decline was perhaps because Ireland had addressed deficiencies in this area over time. It is possible that this was a neglected area. Enterprise Ireland has introduced active measures to enable companies to grow and scale and to assist companies in accessing export markets (Enterprise Ireland 2007). This makes the first supposition more likely. Lowering barriers to establishment had never been the main focus in any of the three reports. It was consistently lower in the number of recommendations than any of the other type of recommendation. The IDA are internationally recognised as assisting in all aspects of set up for foreign-owned multinationals while Enterprise Ireland and the County Enterprise Boards (now LEOs) cater for the indigenous Irish start-ups.

Common criticisms throughout all three reports are that Ireland has an over-reliance on Foreign Direct Investment, resulting in an under-developed, weaker indigenous sector. Another recurrent theme is calls for a means of control or monitoring. How do we check progress on policy changes? Criticisms of education gaps, particularly in the technology and management areas are another common theme that appear in all three reports. However, each of these reports reflect the conditions of their time and directed the changes that were needed to face the uncertain future. According to Haugh (2013), the international economic context has experienced large changes since the 2006 government strategy report “Strategy for Science, Technology and Innovation” for 2006-2013, implying the need for continuous adaptation with changing circumstances.
3.2.3 Government Development Agencies

**Shannon Free Airport Development Company (SFADCO)**

The Shannon Free Airport Development Company was established in 1959 (Second Programme for Economic Expansion Part II 1964). SFADCO was independent of the civil service and responsible for all industrial development in the area. It undertook a factory building programme to encourage and facilitate prospective industrialists. There were 12 manufacturing and 6 trading concerns established in the Shannon Free zone by March 1964. Manufacture of transistors and electronic products were mentioned as two of the types of business there (The Second Programme for Economic Expansion Part II 1964). Sony was manufacturing transistor radios for the export market and, later, in 1963 the GE subsidiary, EI, started up. The pre-building of factories appeared to be a successful strategy and, by 1970, forty-five companies had established in the Shannon region employing 3,500 people (McSharry and White 2000). In 1964, the success of Shannon led to the formation of a committee called "Committee on Development Centres and Industrial Estates" and, following this, two industrial estates were established in Galway and Waterford and these provided the models for further industrial estate development throughout the country.

**Údaras na Gaeltachta**

Gaelterra Éireann was founded in 1959 as the industry development agency for the Gaeltacht, (Irish language speaking areas), of the country. Údaras na Gaeltachta was later established under the Údaras na Gaeltachta Act of 1979. While the organisation’s primary goal is the preservation and promotion of the Irish language, it also has the goal of industrial development for the Gaeltacht areas and co-operates with the other industrial development agencies. Gaeltacht areas of Donegal, Mayo, Galway, Kerry, Cork, Waterford and Meath are supported by Údarás and in the technology area have been successful with light engineering and software businesses (Tiernan et al. 2006).

**The IDA - Industrial Development Authority/Agency**

**The Founding of the IDA**

The founding of the Industrial Development Authority (IDA) was announced in 1949 during the protectionist era and caused controversy both within the civil service and the
Government opposition (Donnelly 2010). It initially employed a small staff of 11 civil servants, mostly from the middle to senior civil servant ranks (Hardiman and MacCarthaigh 2010). In 1951, with Fianna Fail in office, Sean Lemass, the Minister for Industry and Commerce, defined the role of the IDA more clearly.

The IDA had two primary functions - it served as both an industrial development advisory body for the Minister and it also was mandated to promote investment in Irish industry from all available sources. This second IDA function of investment promotion included the encouragement of FDI. Over time, this role was to take on increasing importance. The American consultancy group, IBEC Technical Services Corporation, carried out an analysis of the Irish economy in 1951. They concluded that government control was stifling business development in Ireland (McSharry and White 2000). The Underdeveloped Areas Act followed in 1952 and during this time the vetting and payment of financial grants was given to An Foras Tionscal (the Industry Board). This left the IDA to concentrate on promoting new investment (Gorman and Cooney 2007). In 1956 a Finance Act was passed to give tax relief to business on export profits. Initially, this relief was 50% but this was later increased to 100%. In 1958, the Control of Manufactures Act eased restrictions on foreign ownership of Irish industry. Throughout the 1950s, the IDA divided the regions into “designated and non-designated” areas. The least populated and least wealthy areas were the designated areas (Gorman and Cooney 2007). Meyler and Strobl (2000) identified Sligo, Leitrim, Roscommon, Mayo, Galway, Clare, Donegal, Kerry and West Cork as designated areas.

The 1960s

These statute changes, described above, paved the way to the more open economic outlook expressed in T.K. Whitaker’s Economic Development, published in 1958. The subsequent First Programme for Economic Expansion covered the years 1959-1963. Over the period of the First Programme, staff in the IDA grew from 20 in 1958 to 58 by 1964 (Hardiman and MacCarthaigh 2010). Exports were seen to be the best way to counteract the small home market and improve employment prospects in the country. Without changes to tax relief for exporting and the removal of the restriction on foreign ownership of companies, the IDA would not have been as successful in promoting Ireland for external inward investment in industry.
Lee (1989, p.531) states that the foreign firms that came in the 1960s had mostly technically mature and developed labour intensive products and required no high level of skills or knowledge. He indicates that in the late 1960s, the IDA shifted their policy to attracting firms with more technologically advanced products and particularly targeted the pharma-chem sector and the electronics sector. These sectors were suitable for geographical separation of the product chain where research, production and marketing could be carried out at separate locations. There was initially general acceptance nationally of this FDI policy, although later there was some scepticism as to whether the policy would have long-term benefits.

In 1967, a report from A.D. Little, an American consultancy company, showed up areas of weakness within the IDA (Donnelly 2010). The dependence on the civil service and the loss of talent by promotion within the civil service meant that the development agencies had difficulty retaining experienced staff. Recommendations from the Little Report were addressed in the Industrial Development Act, 1969. This covered IDA promotion, capital grants, industrial estates and advance factory developments and other areas, such as housing for workers, training grants, the ability to take equity stakes in companies, as well as to finance company research and development. In addition, the IDA was given responsibility for the development and growth of indigenous Irish industry. The IDA became a state sponsored body separate from the civil service or state agency (Hardiman and MacCarthaigh 2010). The number of IDA staff grew correspondingly to 237 by 1971.

The Buchanan Report (Buchanan and Partners 1969) recommended industrial development based around regional development centres and this report generated much debate about regional development policy (Meyler and Strobl 2000). Meyler and Strobl (2000) state that regional policy in the 1970s focused on two main tenets: (1) they sought to prevent a rural drift into urban areas in pursuit of higher paid jobs and (2) they sought to distribute the foreign-owned MNCs throughout the country to avoid high concentrations in some areas. The Regional Industrial Plans (1973-1977) of the IDA sought to disperse new industrial employment and focused on a large number of town clusters (forty-seven) which encompassed 177 towns (Meyler and Strobl 2000). As part of this strategy, job targets were established and sites were purchased and advance factories were built.
Meyler and Strobl (2000) indicate that this regional job policy had four effects (1) to increase the speed of the start-up process and to give encouragement to overseas firms to move into chosen areas, (2) once a factory had been built there was strong organisational pressure within the IDA to secure a client company for that factory, (3) the IDA were often able to influence the location choice by use of selective predetermined “itinerary” routes for prospective companies and, 4) job targets per town group also created organisation pressure to meet the set targets. Meyler and Strobl (2000) further state that this policy of job targets for particular town groups was continued until about 1982. Thereafter, while policy retained an explicit regional nature, following the Telesis Report (1982), there was a shift of emphasis to a more strategic industry approach (Meyler and Strobl 2000; Gorman and Cooney 2007).

The 1970s

Starting in the 1970s, the IDA applied a “closed-loop model” to identify growing sectors that would be good for Ireland. The selection of the pharma-chem and the electronic sectors, as suitable target sectors, was supported by a research paper carried out for the National Science Council. It resulted in a study by experts from the University of East Anglia to identify sectors in which Ireland should aim to attract investment. These studies identified electronics and also fine chemicals as being the best match for Irish requirements.

According to White (McSharry and White 2000), the IDA sought to provide a ‘one-stop shop’ service for all new companies locating in Ireland. With overseas offices, they were in a unique position to keep in touch with both the newly formed Irish operations as well as the source parent plant. Among the obstacles to FDI encountered, White (McSharry and White 2000) mentions the seven-month bank strike in 1970/1971 which was followed by further bank strikes, and ESB, postal and airline strikes, also in the 1970s. The Northern Ireland troubles and government financial mismanagement, alongside two oil-crises in the 1970s made for a difficult economic climate and added to difficulties in attracting FDI. The recession, following the oil crisis in 1973, had a major negative impact on the number of foreign projects negotiated by the IDA. They dropped from eighty in 1973 to forty in 1975 (despite Ireland’s membership of the EEC in this period) but had rebounded by the end of the 1970s.
In 1973 the IDA, in its Service Industry Programme, began to target the area of technical services in Engineering Consultancy and Computer Services such as software production. This programme was intended to offset some of the contraction in manufacturing occurring at this time.

The IDA strategy for development of an electronics industry was formulated in 1975 when approximately 5,000 people were employed in the sector. The early 1970s also saw the IDA interest in software development and Software services develop (NESC 1982). The second oil crisis in 1979, IRA activities and rising inflation were to make the 1980s recruitment drives more difficult for the IDA. Before the effects of the downturn, Apple announced its plans to choose Ireland as its production base. Not only was this important in its own right but it had an important “demonstration effect within the electronics industry” in Silicon Valley (McSharry and White 2000).

Indigenous industry in Ireland fared badly with increased competition from free trade after Ireland’s accession to the EEC. The IDA had promoted small (up to 50 employees) native firms through its Small Industries Programme. An Enterprise Development Programme was produced in 1978 to aid companies with good growth potential. The IDA looked to assist development of the native sector with good “linkages” between the foreign-owned companies and local firms. The IDA moved also from direct funding to create jobs to a strategy of company development. Irish indigenous industry revived from about 1987.

In reviewing progress over the decade 1970-1980, four areas of success were identified by White (1982). These were (1) A strong modern industrial base, aware of and equipping itself with the best ‘state of the art’ technology, (2) A young highly-skilled management team, (3) a forward looking educational infrastructure and (4) experience of a decade of free trade conditions (White 1982). White (p.71) summarised the IDA’s electronics policy as

“select the best companies in stable productions, - encourage the development of highest quality electronics infrastructure - encourage decentralisation to the Irish plant of product modification and adoption and research and development aimed at the European market” (White 1982, p.71).
and he warned about "unrealistic expectations of the time-scale needed to convince companies that the Irish environment and workforce are capable of undertaking this work".

**The 1980s**

By the start of the 1980s, a base had been established in electronics (White 1982). Inflation (up to 20%), in the early 1980s, was to prove a major problem. Also, at this time, competition for foreign inward investment from other developing countries was increasing. Up until 1986, successes, even large successes, were not sufficient to offset the gloom as employment numbers were falling (McSharry and White 2000).

In the 1980s, following a survey of senior executives in the USA and with subsequent in-depth interviews, the IDA found that its advertising was successful in raising Ireland's profile as a European investment location. The survey and interviews also showed that there was a large credibility gap. Americans had difficulty reconciling their rural, backward image of Ireland with the claims of highest return on investment in the EEC, based on their own United States Department of Commerce reports. Following further qualitative research into the decision-making process to locate in Ireland, the results pointed to the quality of the workforce and the availability of highly-qualified graduate staff as other main drivers for industrial FDI successes (McSharry and White 2000). In 1981 the pharma-chem and electronics sectors together had generated £1,500 million of exports or 43% of manufactured exports – these had been only £35 million and 13% respectively in 1970 (White 1982). While, by this time, manufacturing employment had increased by about 28,000, this did not reflect the cyclic nature of the employment. White (1982) illustrated the rate of change in the industry with data from the IDA employment survey. He reported that 92,000 jobs in industry in 1981 had not existed in 1973 and counter to this, 81,000 jobs which had existed in 1973 no longer existed in 1981.

By the early 1980s, software had become a focus. In 1977, Michael Wilson of the IDA called the Irish software service providers together to discuss the possibilities of exporting. Also, at this time, An Córás Tráchtála included software developers in its export promotion services and the National Board for Science and Technology included the software industry in its policy analyses (Sterne 2004). Around this time, and perhaps prompted by the criticism in the Telesis Report, the IDA set up a unit to deal with grant applications from
internationally trading software companies. Sterne (2004, p.89) indicates that the 1980s were a time of high unemployment and high emigration and the IDA was more interested in "crude workforce headcounts" and the overseas hardware electronics firms would provide hundreds of jobs against around a dozen, in a successful small Irish software company.

With the 1980s recession, global unemployment rose, in part, due to the replacement of jobs by increased automation and technology. This ran counter to the IDA policy of looking for investment with maximum jobs for Ireland and prompted a review. The ensuing consultation with the McKinsey Consulting Company resulted in the IDA’s Strategic Plan for 1982-1992 being formed. The year 1982 was also the year the Telesis Report was published. A change in policy was proposed to focus on industry that would achieve high-output growth using the best technology available, while maximising the spending on Irish services and materials. Electronics, computer software and other niche areas like healthcare and biotechnology were identified as having the desired high-growth characteristic. This change of approach was approved in the government White Paper on Industrial Policy in 1984.

Lee (1989) indicates that the IDA sought to discredit the Telesis Report and at the same time stated that they had already implemented many of its recommendations. He identifies that there was a shift from job creation to wealth creation as the criterion for success, with the main underlying idea being that wealth creation would create many jobs in the service areas to support every new job in manufacturing. The exact number of these extra jobs in the service sector and elsewhere was a matter of opinion that varied widely between nineteen and one. Power (2006, pp.77-78) also concurred with this. She identified a shift of emphasis from a target of job creation to a “more selective policy aimed at attracting higher quality foreign investment”. This shift in focus was also expressed by the IDA itself.

"The IDA is therefore looking at a concept of industrial development which focuses on the output of income generating capacity of industry. Here the role of industry is to generate the maximum possible output and wealth in highly productive enterprises while the main employment benefits are generated and captured outside the manufacturing entities themselves" (White 1982, p.55).
There was some criticism of this policy. Lee (1989) indicated that the IDA was indignant at the implication in the Telesis Report that, as a country, we were over-reliant on the electronics industry.

One of the criticisms in Telesis was that the indigenous Irish sector had poor linkages with the foreign-owned multinationals and this led to the development by the IDA of The National Linkage Programme which commenced in 1985 (Power 2006). This programme looked to maximise the benefit of the success in FDI. Where successful, it would have the benefit of upgrading the indigenous sector. Telesis was critical of sectoral strategies based on FDI as they considered “the economic rationale which guides the foreign-owned high technology multinational firms” as a major constraint on Irish development in any sector – not just electronics. The IDA did concede that linkages had been disappointing. Lee (1989) identified the “whole electronics strategy” as high risk because the industry itself was rapidly changing with an associated risk of failure of individual firms. Poor selection of the industries attracted would mean a high rate of firm closures. But even with good firms chosen, the nature of the industry might leave Ireland with only assembly-type operations and the ensuing pressure to keep costs and wages low to compete with other low cost locations to survive.

“Even if doubts about the wager on electronics prove to be misplaced the question must still remain whether a small open economy should concentrate so heavily on a single growth sector. It may have little choice, but if it chooses as volatile a sector as electronics, then it must expect to pay the consequences, including occasional severe setbacks” (Lee 1989).

Between 1980 and 1986 two further initiatives were to be successful for the IDA, namely, focus on a new International Services Programme targeting, among others, data processing and software development. It resulted in the successful set up of the IBM Software Centre in 1983, Lotus Software in 1984 and Microsoft software in 1985 and the creation of thousands of jobs with a thriving software sector. Sterne (2004) indicates that the state support structure for indigenous software companies grew during the 1980s with the IDA awarding grants for employment and research to promising business proposals. Further support in the area of technical advice was available from the National Software Centre.
while Córas Tráchtála advised on export markets and assisted with the finding of distribution partners overseas. The funding required was addressed by the National Enterprise Agency. This infrastructure was not long in place when the recession began to impact.

The policy shift, identifiable in the Government White Paper (1984), was a move away from support of fixed asset investment and toward support for technology acquisition, marketing and R&D skillsets and was aimed at overcoming the “specific competitive disadvantages” of indigenous industry with greater emphasis on selectivity of projects (Foley and McAleese 1991). While it was recognised that change was needed, the comment “no sudden or radical changes are proposed in incentives for foreign investment” (Government White Paper, p.115) summed up policy strategy. In 1983, the Minister for Industry and Energy announced that the IDA would set up a National Software Centre in Dublin. The proposal that the centre should be self-funding within three years threw up a contradiction that the centre would be advising Irish companies but at the same time competing with them for business. The NSC lasted four years before it closed down in 1988 (Sterne 2004).

The NESC published the report, “A Strategy for Development, 1986-1990” and this influential document was credited with preparing the way for a consensus on the national debt problems (Foley and McAleese 1991). One of the report’s recommendations was that Government should publish a regular review of industrial policy and the first Review of Industrial Performance was produced by the Department of Industry and Commerce in 1986.

The year of 1986 was a difficult one for the country economically and by 1987, the country was in such poor economic condition, with such high levels of debt, that there were fears that the International Monetary Fund would have to intervene. Following the general election in 1987, stringent measures were taken to reduce Irish debt and this helped restore confidence both at home and abroad. As part of the recovery measures, a hundred jobs were cut in the IDA, grant-giving conditions were tightened, making them repayable if targets were not achieved, and a commitment to win more jobs was required. Both Motorola and Teradata from the US announced projects in Ireland, followed by computer companies
Intel, Stratus, and Electronic Data Systems. SCI set up to make computer sub-assemblies in Fermoy and Fujitsu Isotec, started a printer-component project. Motorola was a major coup and by 1998 had 1,600 people employed in mobile communications. Intel stands out as a major longstanding success story for Ireland. It chose Ireland as the location for its microprocessor manufacture amongst very stiff competition from other countries and by 1998 had 3,500 people employed in Leixlip and was opening “FAB-14” to make its most current microchip.

An IDA mentor programme was launched in December 1988 as part of the assistance available to small industry where the IDA had identified a lack of management experience (Doyle 1989). This programme looked to put talented and experienced managers in touch with small companies in need of contacts or knowledge to allow them to progress in their businesses. Where many firms had signed up (some in the electrical or light engineering areas), the mentor panel was proving harder to fill. It was “short on men with an engineering background who have a wide and successful history of general experience” (Doyle 1989).

By the end of 1986 there were around 400 companies in the electronics and electrical engineering sector, employing around 24,000 people and accounting for approximately 30% of industrial exports (Kelly 1989). Kelly, who was manager of the Electronics Division in the IDA, pointed to 8 challenges and opportunities that faced the sector. These were (1) integrated offices where key products needed ‘connectivity’ (2) Computer Integrated Manufacturing - he indicated that the DEC plant in Clonmel and Mentec had introduced MRP and CIM (3) Flexible Manufacturing systems with “no scope for confrontation practices” (4) Value Engineering to reduce manufacturing by re-engineering (5) Contract Manufacturing Services would be an area of opportunity (6) Chief Executives – “we need Irish engineers with drive and vision taking the helm of our overseas companies to ensure long range planning and positioning” (7) Irish Start-ups, where “Irish engineers and CEOs will be the seed-corn of our native electronics industry” and (8) Sales and Marketing – an area of deficiency and, typically, graduate engineers were not attracted to it.
The 1990s

1990 was one of economic boom for Ireland. The attraction of foreign investment was aided by the thriving of American markets and an Irish recovery with a 7% growth rate in 1994, low inflation and falling national debt. However, 1991 saw recession in Britain and the USA. Des O’Malley, Minister for Industry, called for an industrial review that resulted in the Culliton Report being produced. This report called for a splitting of the IDA in two, with one section responsible for foreign investment and the other to promote and provide services for indigenous industry. Three agencies were created in 1993 as a result: the IDA (Industrial Development Agency) to deal with foreign investment, Enterprise Ireland to assist indigenous industry and Forfás to give policy advice.

Sterne (2004) points to a maturing of the localisation skills within the software industry in the 1990s. The IDA targeted call centres and customer services businesses. This was reflected in the types of companies attracted by the IDA. Successes from this time were Dell, Gateway 2000 and the Compaq Customer Service Centre with 600 jobs. Hewlett-Packard established in Leixlip in 1995 to manufacture printer-toner cartridges. (Compaq and Hewlett-Packard had originally set up in Scotland). In 1996, eight projects, each with over 500 jobs, were won by the IDA. Amongst them was the IBM Corporation with a 3,000 job customer-support centre for European IBM customers. The successful operation of the previous IBM one hundred person Software Development Centre stood Ireland in good stead and led to the creation of 3000 further IBM jobs and was in line with the development of the IDA’s successful call centre packages and the trend towards e-commerce. In 1997, Seagate in Clonmel closed with the loss of 1,400 jobs. Seagate made computer hard-disks. Collins and Grimes (2008) cite this as a wake-up call for other subsidiaries or affiliates – a realisation of the vulnerability of manufacturing sites which had production only on site.

In 1996 the IDA actively discouraged large companies from locating manufacturing of certain types of product here in Ireland, particularly if low cost was a key requirement, according to Barry and vanEgeraat (2005). They identify a shift in IDA policy at this time to new sub-sectors such as software development, computer networking and data-communication as key targets while the “peripheral and media” sector had been dropped as a target sector.
**County and City Enterprise Boards (CEBs)**

Before the establishment of the CEBs, the IDA Small Industry Programme operated from the late 1970s to the late 1980s. A Forfás Report (2003) cited deadweight and displacement as reasons for the suspension of this programme. In the early 1990s, the City and County Enterprise Boards were established by the government to support indigenous industry and particularly start-ups. This was the first time that government policy actively looked to support the micro sector (fewer than ten employees).

In 1993, the government established, on an interim basis, a system of local enterprise agencies in every county and city in the country and this was formalised in 1996 (Forfás 2003). Each Board, operated with agreement of the Minister for Enterprise Trade and Employment, as a separate company. Boards are funded by the Department of Enterprise, Trade and Employment (DETE), and use is made of EU Structural Funds co-financing (Forfás 2003). In the twelve designated areas, County Development Teams and County Development Officers had been operating but these transferred to the CEB in 1993 (Forfás 2003). Table 3.3 below outlines the key milestones in the CEB development from inception in 1993 to 2003 (Forfás 2003).

**Table 3.3 Some Key Milestones in Development of the CEBs**

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>35 County and City Enterprise Boards first established on an interim basis</td>
</tr>
<tr>
<td>1994</td>
<td>First full year of operation of the CEBs as seed capital/grant giving agencies</td>
</tr>
<tr>
<td>1994-1999</td>
<td>Operational Programme for Local Urban and Rural Development provided funding and framework for CEBS. Extended role of CEBS to include training, mentoring etc.</td>
</tr>
<tr>
<td>1995</td>
<td>Industrial Development Act provided a statutory framework for the CEBs, ending the interim status of the Boards</td>
</tr>
<tr>
<td>1998</td>
<td>Industrial Development (Enterprise Ireland) Act created Enterprise Ireland.</td>
</tr>
<tr>
<td>2000-2006</td>
<td>National Development Plan changed the emphasis of the CEBs. In addition, repay ability of grants was introduced, with 35% being refundable in the BMW Region and 40% being refundable in the S&amp;E Region.</td>
</tr>
</tbody>
</table>

(Source: (Forfás 2003))
In 2012, the government decided to dissolve the 35 CEBs and to transfer their functions to Enterprise Ireland. These functions were to be carried out locally by a network of Local Enterprise Offices (LEOs). The LEO was to be staffed by the combined resources of the former CEB and the staff of the Business Support Units of the Local Authorities.

**Enterprise Ireland**

The IDA had responsibility for the promotion of indigenous Irish industry, as well as foreign-owned industry, up until January 1994 when it transferred to Forbairt. Forbairt was a stepping stone between the IDA and the starting of Enterprise Ireland, which formed in 1998. The indigenous support policy started with the aim of creating a climate favourable to start-ups and shifted over time to removing the barriers to growth and encouragement for scaling by looking to meet each individual firm’s specific requirements (Tiernan *et al.* 2006).

Enterprise Ireland functions can be divided into four main areas. (Tiernan *et al.* 2006). These are

- Provision of business advice and support.
- Encouraging R&D within companies and promoting interaction between indigenous companies and research institutes.
- Promoting and facilitating internationalisation of indigenous firms.
- Regional balance in industrial development.

In 2000, the Enterprise Ireland annual report indicated that the indigenous electronics sector recorded the highest growth in export sales, with an increase of 20.7% to €942 million (IR£742 million). The Irish-owned electronics sector had been successful in developing strongly in global niche markets, mainly with proprietary technology leading to growth and employment in the sector. Software was expected to be a high growth area in the year 2000.

The 2002 Enterprise Ireland Annual Report indicated that a total of 15 High Potential Start Ups (HPSUs) had been assisted by the agency and these were mostly in the electronics and healthcare areas. Four had developed from innovative proprietary technologies developed in third-level institutions. A number of sectors put in exceptionally good export performances during the year. Internet and communications technology companies
increased their overseas sales by 18%, but the electronics sector was hardest hit by falling global demand, with a 27% decrease in exports according to the 2002 Enterprise Ireland annual report.

3.2.4 Summary

"Trade liberalisation and state interventionism" are identified "as two main pillars of economic policy" in Ireland (Smith 2006, p.525). Where trade liberalisation has persisted throughout the five decades considered in this study, it is the nature of the intervention by the State that has changed with changing circumstances. Four modes of state engagement with society's economic resources are: 1) Demiurge or direct production 2) Midwifery or direct aids to producers using tariff or subsidies 3) Husbandry or indirect supports for private enterprises and 4) Custodial or provision of regulatory frameworks (Hardiman and MacCarthaigh 2010, citing Evans 1995). At various stages in the period 1960-2010, the Irish government had used approaches from all four modes.

Government policy moved from protectionism and tariffs to an open export led economy over the course of the five decades. Industrial training to meet the new industrial needs then came into focus. Joining the EEC occurred in an otherwise difficult time for Ireland. Throughout the 1970s, services began to appear and the IDA began a service industry programme. The 1980s saw an international services focus. The Telesis Report was an influential report that stimulated much debate and prompted changes. However, there was worry about changing too much and particularly in the areas that appeared to be working well. The linkage programme sought to continue the success of the policy of FDI and use this to generate benefits in the indigenous industry sector, particularly in the electronics industry. With the success of the PC in the 1980s, software development grew and the IDA opened a National Software Centre in Dublin in 1983.

Serious attempts were made to bring the national debt under control in 1987. With the Programme for National Recovery under way, "A Time for Change" (The Culliton Report) was published. Globalisation was mentioned as a reason for change. Many of the recommendations of the report were implemented. The structure of the development agencies was changed again. Small business became the focus with the setting up of the County Enterprise Boards to serve local needs of microbusiness. Science and Technology
was also a priority. The IDA Strategic Plan (1982-1992) focused on a need for more targeted foreign investment which included attraction of the most technologically advanced industries with high output growth that could invest in Irish services. Focus turned to the indigenous sector – particularly those looking to export with the setting up of Enterprise Ireland.

The millennium ushered in the ICT age and the report “Ahead of the Curve” reflected this in its calls for technology platforms and collaboration and the move to a knowledge driven and market led economy. This type of smart economy is based on innovation and requires an entrepreneurship focus. “ICT policies have changed considerably in the last ten years. They are now mainstream policies underpinning growth and jobs, increasing productivity, enhancing the delivery of public and private services and achieving broad socio-economic objectives in the areas of health-care, education, climate change, energy efficiency, employment and social development” (OECD 2010). This section concludes with a time series for government policy developed from the literature review process.

3.2.5 Time Series for Government Policy by decade

Table 3.4 Government Policy Table: 1960-2010

<table>
<thead>
<tr>
<th>Year</th>
<th>Time Series One Government Industrial Policy Milestones</th>
</tr>
</thead>
</table>
| 1961 | • Application made to join EEC  
• Reorganisation of the Institute for Industrial Research and Standards |
| 1963 | • Second Programme for Economic Expansion  
• Ireland joined a pilot scheme by OECD Committee for Scientific Research  
• The National Industrial Economic Council (NIEC) was established |
| 1964 | • An Foras Forbartha established |
| 1965 | • Anglo Irish Free Trade Agreement  
• Government White Paper on Manpower Policy |
| 1966 | • Ministers and Secretaries (Amendment) Act, 1966 – Ministry of Labour created |
| 1967 | • Third Programme for Economic Expansion  
• A.D. Little, an American consultancy report on the IDA |
| 1968 | • Legislation for Redundancy Payment Schemes (amended in 1971 and 1974) |
| 1969 | • Industrial Development Act, 1969- merges IDA and an Foras Tionscal  
• Buchanan Report- nine regional development centres recommended  
• The Third Programme for Economic Expansion |
| 1970 | • National Manpower Service set up in 1970 under Department of Labour |
| 1971 | • OECD Manpower Policy survey began (reported in 1974) |
| 1972 | • The IDA’s “Regional Industrial Plans 1973-1978” |
| 1973 | • Ireland joins the EEC  
• IDA Service Industry Programme |
<table>
<thead>
<tr>
<th>Year</th>
<th>Time Series One Government Industrial Policy Milestones</th>
</tr>
</thead>
</table>
| 1975 | • IDA project identification unit was established to identify and encourage the exploitation of new manufacturing opportunities in Ireland  
• M. Killeen, IDA address “Increasing Employment in Ireland” to The Statistical and Social Inquiry Society |
| 1976 | • Government cancelled the National Census |
| 1977 | • EEC Review of State Aid |
| 1978 | • IDA Enterprise Development Programme (to encourage first-time entrepreneurs)  
• Ireland decides to join the EMS (European Monetary System)  
• IDA Industrial Plans 1978 – 1982 |
| 1979 | • Údaras na Gaeltachta Act set up development agency for Gaeltacht areas  
• Government White Paper - Programme for National Development 1978-81 |
| 1980 | • Second National Understanding (Wage Agreement) |
| 1981 | • IDA International Services Programme  
• 10% tax on manufacturing sector replaced export tax reliefs |
| 1982 | • The Telesis Report  
• IDA Strategic Plan 1982-1992 |
| 1983 | • National Software Centre set up in Dublin |
| 1984 | • White Paper on Industrial Policy (emphasis on indigenous industry)  
• Company Development Programme |
| 1985 | • The National Linkage Programme commences |
| 1986 | • First Review of Industrial Performance  
• Industrial Development Act – new framework for support of enterprise |
| 1987 | • Programme for National Recovery (social inclusion and negotiation)  
• Ministry for Science and Technology  
• Single European Act |
| 1989 | • Eolas “Electronics Manpower Study: Trends in the Irish Electronics Manufacturing Industry up to 1995”  
• The Operational Programme for industry (co-financed by the EEC) which included the Programmes for Advanced Technology (PATs) in the Universities |
| 1991 | • Programme for Economic and Social Progress (PESP)  
• LEADER I Programme (1991-1993)  
• Industrial Policy Review Group |
| 1992 | • The Culliton Report |
| 1993 | • The Industrial Development Act established Forfás, Forbairt (now Enterprise Ireland) and the ‘new’ IDA  
• Treaty on European Union (Maastricht Treaty) – Single Market |
| 1994 | • Forbairt take on responsibility for indigenous Irish industry  
• LEADER II Programme (1994-1999) to co-incide with EU structural programme |
| 1995 | • Industrial Development Act –established CEBs on a statutory basis |
| 1998 | • Enterprise Ireland Industrial Development (Enterprise Ireland) Act - (incorporating Forbairt, An Bord Tráchála and some FÁS activities)  
• Deregulation of Irish Telecommunications (21 general licenses awarded) |
<table>
<thead>
<tr>
<th>Year</th>
<th>Time Series One Government Industrial Policy Milestones</th>
</tr>
</thead>
</table>
| 1999 | • Economic and Monetary Union started and change to Euro by early 2002  
      • Programme for Prosperity and Fairness  
      • OECD Economic Survey of Ireland  
      • “IDA 2000+” strategy developed |
| 2000 | • Technology Foresight Fund established  
      • Science Foundation Ireland set up – ICT a key focus area  
      • Intertrade Ireland established  
      • LEADER + (2000-2006) |
| 2001 | • Driving Growth in Regional Enterprise (3 year strategy document from EI)  
      • ICT Ireland was established to represent the technology sector in Ireland |
| 2003 | • Department of Enterprise, Trade and Employment - Review of Industrial Performance and Policy  
      • Review of the Role of County and City Enterprise Boards |
| 2004 | • The O’Driscoll Report – “Ahead of the Curve: Ireland’s Place in the Global Economy”  
      • Tax Credit introduced to support R&D (Haugh 2013) |
| 2005 | • Government “Enterprise Action Plan”  
      • “Creating a High-Tech High-Growth Economy” – Second Enterprise Development Forum  
      • Enterprise Ireland strategy 2005-2007 “Transforming Irish Industry” |
| 2006 | • Strategy for Science, Technology and Innovation, 2006-2013 |
| 2008 | • Future Requirement for High Level ICT Skills in the ICT Sector, EGFSN  
      • Transforming Irish Industry 2008-2010 – Enterprise Ireland  
      • “Catching the Wave: A Services Strategy for Ireland” Forfás |
| 2010 | • The National Recovery Plan 2010-2014  
Figure 3.2 Time Series for Government Industrial Policy 1960-2010.
3.3 Educational Progress

This section turns to educational developments and focuses on the area of technical education.

"Technological change, pervasive as it is in all walks of life, offers a continuing challenge to educational systems particularly third-level education, where accelerating technical change renders current knowledge obsolete very quickly, (the average technical life of an engineer is 15 to 20 years)"

(NCEA and Galway RTC 1984)

Hardiman and MacCarthaigh (2010) indicate that changes in policy direction can be traced through changes in state organisation. This was discussed previously in Section 3.2.1. In the area of education, it is notable that the emphasis on science and technology became so great that the Department of Education changed its official name to incorporate science in its title in 1997. A further policy shift can be seen with the addition of the word ‘skills’ in 2010. “Politicians are understandably more preoccupied with the short term than with the long-term, with the next election rather than with the next generation” (Lynch 1979).

Continuity through the position of Minister of Education was also variable. Appendix C lists the Ministers for Education for the timeframe of interest for this study. Of the twenty-seven ministers who served in the Department of Education from 1960 to 2010, twenty were from the Fianna Fáil party, five were Fine Gael. Niamh Bhreathnach was the only Labour Party member to serve as Minister for Education and also the only person to hold the post in two separate governments. Of the twenty seven appointments as Minister of Education from 1960 to 2010, fourteen held the post for one year or less. Of note is that four separate people held this position in one calendar year, the year 1982.

White (2001, p.29) indicates that between 1958 and 1968, four of the five successive Ministers for Education were appointed to the cabinet by Séan Lemass and were associated with “a fundamental shift in attitude among government ministers.” This internal pressure for change coincided with the external influence of the OECD and helped move the educational debate in Ireland “away from purely educational and language revival questions towards the social and economic dimensions”(White 2001).
3.3.1 The Connection between Education and Economic Development

American sociologist, Martin Trow, categorised higher-educational systems into three types, namely: elite, mass and universal (White 2001). Elite systems enrol up to 15%, mass systems enrol between 15% and 40% and universal systems enrol more than 40% of the student age group. Ireland had an elite educational system in the 1960s where few were able to attend full time higher education courses. It developed, over time, into a universal system. White (2001) reports that, by 1995, 80 per cent of the age cohort had completed Leaving Certificate examinations and, of these, 50 per cent had proceeded to higher education, indicating that by this time Ireland had a universal system. This increase in numbers in third-level education over the years 1965 to 2002 is shown in Tables 3.5 and 3.6 below.

**Table 3.5  Growth in University Full-time Student Numbers 1965-2003**

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</thead>
<tbody>
<tr>
<td></td>
<td>16,007</td>
<td>23,121</td>
<td>32,388</td>
<td>56,698</td>
<td>73,600</td>
</tr>
</tbody>
</table>


**Table 3.6  Full-time Enrolments in the RTCs/IoTs, 1980-2001**

<table>
<thead>
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</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5,965</td>
<td>11,139</td>
<td>16,801</td>
<td>26,820</td>
<td>38,000</td>
</tr>
</tbody>
</table>

Source: Council of Directors of Institutes of Technology CDIT (1999) Technological Education; The Key to the Competitive Knowledge Society and DES figures- Source (OECD 2006, p.186)

Major changes in the educational system began in the 1960s while Dr Patrick Hillery was Minister for Education. Since then, a continuous focus on education as a priority has been one of the key determinants in promoting the development of industry. It has been a major factor in attracting foreign direct investment and much of this foreign investment has been in the ICT sector. "Knowledge is now universally acknowledged to be the key factor in determining long-run economic progress" (Forfás 1998). Education was top of the list for the Intel CEO, who claimed that there were four criteria used by knowledge-based companies to assess a country's competitiveness (Begley et al. 2005). These are: 1)
investment in education, 2) infrastructure for a knowledge economy e.g. broadband etc., 3) spending on R&D and 4) pro-business attitude by government.

A nation's competitiveness depends on economic and industrial performance. This in turn depends on technical capabilities to allow firms to compete internationally. Highly skilled workers are both a function of, and driver for, the local training and education system. These technical capabilities are firstly based in the skilled, technical workers and then secondly, by the general educational level of the workforce (Malecki 1997). According to Haugh (2013), in Ireland, a greater emphasis is required on the "acquisition of high-quality skills".

Barry (2007) indicates that our advancement to higher technology functions could be interpreted as a comparative advantage for industry. It is the continuous improvement in the educational attainment level of the workforce that has allowed this to happen. Barry (2007) warns that continuing and further progress in this area is a requirement to maintain the competitive advantage earned. This identification of education as a key determinant to economic growth was echoed by O'Rourke cited in O'Hagan (1991).

The 2006 OECD report "Higher Education in Ireland – Review of National Policies" - equated "tertiary education" with the term "higher education" which is the more commonly used term in Ireland (OECD 2006a). The report divided tertiary education into Type A and Type B education programmes. Type A programmes were defined as being "largely theoretically-based and designed to provide qualifications for entry to advanced research programmes and professions with high skill requirements". Type B programmes were defined as being "more occupationally-orientated and leading to direct labour market access" although classified as at the same level of competency as type A (OECD 2006a). The report indicates that sub-degree programmes such as those offered by the Institutes of Technology (IoTs, formerly RTCs) as type B while degree programmes at both IoTs and universities would be classified as type A.

While economic planning began with the publication of the First Programme for Economic Development in 1958, it contained no mention of education, apart from agricultural
education. In 1964, the Second Programme for Economic Expansion contained a chapter on education and made reference to the role of education in furthering economic growth.

"Better education will support and stimulate continued economic expansion. Even the economic returns from investment in education and training are likely to be as high in the long run as those from investment in physical capital" (White 2001, p.27).

In 2004, an OECD committee reviewed Ireland’s higher education policy. The Irish government had fixed the educational objectives as follows: being in the top OECD ranks for quality and levels of participation in higher education and also as “creating a world class research, development and innovation capacity” (OECD 2006, p.12). They found that Ireland lacked a “unified strategy for its tertiary education system” but indicated that, to reach the second objective, the tertiary education system would need to act as a key driver.

Education and technical education started from a low base. The Department of Education took over the funding of Irish universities in the late 1950s and “had no tradition of policy-making for higher education, and hence no policy” (White 2001, p.17).

3.3.2 Educational Background prior to 1960

The 1930 Vocational Education Act, provided the framework for much of the technical education development outside of the universities. Outside of the apprenticeship system, Technical Institutes in Dublin such as Kevin Street, Bolton Street, Chatham Row and Parnell Square, as well as an Institute in Rathmines, provided technical and business courses. Many of the courses were part time, at apprentice and post apprentice level under the auspices of the City of Dublin Vocational Education Committee. Such courses were also available in Limerick and in Cork’s Crawford Municipal Technical Institute.

3.3.3 Primary and Secondary School Structures and Examinations

The changes in education in the 1960s were mostly at secondary school level. The modern education system is Ireland is illustrated in Figure 3.3.
In the 1960s, the early education section was somewhat different. Up to 1967 a Primary Certificate examination was available and could be taken in sixth class in primary school at 12 years of age. Many went directly into the workforce after taking this examination. Before around 1965, three state examinations were available at secondary school level. The Group Certificate was a vocational education examination which was taken after two or three years of study in a VEC school, with technical or business oriented skills. The Intermediate Certificate was taken after three years of study in a secondary school and...
marked the end of compulsory education at 15 years of age. The Leaving Certificate programme typically required a minimum of another two years of secondary school education after the completion of the Intermediate Certificate. Both the Intermediate and Leaving Certificate programmes were academically oriented (Buck and McGinn 2005).

Ireland’s policies for science and education were reviewed in 1959 and the teaching of science in schools and colleges was examined. A second review, suggested by the Irish authorities, considered technical education in relation to economic development and especially emphasised the role of the technician (White 2001). Following the “Economic Growth and Investment in Education” policy conference in 1961, Ireland agreed to a national survey of their entire educational system by the OECD. The survey was begun in 1962 and the report published in 1965. According to White (2001), the survey and its results, published in the report “Investment in Education”, are both ‘landmarks’ in educational development in this country.

The OECD report found inequalities in levels of participation and the ability of the educational system to meet the future skills needed to allow economic growth as over half of Irish children left school at or before the age of thirteen. The OECD report showed that 42% of primary school leavers transferred to secondary school, 29% transferred to vocational school but 29% entered the labour market directly.

Dr Hillery (Minister for Education from 1959 to 1965) looked to extend the school curriculum and to increase participation rates in education. Study for the Leaving Certificate was provided by secondary schools while students from vocational schools could sit a Group Certificate Examination and then they often went on directly to work or to pursue apprenticeships. In 1963, Dr Hillery gave a major policy speech outlining plans for reform in the post-primary education system and announced the setting up of comprehensive secondary schools and the building of Technical Colleges throughout the country. He indicated that the Bishops of the Catholic Church were very much opposed to State involvement in education (Hillery 2009). Between 1965 and 1967 free secondary school education was introduced by Donagh O’Malley. No fees for secondary schools meant that attendance increased from 104,000 in 1966 to 144,000 in 1969 (Lee 1989).
In 1966, George Colley, Minister for Education, announced that vocational schools would offer courses leading to Intermediate and Leaving Certificates adding 342 more schools to the country’s existing 585 secondary schools and provided a path for higher level education (McMillan 2000). Using 1980-82 data, O’Rourke cited in O’Hagan (1991) reported on a survey of children completing the Leaving Certificate. By the early 1980s there was still a ‘way to go’ to making secondary education equally available to all social groups. In 1989, the Group Certificate and the Intermediate Certificate were converted into a single state examination called the Junior Certificate examination.

The trend for higher participation in secondary education continued and an ESRI Medium Term Review: 1997 – 2003 (by Fahey and Fitzgerald) found that between 40% and 50% of those who left the educational system had experienced third-level education. Over 80 per cent had reached Leaving Certificate standard. So, while in general education uptake and completion were improving, at around that time the Government identified a lack of adequate supply of skills in the ICT sector.

3.3.4 Development of the Third-Level Education Structure

Apprenticeship

The Apprenticeship Act of 1959 established An Cheard-Chomhairle to promote and regulate apprenticeship schemes for trades and industries. For the education of apprentices, An Chomhairle could: make arrangements with the VECs for courses required, liaise with the Department of Education for examinations and practical tests for apprentices and arrange for certification on satisfactory completion of an apprenticeship. A four-stage strategy was developed by An Cheard-Chomhairle consisting of: 1) a survey of existing apprenticeships in Ireland and overseas, 2) establishing the principles for a sound and progressive system for apprenticeship, 3) publishing and explaining these principles and 4) making arrangements for the implementation of sound principles in the trades and industries designated (McMillan 2000).

An Cheard-Chomhairle, after approximately five years in existence, recommended to the Minister for Industry and Commerce that the establishment of “an authority for providing for industrial training needs in general, including training by way of apprenticeship” was
needed and "An Chomhairle has come to the conclusion that having regard to the employment targets in the Second Programme for Economic Expansion, the needs of industry for skilled workers could not be met by means of apprenticeship training alone" (McMillan 2000).

This new requirement for broadening industrial training led to the establishment of An Chomhairle Oiliúna (AnCO). In 1968, AnCO was given powers to set up and manage its own training centres not only for apprentices but for other manual, business and managerial occupations. Block release and part-time apprenticeship training courses were still offered at RTCs and some VEC schools. Training courses were increasingly provided directly by AnCO itself (McMillan 2000). Apprenticeship benefitted greatly from being transferred to the responsibility of AnCO who had new well equipped training centres and skilled instructors. (Ryan cited in McMillan 2000).

When, at a later stage, funding became available from the European Social Fund (ESF), it allowed the recruitment and training of extra apprentices to fill the manpower shortages. When the oil crisis and economic recessions caused large job losses and unemployment in the 1970s, AnCO, using European ESF funding, was able to assist apprentices in completing their training (Ryan cited in McMillan 2000). However, Ryan pointed out that apprenticeship training was considered by many to be old fashioned and "not amenable to a 'high tech' approach" (McMillan 2000).

An Foras Áiseanna Saothar (FÁS) was established in 1988 under the Labour Services Act and consolidated the work of AnCO, the Youth Employment Agency and the National Manpower Service. There were 12,943 apprentices in 48 occupations under 7 designated trade groups registered at that time (McMillan 2000). In the middle of 1989, the Apprenticeship Review Group issued their report which included the establishment of a National Apprenticeship Advisory Committee, a standards-based qualification system, modular training with flexible time periods, reduction of sources for training to one resource (removal of duplication in that both FÁS and VEC were both offering the same training).
A Forfás Interim Skills Group (1996-1997) was set up in 1996 to examine skills needs and "An Action Plan for Skills" was announced in March 1997. This plan called for an extra 3,200 third-level student places for professional software people, electronic technicians and teleservice staff. FÁS also had occupation-specific skills training courses which were offered in FÁS centres or other approved locations. Computers, software development, engineering and video production are some of the ICT specific areas that were covered. These programmes were typically of duration 24-40 weeks and included work experience (Buck and McGinn 2005).

By 2003, there were around 25,000 registered apprentices in 25 designated trades in the country (Buck and McGinn 2005). The rationale for apprenticeship had shifted from a time-served approach to a standards-based approach. A draft report prepared by Buck and McGinn (2005) shows that the female uptake in the area of these apprenticeships was particularly low, as illustrated by Table 3.7 below. An incentive scheme was introduced to encourage employers and raise the number of females applying for apprenticeships.

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Male</td>
<td>12,830</td>
<td>10,639</td>
<td>23,812</td>
<td>25,955</td>
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<tr>
<td>Female</td>
<td>157</td>
<td>133</td>
<td>116</td>
<td>117</td>
</tr>
<tr>
<td>Total</td>
<td>12,987</td>
<td>10,772</td>
<td>23,928</td>
<td>26,072</td>
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</table>

Source (Buck and McGinn 2005)

**Technician Training**

Technician training became a focus in the early 1960s according to Dooge cited in Cox (2006). With the industrial policy aim of attracting foreign investment, a requirement for technicians and technologists, who would require training, became apparent. The Second Programme for Economic Expansion outlined the technical education proposals of the Minister for Education in 1963. Co-operation would be needed between industry and the vocational schools to produce a skilled labour force.

OECD examiners published a report in 1964 on technical training (White 2001). Around this time, Dr Hillery announced the development of Technical Colleges and a Technical
Schools Leaving Certificate. There was difficulty in fitting any accepted definitions of the term technician to the Irish industrial landscape. Irish industry had developed on the basis of a British craft/apprenticeship system and trade union practices and it was therefore unable and unmotivated to specify or quantify a demand for technicians to the educational authorities. The OECD report recommended better manpower surveys to inform future requirements and emphasised mathematics and physical sciences as the basis of advanced technical training.

In 1978, a book entitled "Technician Careers in Ireland" identified 26 different major technician areas (Casey and Murray 1978). They divided industry into two main divisions – "heavy current (or power) and light current which is mainly electronics". The ESB, electrical contractors and electrical manufacturing had requirements for the electrical engineering technicians. Radio, television and telecommunications were all listed as areas where electronics technician knowledge was required.

There were two methods of becoming an electronics technician. The first was by undertaking a full-time study course at one of the third-level institutions offering the National Certificate in Electronic Engineering (NCEA Certificate: two years; Diploma: three years). The second was by part-time study and on-the-job training. Technician level in electronics could also be obtained by completing an electrical trade apprenticeship and then proceeding to the Technician Certificate of the City and Guilds or the National Certificate in Electronics of the NCEA, the Telecommunications and Electronics Technician Certificate, an Instrument Technology or an Industrial Measurement and Control Certificate from City and Guilds (Casey and Murray 1978).

A Technician's Taskforce (chaired by Dr. Seán McDonagh) was set up in July 1997 to examine technician requirements for the broad electronic sector. Accelerated Technician Programmes, of eighteen months duration, were introduced in early 1998. These short duration courses were conducted for a few years to fill the shortfall in technician supply.

*The Development of the Technical Colleges and Institutes of Technology*

The 1970s were notable for the growth in the non-university system in Ireland. White (2001) reports that, in the years from 1972/73 to 1988/89 there was a 34% increase in the
numbers attending universities full-time, whereas the corresponding increase in the non-university technological sector was 431%. The major part of the work of the Regional Technical Colleges (RTC) up to 1974 was at technician and higher technician level.

A Steering Committee on Technical Education, chaired by Noel Mulcahy, was set up by the Minister for Education, Donagh O’Malley, in September 1966. The Committee’s aims were to advise the Minister on technical educational matters and provide a brief for the upcoming RTCs including outlines for the courses that each college would offer. One of the recommendations of the Committee, which reported nearly a year later in April 1967, was that a national council to confer educational awards should be established. Thus the National Council for Educational Awards was established. This council would validate the courses developed by the new RTCs and would set the standards both for admission to courses and also the qualifications from the various courses.

The report from the Steering Committee found that there was a serious gap in technical knowledge and skills and viewed the setting up of the proposed Regional Technical Colleges as addressing this need. Long-term, it considered that the colleges would provide education for business and industry over a broad spectrum of occupations and, short-term, it would fill the manpower shortage in the technician area (White 2001). The Committee realised that there was a lack of information to match the upcoming demand for places on RTC courses but were able to point to the OECD reports for support of their proposals, without being able to give an accurate level of demand for student places. White (2001) indicates that the Steering Committee had great influence and most of the conclusions in the report were adopted as policy. White (2001) contrasts this with the recommendations of the long-sitting Commission on Higher Education (1960-1968).

The Steering Committee recommended that the new RTCs should be managed by Regional Education Councils which would help to develop a fresh image for technical education and to cement the regional aspect of the new RTCs over the existing VEC county structure. The County Carlow VEC found that this went against the existing 1930 Act and they called for the Irish Vocational Education Association to address this with the Minister. With continuing pressure on the Department of Education and in the Dáil, the Minister
announced that a board of management for each RTC would be appointed in line with the requirements of the Vocational Education Act 1930 (Section 21(2)).

Both White (2001) and Barry (2007) report that the functions to be provided by the RTCs were initially fourfold. These were (i) post-primary courses leading to Leaving Certificate (although this function was shed quite quickly), (ii) Junior and Senior Trade Certificate courses for apprentices released from work for this training, (iii) courses for technicians or professional qualifications at various levels and (iv) adult education and retraining. It was intended that these courses would be shorter than university courses with an emphasis on meeting the skills needs of local business and industry. They would mostly be in the area of engineering or business studies.

In September 1969, Regional Technical Colleges were opened at Athlone, Carlow, Dundalk, Sligo and Waterford. In 1969, the Higher Education Authority (HEA) had proposed to the Minister for Education that the NCEA would provide a mechanism to award degrees to the proposed third-level college, National Institute for Higher Education (NIHE) Limerick. The university styled institution provided to Limerick following a lengthy campaign for a full university. A sub-group had been set up in the HEA to consider the setting up of this awards body and also the question of a third-level institution for Limerick. The sub-group recommended that a council should be set up but wished to consult with the universities and the Irish Federation of University Teachers to ensure that NCEA awarded degrees would match those of universities.

In 1974, Cork RTC opened in a greenfield site in Bishopstown and the third-level section of the Crawford Municipal Technical Institute moved to the new site. The RTCs provided short-cycle sub-degree courses although, with time, the trend in the RTCs moved to the provision of diploma and degree courses (Clancy and Kehoe 1999).

O’Halloran (2009) joined the Cork Crawford Municipal College/RTC in 1970 to take over lecturing in the second year of a new Electronics Technician course which included a specialisation in computer engineering. In Ireland, there was a technical gap between the professional engineer and the craftsperson. This gap did not exist in the UK as, due to National Service, the UK forces produced many experienced electronics people and the UK
was more industrially developed than Ireland. As there was no Irish certifying body for the
new course, validation came via the City and Guilds examinations. This course was the first
to include "computer engineering" in Ireland as a subject.

By the end of the 1980s, following the growth in demand for technical training, the City of
Dublin VEC found that they were short of accommodation and were unable to provide
entry for all applicants on some courses. They submitted a report (the Ballymun Project)
proposing a new single campus, amalgamating some departments from three Dublin
colleges. Higher technician and technological education was included in this proposal. The
HEA accepted that additional technician training places were required in Dublin but that
the recommended governing structure for the new proposed Ballymun Project did not meet
with the approval of the City of Dublin VEC.

The HEA report recommended that the controversial proposed merger of the two Dublin
Universities was not practical and pointed out that the universities were already
experiencing an accommodation crisis. The Minister delayed publishing the HEA report
and, six years later, the promised Ballymun Project still had not got off the ground. White
(2001) believes that this indecision had implications for technical training in Dublin. The
Dublin colleges, with the exception of Bolton Street and Cathal Brugha Street, did not seek
NCEA awards for their courses, providing their own sub-degree awards and degrees
recognised by TCD.

The newly established Higher Education Authority, according to White (2001), found that
technical education was underdeveloped and needed upgrading and extending and that it
"would be a departure from the raison d'être of institutions of technology for them to
conform to the methods and requirements of a university, particularly as they had to cater
not only for students of degree calibre, but for many others engaged in a variety of
disciplines leading to other than strictly academic qualifications." This first HEA report
was a milestone document and provided the rationale for the introduction of a 'binary
system' of higher education in this country (White 2001). The resulting National Institute
for Higher Education (NIHE) in Limerick (1972) was a 'flagship' project for the new type
of technical and technological education.
The Limerick institute was directed by Dr Edward Walsh and incorporated many US inspired innovations in technical education such as modular development of courses, compulsory industrial work placement and educational planning in the form of a twenty-year development plan. There were 113 places on offer in the first courses and Applied Electronics was one of the first degree courses on offer.

NIHE Limerick was established in 1972 and the Dublin NIHE was established in 1980. Both of these institutions were re-designated as universities in 1989, i.e., University of Limerick and Dublin City University.

From 1975 onwards, the non-university sector students were able to benefit from ESF funds. These funds were directed at the short-cycle higher education. By 1984-85 there were 12,000 students attending ESF funded courses (OECD 2006a).

In 1978 the two colleges of technology located in Dublin were amalgamated to form the Dublin Institute of Technology (DIT). Also, in 1978, the Manpower Consultative Committee was established to act as an advisory body on manpower policy. The IDA had advance knowledge to predict the upcoming skills need and the adjustments that would be needed in the Irish education system. With the upgrading of NIHE Limerick to the status of a university in 1989, university numbers began to outstrip the non-university technological sector and White (2001) reports that between 1988 and 1994, full-time student numbers in the university sector grew by 87%, whereas the non-university or technical vocational sector grew by 66%.

In 1992, a Regional Colleges Act was passed. It gave a greater degree of autonomy and self-governance to the RTCs but the Department of Education and Science still monitored them directly. A National Education Convention took place in 1993 and discussed the binary issue and it reported that the Institutes of Technology opposed to any limiting of the level of work they could undertake but concern was also expressed about the potential for "academic drift" (OECD 2006a). A HEA steering committee report (1993) had recommended a change of title from RTC to "Regional Technical Institutes" and favoured the retention of the binary system with
"the distinctive role in the area of technician training, the ‘practical’ orientation of its programmes, the engagement with applied research and experimental work in product development and the regional focus of its work" (OECD 2006a).

In 1997, the Minister for Education agreed to change the title for Waterford RTC to the Institute of Technology, commenced by Cork RTC. The Minister set up an advisory group for the technology sector who advised that all RTCs should be changed in name to “Institutes of Technology” and this change took place in January 1998. By 2003, two of the Institutes (Waterford and Cork) had delegated authority from the NCEA to award their own degrees in some areas of study. The designation of the NIHEs with university status was, according to Barry (2007), in line with “academic drift” where the institutions such as NIHEs moved towards providing degree level courses. He indicates that this pattern is similar to what happened in the British Polytechnics and is a well-recognised trend in higher education generally.

The University Sector

In 1959, the total UCD student body numbered around 5,000. This was double the numbers of Trinity College and of UCC. In October 1960, a Commission on Higher Education, chaired by Chief Justice, Cearbhall Ó Dálaigh, was set up to inquire and make recommendations about university, technology, higher education and professions. It would be 1967 before the Committee issued an interim report.

In the early 1960s, there was no national educational curriculum that included computers and computing and the computer manufacturers provided training both for their own staff and for their customers’ staff. TCD undergraduate courses in computing began in 1966 and a Department of Computer Science was established in 1969. A newly created Chair of Computer Science was established in 1973 and first filled by John Byrne (Cox 2006). The first computers installed in the universities were the IBM 1620 which was installed in UCD in 1962. TCD and UCC installed computers shortly thereafter. While these machines were initially used for research and for teaching of computing, a subject area called Computer Science quickly emerged and computing courses began to appear. Other universities developed their computer capabilities in a similar manner (Cox 2006). In 1960, no females were enrolled in any of the Irish university engineering courses although women made up
25 per cent of the student population in Ireland in general. There was virtually no support, either from government or from industry for research (Cox 2006).

The year 1977 saw the National Board for Science and Technology Act passed. It reported to the Minister directly, allowing a flow of technological advice into the Department “best able to assimilate and diffuse it into policy formation. In 1983, TCD’s first set of graduates on the Computing Course qualified with a BA degree. Dublin City University (DCU) awarded its first computing degrees in 1984. The year 1983 also saw the first output of degree course in Electronic Engineering including Computer Engineering in Cork RTC.

Despite changes of government during the 1990s, educational policy was broadly consistent. An exception was whether or not to establish regional education boards or to retain control within centralised government. The latter was the chosen route which was brought into legislation. White (2001) points out that Ireland is reasonably unique in Europe in the centralised control of higher level educational establishments. In 1995 the government allocated 1,800 extra engineering and software places in the university sector. The engineering and science professionals and technicians accounted for 3.5% of the workforce, where the USA figure was 3.7% in 1996 but in high technology oriented states such as Massachusetts, were at 6.4% and Silicon Valley 12% (Forfás 1998). In 1996 the Minister for Education abolished fees for full-time degree courses in University and public sector colleges. Clancy and Kehoe (1999) find that Ireland has a unique position relative to other European countries in this regard.

In May of 1997, the Universities Act was passed. It provided for recognition of the NUI universities as autonomous universities and was passed following amendments after consultation with the universities, the HEA and the Minister for Education and Science. It is identified in the OECD review (OECD 2006a) as a “landmark in the history of university education in Ireland” and provided balance between key aspects of institutional autonomy and providing for the needs of public policy and accountability, while updating the composition of governing authorities and modernising institutional procedures (OECD 2006a).
Between the years of 1997 and 2003, DCU saw a dramatic drop in the numbers applying for computer applications as a first choice. In 1997, the number of applicants was 800 and by 2003, this had fallen to 243 (Sterne 2004). An IDA newsletter (Spring 2011) called “Information & Communication Technologies – Ireland” indicates that the numbers in ICT related third-level undergraduate courses were on the increase since 2007 (with computer/software courses up 40% and electronic engineering up 20% following the dot.com economic collapse).

**Standardisation and Qualifications**

With the development of a network of regional technical colleges, a means to accredit and certify the courses in these institutions was needed. The National Council for Education Awards (NCEA) was founded in 1972 and they began to take over validation of courses. Before this, Poland (2009) indicates that the City and Guilds of London Institute examinations were the means of providing qualification certification for electronics technician course candidates. The three categories for awards under the NCEA were as follows: National Certificate after two years of full-time study, National Diploma after a further year of specialised study or completion of a three year full-time study course and Degree after four years of full-time study. The Government decided that the funding and scrutiny of the universities would lie with the Higher Education Authority.

Between the years 1972 and 1974, three quarters (total of 1,429) of the awards issued by the NCEA were in engineering and science and most of the awards were issued at National Certificate level (White 2001).

In 1974, Richard Burke, Minister for Education, announced that a radical administrative restructuring of higher education was to take place. This proposed a new remit for the NCEA where all degree awarding powers would be removed from them. The aim was to move from the “binary system” to a “comprehensive system” with all degrees being awarded by three proposed universities. The NCEA (with proposed name change to the Council for Technological Education) was to be responsible for the Regional Technical Colleges and the sub-degree work of the NIHEs. While losing its power to confer degrees, it would gain in planning, institutional co-ordination and finance functions for the RTCs and NIHEs (McMillan 2000). The RTCs were unhappy with this arrangement which meant
that they had indirect influence on the NCEA only through membership of governing bodies of the NIHEs.

The NCEA terms of reference were changed for a second time in 1976 and again in July 1980 when the National Council for Educational Awards Act 1979 came into operation. In 1979, the National Council for Educational Awards Act formalised the constitution of the NCEA and degree powers were again restored to it. The National University of Ireland had conferred degrees in the hiatus time period for NIHE Limerick. In 1973, 83% of all NCEA awards were in the area of engineering and science. In 1974, this declined to 71% and in 1975, 68%. Most of the NCEA awards were given in VEC colleges and the RTC sector had the most awards within the VEC-controlled sector (McMillan 2000).

Awards that could be issued by the NCEA were as follows: One Year Certificate, National Certificate, National Diploma, Primary Degree, Graduate Diploma, Master’s Degree. The first Master’s Degree was conferred by NIHE Limerick in 1981. In total, MacDiarmada, NCEA Director, reported that engineering awards represented more than 40% of all NCEA awards conferred up to 1982. In 1982, in the discipline of electrical/electronics, 202 (or 23.7%) of NCEA awards were at Certificate level and 106 (or 28.3%) were at Diploma level.

White, cited in McMillan (2000, p.274), indicates that the ad hoc nature of the NCEA for eight years made it very difficult for them to function successfully after the statutory constitution was put in place. He points to the drive and subsequent award of university status to the two NIHEs in 1989 as having a significant negative impact on the NCEA. The other major change that affected the Council was the passing of legislation removing DIT and the RTCs from the responsibility of the VECs and giving them greater autonomy. While DIT had never had close links with the NCEA, the RTCs had formed much of the core work of the NCEA since its establishment.

In 1991, 40 per cent of students in higher education were attending technical colleges (McMillan 2000). Mary O’Rourke, Minister for Education, established the National Council for Vocational Awards but this decision was reversed in the 1992 Green Paper and
a new statutory council which would cover all aspects of vocational training as well as covering the higher education functions previously covered by the NCEA, was established.

In 1995, educational direction changed again with *Education – Charting our Future*, a White Paper which announced an ad hoc Irish National Certification Authority, Teastas, for all non-university third-level courses and that the NCEA was to become a sub-board of Teastas. This was a project of the Minister for Education from 1993 to 1997 but Teastas was never established on a statutory basis. Teastas laid the groundwork for the Qualifications (Education and Training) Act in 1999 which established the National Qualifications Authority of Ireland (NQAI).

By the end of 1998, NCEA had made a total of 155,146 awards and of these 28.8% or 44,736 were in engineering and 32,578 or 21.0% were in science. In 1987, awards in business studies outnumbered the engineering awards but from 1972 to 1987 engineering awards dominated in numbers (McMillan 2000).

In 1999, Micheál Martin, as Minister for Education, brought in the Qualifications (Education and Training) Bill and later that year the NCEA was merged with the new Higher Education and Training Awards Council (HETAC). The National Council for Vocational Awards was replaced by the Further Education and Training Awards Council (FETAC) and this new body incorporated the educational and training functions of FÁS, Teagasc and the National Tourism Certification Board. An umbrella organisation, the National Qualifications Authority, covering both FETAC and HETAC was established under the Qualifications Bill. White cited in McMillan (2000, p.276) indicated that as the NCEA did not retain its title, many of the awards that had been issued by it were effectively devalued as they were awarded by an organisation that had not survived as long as a single generation.

Quality and Qualification Ireland (QQI) was formed under the Quality and Qualifications Assurance (Education and Training Act) 2012. It took over functions from FETAC, HETAC, NQAI and the Irish Universities Quality Board (IUQB). QQI’s functions now include the maintenance and development of the National Framework of Qualifications (NFQ), the validation and awarding of qualifications, and the monitoring and review of
quality assurance of providers of education and training. Figure 3.4 shows the current qualifications framework for the QQI.

Figure 3.4 National Qualifications Framework

Engineers Ireland (The Institution of Engineers of Ireland)

The Institution of Engineers of Ireland updated its Charter in 1969 (the original charter was received in 1877) to take of the multi-disciplinary nature of engineering. Around 1982, the Institution of Engineers began a programme of engineering degree course accreditation in the Universities and the National Institutes for Higher Education. Lynch, (former President of the Institution of Engineers Ireland in NCEA and Galway RTC seminar 1984) outlined five requirements for accredited engineering degree courses. These five requirements were that each engineering course: (i) Contain at least 2,500 hours devoted to academic activities appropriately distributed between lectures, tutorials and laboratory work; (ii) Contain at least 1,000 hours devoted to mathematics and to basic and engineering science; (iii) Include a substantial final year project; (iv) Include an appropriate amount of non-technical studies; and (v) Ensure that students acquire skills in oral and written communication.

Chartered Engineer status was awarded by the Institution to those who met the requirements of graduate membership by examination or approved, accredited degree and who showed an acceptable level of overall professional competence in engineering. The register of Chartered Engineers is held by the Institution. Lynch (in NCEA and RTC
Galway 1984) indicated that diploma and certificate holders could join the Institution as: Technician for the certificate holder, as an Affiliate for the diploma holder without experience and as an Associate for the diploma holder with approved postgraduate training.

**Research and Linkages**

In 1979, funding for a micro-electronics research centre in Cork under the leadership of Professor Gerry Wrixon was announced and the ensuing National Microelectronic Research Centre opened in 1981 with 20 people employed. This centre aided in encouraging microelectronic development in the country. In 1981, the Government also founded the National Microelectronics Applications Centre Ltd, based in the University of Limerick. The mission for this centre was the commercial application of IT and electronic knowledge to benefit industry. These research centres became a focal place for the IDA visits when perspective overseas companies were considering setting up in Ireland.

In 1983, the European Commission research programme "Esprit" called for preliminary proposals. Brian O'Donnell of the National Board for Science and Technology aided several university researchers with proposals and assisted them in getting a start on the research teams. Chris Horn, founder of Iona Technologies, on completing his PhD in TCD in 1984, spent a year in Brussels reviewing proposed Esprit computer networking projects. When he returned to Ireland in 1985, he had made many useful contacts in technology companies that allowed TCD to form partnerships of the type required to be successful in Esprit proposals. Sterne (2004) indicates that TCD was receiving more money from Esprit than any other European university by the end of the 1980s and that this success created a momentum in university research in Ireland.

The 1993 National Education Convention was critical of the low level of both funding and esteem for research in higher level education in the country. In the year 1995 the Science, Technology and Innovation Advisory Council looked strategically at how science and technology in Ireland could be used for the betterment of society. In 1996 the Government released its first ever Government White Paper on Science, Technology and Innovation. In the National Development Plan 2000-2006, investment in these areas was increased by a factor of five. Then in 1997, a new research advisory council was established.
"In the light of subsequent developments, the focus and debate on research policy in the mid-1990s may be noted as a turning point for research in Irish higher education. The analysis, diagnosis and prescriptions had been made and, crucially, the political, public and collegiate will were not found wanting with regard to strategic decisions in setting a new dynamic agenda for high-level research” (OECD 2006a)

Around 1996, the HEA commissioned the CIRCA group to carry out research to provide “a comparative international assessment of the organisation, management and funding of university research in Ireland and Europe” (OECD 2006a). Their report found that research was severely underfunded and that research in Ireland lagged behind best practice in Europe. They recommended the setting up of two research councils and better interfacing between industry and services as well as better inter-university and inter-disciplinary collaboration. The Minister set up two research councils, these being: The Irish Research Council for Science, Engineering and Technology (IRCSET) and the Irish Research Council for Humanities and Social Sciences (IRHCSS). The Programme for Research in Third-level Institutions (PRTLI) saw 24 research centres established. This programme was launched in 1998.

In 1999, the Irish Council for Science, Technology and Innovation (ICSTI) submitted a report to the Technology Foresight project and identified a gap in Irish capabilities in the area of world class research in the third-level sector and in industry. Forfás studies of R&D needs in the late 1990s identified demand in both electronics and software in the areas of IC design and communications software as likely dynamic growth areas requiring PhD output.

“In relation to high-tech firms, there are complex and not fully understood relationships between the existence of a pool of highly trained researchers and the growth of firms and industries based on the application of new knowledge and new technologies” (Forfás 2000).

Advanced research was identified as a requirement to drive higher value-added products and services and to allow the development of new high tech companies by emerging university researchers.
In 2000, the Department of Enterprise, Trade and Employment established Science Foundation Ireland to oversee the administration of the Technology Foresight Fund of €711 million over seven years. ICT research was one of the niche areas for research targeted by the fund. The Finance Act of 2004 brought in a 20% tax credit for incremental R&D (Barry and vanEgeraat 2005). The Technology Foresight Ireland Report concluded that the areas of biotechnology and ICT represented: “the engines of future growth in the global economy ... A world class research capability in selected niches of these two enabling technologies is an essential foundation for future growth.”

Science Foundation Ireland (SFI) funded five joint-partnerships for collaborative research between industry and research (Barry and vanEgeraat 2005). The OECD report “Higher Education in Ireland” in 2006 pointed to a dramatic increase in research funding between 1996 and 2002 but that, even with the changed research culture, both industry and government would require higher investment to meet the Lisbon target of 3% of GDP (OECD 2006). The OECD report on Higher Education in Ireland estimated that foreign-owned firms accounted for more than two-thirds of the Business Expenditure on R&D (BERD) in Ireland and that this made growth in this area dependent on world economic factors as well as government and education. They indicated that the successful creation of an “Innovation Society” would be dependent on the ability to generate an indigenous research-based economy. They pointed out that all of the IoTs now had incubator centres which had been funded by Enterprise Ireland and that similar development in the universities was recommended.

**Expert Group for Future Skills Needs (EGFSN)**

In the late 1990s, the EGFSN was the first long-term coherent framework for planning future technological skills needs for the country. The fact that Information Technology was transforming the global economy meant that the demand for IT skills in computers and engineering was accelerating worldwide. The software and hardware sectors had expanded in Ireland leading to a shortage of required skills.

Late in 1997, in response to the shortage of skilled labour, the government established a partnership comprising of The Business, Education and Training Partnership Forum, The Expert Group on Future Skills Needs and the Management Implementation Group, to
develop a national strategy for skills and manpower development in the country. The First Report of the EGFSN was published in 1998 and concentrated on skills in the IT area. This was counted as a priority for the country, not just because of the large contribution of the electronics/software sector but because other, non-technological, businesses now also had an IT skills requirement due to advances of the Information Age. Other reasons given for focusing on the ICT sector first were: it had the greatest skills demands and shortages, improvements in skills would benefit Irish industry as a whole and would encourage further foreign investment in the sector and there was a long lead-time to build up skills in the high technology area (of the order two to four years depending on the level of skills required).

*The First EGFSN Report (Forfás 1998)*

Three scenarios were examined (i) the high employment growth scenario which predicted an annual demand of 8,300 technologists; (ii) basic growth which predicted a requirement of 6,500 annually and; (iii) the reduced growth scenario which still required an annual output of 2,800 engineering and computer science graduates. Assuming a high growth scenario, the report indicated a shortfall of 2,200 people, with 800 of these at professional level i.e. primary or higher degree level and 1,400 at technician level.

The report addressed this shortfall by proposing an increase in the number of student places for technology courses in the third-level sector but also by conversion courses, employee up-skilling and skill development and by improvements in the completion rates at degree level for technology courses.

Other mechanisms to fill the technology gaps were also recommended. These included: recruiting skilled people from overseas, in-company training, accelerated learning programmes, multi-skilling/conversion courses and modular delivery of programmes. It recommended that at sub-technician level, around 800 entrants to relevant FÁS programmes and about 500 entrants for Post Leaving Certificate (PLC) Programmes would be required annually. The need for higher numbers of research students, not only to staff the third-level requirements but also to support the IDA policy of encouraging R&D development in existing multinationals in Ireland, was also highlighted. The report also mentioned the desirability of both widening and deepening the electronics sector by attracting more telecommunications companies and by developing existing company R&D
and indicated that the skills availability would come to be even more important as grant
incentives reduced in line with EU policies.

Priority was to be given to making technology courses more attractive to students from
second level by such means as skills awareness programmes, promotional workshops or
company visits along with a dedicated skills opportunity website. The report estimated a
required increase from 17% to 24% of students taking technology based education to keep
the skills base populated.

The report recommended partnership between industry and education on various levels,
including individual, local, regional and national levels. The report looked at initiatives to
encourage a greater percentage of school-leavers to select engineering and science courses
and recommended a study be carried out into student career choices at second-level. It
further recommended that the successful 'Opportunities Ireland' campaign to attract
software people back to work in Ireland should be extended to the hardware electronics
sector.

The Second EGFSN Report (Forfás 2000)

The second report of the EGFSN broadened its scope and focused on manpower shortages
but included an updated section on the ICT sector. The report identified that an increase in
the numbers engaging in research to PhD level was needed. In line with the Technology
Foresight recommendations, the education sector and high technology industries, alongside
the Department of Education and Science research programmes would have the largest
demand for PhD graduates. The numbers registering for PhD programmes had plateaued,
meaning that the numbers qualifying in future years would not be likely to rise quickly.

Amongst the recommendations in the report were: (1) an awareness campaign for Science,
Technology and Innovation, (2) that the HEA review support for postgraduate and post-
doctorate researchers/students and career prospects, (3) looking abroad to meet short-term
needs and (4) establishment of a central database on higher education research activities for
all colleges. The report was satisfied with the increase in spending by the Government
(€95.23 million) to grow the number of degree professionals and technicians and believed it
would have a beneficial effect. No further recommendations for further places were made but the committee intended to continue to monitor the situation.

The report did however update its employment projections for the computer hardware areas in the ICT sector. The demand for degree professionals, as a percentage of total employment, would be higher than it had anticipated in its first report in 1998 (now 20% versus previously predicted 13%) but this was offset by a lower demand for technicians (25.5% down to 22%). They estimated an overall lower projected employment. This was attributed to growth in projects requiring higher skill levels in line with development agency policy at the time and also that more companies were focusing on R&D activities. No explanation was given for the overall drop in total employment predicted. Even with this projected lower employment in the computer hardware area, the report expected that the shortage in degree-qualified engineers would continue until 2003 but that they expected an improvement would follow.

**The 2008 EGFSN Report**

In 2008, the EGFSN (Forfás 2008) focused again on the ICT sector but with an emphasis on high-level skills. The objectives were twofold: to determine future requirements in Ireland for high-level ICT skills in the sector and to identify what actions needed to be undertaken to supply these skills within the country. High-level skills were defined as those needing Level 8 qualification (Honours Bachelor Degree) or a higher degree in engineering or computing. The report indicated that graduate numbers in Honours Bachelor Degree courses in computers and engineering had peaked in 2002 and had decreased thereafter.

Demand determinations, made in the report, again considered the three scenarios of “continuing recovery”, “accelerating recovery” and “loss of competitiveness”. Both of the recovery scenarios showed an insufficient supply of graduates to meet demands. Demand would be approximately met under the “loss of competitiveness” scenario. They pointed to projected gaps of up to hundreds of Bachelor Degree qualified electronic engineers and up to an average of 2,000-3,000 computer graduates. Immigration was foreseen as filling the expected gaps well into the future. With the high-level technical skills required for upcoming jobs, they pointed to a reduction in the number of school leavers with high points choosing to study in the electronic and computer degree areas. This they attributed to
feelings of insecurity about the sector, slow growth in pay compared to other sectors, competition from other career areas and change in mathematics performance levels in schools.

The 2008 EGFSN report pointed to a tightening in the market for ICT software skills. They indicated that this was different from the 1990s shortage which was based on growth in software employment and IT service areas. They attributed this tightening to the greater size of the ICT sector which requires high-level skills (although growth in the area was modest) and, also, to a greater emphasis on the relevance and quality of skills. The requirement for discipline or domain knowledge, as well as strong ICT skills, had the effect of reducing the available talent. The fall in the number of students graduating from degree courses and the global demand for skill meant that suitably qualified Irish people could choose to work overseas and overseas talent could equally choose to move somewhere other than Ireland.

The report pointed to a potential difficulty with salary in the ICT sector. If salary was too low student recruitment into ICT related studies would likely not increase, inward migration could suffer and, if salaries were too high it would impact on the country’s competitiveness. This is in line with the supply/demand complexity outlined at the beginning of the following section.

3.3.5 Supply and Demand

“All stakeholders have a role in implementing short-term solutions and in facilitating development of longer-term strategies” to meet changing skills demands (OECD 2002, p.8). The OECD pointed to the need for better data to measure the workforce and new kinds of partnership to address the issues of changing skills demands. Both the supply and demand side measures were being used. On the supply side, measures such as providing student information, addressing IT skills levels in second-level education, teacher training, making careers more attractive were taken. On the demand side, some of the possible measures were: better use of existing employees, more information on skills needs and opportunities as well as training programmes. Immigration was a tool to increase short-term supply but needed to be integrated into the broad policy framework (OECD 2002).
employment of immigrant skilled workers over longer terms could serve to dampen growth in wages and thus make the sector less attractive for career prospects.

"Effective education systems need to have the adaptability to engage constructively with society in the light of new needs and developments" (OECD 2006a). While models for supply and demand of skilled ICT labour tend to treat both sides separately, they are not independent factors (OECD 2006). Strong demand comes with retention of existing high-skilled staff within industry, immigration by people with required skills and better recruitment into relevant courses. When demand is weak, conversely, retention is likely to fall. This leads to a rise in replacement worker recruitment, the immigration of highly skilled ICT people falls, as does the intake into relevant courses. Labour costs are affected by the supply demand interaction. Lower labour costs tend to boost competitiveness but may, in the long-term, lead to unattractive pay levels in the area and to students choosing more attractive options. Higher labour costs on the other hand (without productivity increases) negatively affect industry's competitiveness but, over the medium-to-longer term, are likely to boost both quality and quantity of the labour supply. Pay trends in competitor countries and currency exchange rates also impact on supply/demand; and pay in other sectors within the country is also an influencing factor. Also, whether the ICT market itself grows or shrinks will have a large impact (Forfás 2008).

In 1976 1,600 jobs were announced in the area of electronics but, over the next few years, 18,000 jobs in the sector were projected by the IDA. This led to the identification of a problem. Engineering graduate output from Irish universities and technical colleges would not be sufficient to meet the upcoming need for technical staff in the projects already agreed with the IDA. The existing annual output at the time was about 100 engineers and 200 electrical technicians and the timescale for training was dependent on the type of course and was of the order of two to five years. This left a large skills gap. In 1979, the IDA briefed the HEA on the upcoming graduate crisis and upcoming job opportunities. In the near term, one-year conversion courses in electronics, for science graduates, were offered and, for the longer term, existing course places were increased and new courses were to be offered. Funding was made available to the HEA to assist with these course developments (McSharry and White 2000).
Sterne (2004) pointed to an oversupply of graduates in data processing in the late 1970s and early 1980s. Readily available packaged software had led to a decrease in demand for data processing staff which meant that many of the first software degree and diploma graduates had difficulty in finding work. Sterne (2004) pointed out that a high percentage of these graduates emigrated and this trend of emigration, after qualification for software development, continued throughout the 1980s. It was in the early 1990s, that this trend was reversed and a shortage of suitably qualified people appeared again. The 1990s were a time of great re-appraisal and analysis of the educational system. There was pressure to align education to the needs of society and there was considerable debate and subsequent changes to legislation which affected higher level education during this decade.

Analysis of skill needs in the software industry, by McIver Consultants, found that the existing job base of 20,000 jobs in the software sector was likely to rise to 51,000 by 2003, provided there were sufficient skills to supply the high growth scenario (41,000 under basic growth and 30,000 under reduced growth). It estimated an annual requirement of 250 people for the IT staff requirements outside of the IT sector. Analysis of skill needs in the electronic hardware sector by Eirlink International, found an existing job base of 33,000 in hardware electronics in 1997 and estimated that this could grow to 62,000 in 2003, if the skills deficit could be supplied under the high growth scenario (6,500 under basic growth and closure of some plants under reduced growth/recession) and took into account both IDA target demand for 1998 and 1999, as well as the requirements for further research and development centres.

The turn of the century saw a shortage of software skills and the authorities again looked to the colleges to increase the intake of students. By 2002, however, there was again little work for software graduates. In this instance, the oversupply was higher as the number of course places had increased. The result was a drop in applications for computing courses. While there were many claims of shortages of ICT workers, the OECD 2002 report found that this was most pronounced in some categories of ICT workers. The gap in skills between current IT workers and the skills being sought by firms was of more importance, particularly in the area of policy formation (OECD 2002).
The continued success in attracting electronics and computer enterprises into the country had put huge strain on our capacity to produce trained technical staff. In 1997, the IDA complained of the shortage of qualified staff for the sector. The government responded by increasing the output from relevant courses for teleservice staff by 1,000 and announced the creation of a £250 million Education Technology Investment fund. One quarter of the fund was to be used to provide computers and training for schools and school teachers as well as 7,000 extra third-level college places at degree and technician level in high-technology areas (McSharry and White 2000).

“ICT skills have become a new type of ‘general’ skill, like literacy or numeracy” (OECD 2002, p.12). During the Celtic Tiger years, software company chiefs complained that many school leavers with good grades and aptitude for studying computing were unable to get a college place while, after the points dropped for computer science, the professors were worried about the admission of people to courses who might be incapable of completing their degree programmes (Sterne 2004). Wickham and Bruff (2008) point to an alleged link between growth and software industry employers’ search for skilled labour outside of Ireland because of a lack of supply within the country. They indicate that the software industry was both critical to the success of the Irish economy as a whole and is one of the areas which continuously suffers from skills shortages. They concluded that Irish software companies, having “reaped the benefit of employing migrant labour”, had proceeded to make immigrant employees an “integral part of their recruitment and training strategies” (Wickham and Bruff 2008). This type of recruitment policy fitted with the project oriented nature of the work involved. The IDA newsletter (Spring 2011) points to “2,500 software engineers/programmers/analysts, currently not working” available for immediate employment based on CSO Q4 2010 data.

3.3.6 Time-Series for Technical Education in Ireland

A time series in technical education, broken down by decade is shown in Table 3.8. This is also displayed in graphical form in Figure 3.5. Chapter Four explores developments in technology and the global industry and then moves on to explore the development of the ICT industrial sector in Ireland.
<table>
<thead>
<tr>
<th>Year</th>
<th>Time Series Two Technical Education Milestones</th>
</tr>
</thead>
<tbody>
<tr>
<td>1960</td>
<td>• Commission on Higher Education set up in Oct.</td>
</tr>
<tr>
<td>1961</td>
<td>• Committee on Technicians set up by Dept. of Education</td>
</tr>
<tr>
<td>1963</td>
<td>• TCD founded a Graduate School of Engineering Studies.</td>
</tr>
<tr>
<td>1964</td>
<td>• OECD report “Technician Training in Ireland” published</td>
</tr>
<tr>
<td>1965</td>
<td>• OECD report on Irish Education “Investment in Education”</td>
</tr>
<tr>
<td>1966</td>
<td>• Intermediate Certificate Examination was introduced</td>
</tr>
<tr>
<td></td>
<td>• VEC’s to provide courses up to Leaving Certificate</td>
</tr>
<tr>
<td>1967</td>
<td>• The 1967 Industrial Training Act passed</td>
</tr>
<tr>
<td>1968</td>
<td>• Ad hoc Higher Education Authority (HEA) established</td>
</tr>
<tr>
<td></td>
<td>• AnCO was established</td>
</tr>
<tr>
<td>1969</td>
<td>• RTC’s opened at Athlone, Carlow, Dundalk, Sligo and Waterford.</td>
</tr>
<tr>
<td>1970</td>
<td>• Points system first introduced by NUI</td>
</tr>
<tr>
<td>1971</td>
<td>• Higher Education Authority Act</td>
</tr>
<tr>
<td></td>
<td>• Letterkenny RTC opened</td>
</tr>
<tr>
<td>1972</td>
<td>• NIHE in Limerick Founded</td>
</tr>
<tr>
<td></td>
<td>• ad hoc NCEA was established</td>
</tr>
<tr>
<td></td>
<td>• Ireland became a member of the European Economic Community</td>
</tr>
<tr>
<td></td>
<td>• Galway RTC opened</td>
</tr>
<tr>
<td>1974</td>
<td>• Cork RTC opened</td>
</tr>
<tr>
<td>1975</td>
<td>• European Social Fund (ESF) available to non-university sector students</td>
</tr>
<tr>
<td>1976</td>
<td>• IDA advise of upcoming skills shortage in ICT</td>
</tr>
<tr>
<td></td>
<td>• NIHE Limerick was recognised as NUI college until end of 1977</td>
</tr>
<tr>
<td>1977</td>
<td>• The National Board of Science and Technology Act.</td>
</tr>
<tr>
<td></td>
<td>• Tralee Technical College raised to status of RTC.</td>
</tr>
<tr>
<td>1978</td>
<td>• Two colleges combined to form the Dublin Institute of Technology</td>
</tr>
<tr>
<td>1979</td>
<td>• “Whither Science Policy?” by Lynch</td>
</tr>
<tr>
<td></td>
<td>• Funding for NMRC in Cork announced (opened in 1981)</td>
</tr>
<tr>
<td></td>
<td>• National Council for Educational Awards Act</td>
</tr>
<tr>
<td>1980</td>
<td>• NIHE Dublin founded</td>
</tr>
<tr>
<td></td>
<td>• National Institutes of Higher Education Acts</td>
</tr>
<tr>
<td></td>
<td>• White Paper on Educational Development</td>
</tr>
<tr>
<td>1981</td>
<td>• NMAC in Limerick and NMRC in Cork with focus on microelectronics</td>
</tr>
<tr>
<td>1983</td>
<td>• First graduates from DCU’s BA course in Computing</td>
</tr>
<tr>
<td></td>
<td>• European Commission research programme “Esprit” calls for pilot proposals</td>
</tr>
<tr>
<td>1984</td>
<td>• Programme for Action in Education, 1984-1987</td>
</tr>
<tr>
<td>1985</td>
<td>• Green paper “Partners in Education” signalled structural reform</td>
</tr>
<tr>
<td>1986</td>
<td>• International Study Group chaired by Dr. T.P. Hardiman</td>
</tr>
<tr>
<td>1987</td>
<td>• Labour Services Act (amalgamation of the National Manpower Agency, the Youth Employment Agency and AnCO to form FÁS.</td>
</tr>
<tr>
<td>1989</td>
<td>• NIHEs in Limerick and Dublin were designated as universities</td>
</tr>
<tr>
<td>1991</td>
<td>• OECD review of Irish education</td>
</tr>
<tr>
<td></td>
<td>• National Council for Vocational Awards</td>
</tr>
<tr>
<td>1992</td>
<td>• Regional Technical Colleges Act or RTC Act</td>
</tr>
<tr>
<td></td>
<td>• Dublin Institute of Technology Act or DIT Act</td>
</tr>
<tr>
<td></td>
<td>• Tallaght RTC opened</td>
</tr>
<tr>
<td>Year</td>
<td>Time Series Two Technical Education Milestones</td>
</tr>
<tr>
<td>------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>1993</td>
<td>• National Education Convention</td>
</tr>
<tr>
<td>1995</td>
<td>• Science, Technology and Innovation Advisory Council formed</td>
</tr>
</tbody>
</table>
| 1996 | • White Paper on Science, Technology and Education  
      • Student Fees for full time degrees in University and colleges abolished |
| 1997 | • The Universities Act  
      • Government launch Education Technology Investment Fund (£250 million) |
| 1998 | • First EGFSN – Skills shortage in ICT  
      • DunLaoghaire RTC opened (now IADT)  
      • All RTCs were designated Institutes of Technology  
      • Education Act establishes National Council for Curriculum and Assessment |
| 1999 | • Qualifications (Education and Training) Act establishing the National Qualifications Authority (NQAI) and two new Councils (FETAC and HETAC)  
      • HETAC and FETAC and NQA set up  
      • Blanchardstown RTC |
| 2000 | • Science Foundation Ireland founded to administer Technology Foresight Fund with ICT identified as a niche area  
      • Second EGFSN report  
      • The National Training Fund Act |
| 2001 | • National Qualifications Framework of Ireland |
| 2002 | • National Adult Learning Council established  
      • HEA report “Creating and Sustaining the Innovation Society” |
| 2003 | • OECD Review of National Policies for Education  
      • NQAI’s National Framework of Qualifications launched in October  
      • CDIT Report on "Institutes of Technology and the Knowledge Society: Their Future Position and Roles” |
| 2005 | • NMRC amalgamated into Tyndall Institute |
| 2007 | • HEA oversees both Universities and Institutes of Technology as the statutory funding, planning and policy development agency |
| 2008 | • EGFSN –High level skills in the ICT sector  
      • ICT graduate placement programme (FAS) |
| 2010 | • Department changes name to Department of Education and Skills and takes over responsibility for FAS training |
## Technical Education Time Series

<table>
<thead>
<tr>
<th>Year</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>The Education Act of 1899 established the National Board for Technical Education (NBE), which was later renamed the Central Advisory Board for Technical Education (CABTE) in 1941.</td>
</tr>
<tr>
<td>1930</td>
<td>The NBE's Technical Education Council was established.</td>
</tr>
<tr>
<td>1950</td>
<td>The Government of India established the National Council for Technical Education (NCTE) to oversee technical education.</td>
</tr>
<tr>
<td>1960</td>
<td>The National Council for Technical Education (NCTE) was renamed the National Council for Educational Planning and Administration (NCEDPA) in 1965.</td>
</tr>
<tr>
<td>1970</td>
<td>The NCEDPA was renamed the National Council for Educational Administration and Planning (NCEAP) in 1970.</td>
</tr>
<tr>
<td>1980</td>
<td>The NCEAP was renamed the National Council for Educational Administration and Planning (NCEAP) in 1980.</td>
</tr>
<tr>
<td>1990</td>
<td>The NCEAP was renamed the National Council for Educational Administration and Planning (NCEAP) in 1990.</td>
</tr>
<tr>
<td>2000</td>
<td>The NCEAP was renamed the National Council for Educational Administration and Planning (NCEAP) in 2000.</td>
</tr>
<tr>
<td>2010</td>
<td>The NCEAP was renamed the National Council for Educational Administration and Planning (NCEAP) in 2010.</td>
</tr>
</tbody>
</table>

### Figure 3.5 Time Series for developments in Technical Education.
Chapter 4 – Literature Review Part III

Developments in Technology and the ICT Sector Development in Ireland

This chapter looks at technological developments in the wider ICT industry and then turns to the development of the Electronics and Software industry in Ireland. This chapter aims to provide a time series for the areas of technological development and the Irish industrial sector development. This technology review section draws predominantly from Rosenberg’s (1982) work which traces the evolution of technology and from the work of Chandler (2005) who has reviewed the advent of the “Electronic Century” in both consumer electronics and in the development of computers.

4.1 TECHNOLOGY DEVELOPMENTS

The development of a solid state semiconductor switching device, the transistor, was a vital innovation without which the electronics industry as we know it today would not exist. Prior to the development of the transistor, in the late 1940s, most electronic circuitry used low speed mechanical relays and vacuum tubes with short operating lifetimes. The resulting transistor was smaller, more reliable, longer lasting, produced less heat and consumed less power compared to vacuum tube. After the development of the transistor, huge resources were concentrated in the area of solid-state research with the prospect of a high payoff (Rosenberg 1982). The cost in developing new semiconductor parts was very high, but once designed and tested, the actual manufacturing cost was much less. This was what made volume sales so important in the semiconductor business.

Gordon Moore, a co-founder of Intel, noticed a trend which has become widely known as Moore’s Law. This law states that the number of transistors that can be built on the same size piece of silicon will double every eighteen months. Intel’s memory chips from 1968 could store 1,024 bits of data (Cringely 1992). This law has successfully predicted the reduction in size and the increase in capability in electronics since then.

In 1971, Ted Hoff, working at Intel, invented the microprocessor, the basic building block for every computer. With the addition of some memory and support chips and a programmable microprocessor chip it was possible to make a computer. Cringely (1992) distinguishes between the mainframe business, large computers sold to Governments or
large businesses and the development of the personal computer which were sold for direct use by the individual purchaser. While logic might indicate that the personal computer is a small version of the mainframe, this is not the case. The personal computer grew from the development of the silicon chip. The personal computer relied on a market of millions of little customers where the market for mainframes and minicomputers was based on a few large customers (Cringely 1992).

In the area of computing, IBM alone that was the defining first mover in the 1950s. Chandler (2005, p.170) identified three periods of revolution, equivalent to Schumpeter’s ‘gales’ in the area of computing. These were the development of the IBM360 mainframe in the late 1960s, the development of a mass market for computing with the arrival of the PC in the 1980s and the arrival of the router, the World Wide Web and the browser in the mid-1990s. In the mid-60s DEC defined a new path with their development of the minicomputer for smaller engineering and scientific applications and a small group of firms followed on this path. According to Rosenberg (1982), the mediating variables between technical feasibility and commercial success are as follows: Cost vs Performance; Capital costs increase as circuit element size is reduced; high volume production favours large established firms.

During the 1980s, further development of the microprocessor transformed the industry again. The IBM PC and its clones, all of which used both the Intel microprocessor and Microsoft’s operating system, was the defining product (Chandler 2005). The established functional capabilities in product development, production and marketing over the previous three decades allowed IBM to capture 80 percent of world markets with its mainframe computer product. The privatisation of the internet and allowing commercial use of the internet in 1994 marked a critical point in technical development. This was not just a technical marking point but it also brought in many changes in industry and education. It was the beginning of the age of Information Technology.

Apple microcomputers were highly regarded in the desktop publishing (DTP) and graphic design industries and have set technology trends over many decades since the late 1970s.

A time series for technical development, based on the technologies discussed above is outlined below in Table 4.1
Table 4.1  Time Series Three – Technological Developments

<table>
<thead>
<tr>
<th>Year</th>
<th>Time Series Three - Technical Developments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1947/48</td>
<td>• Development of the first point contact transistor and first junction transistor (Schockley, Brattain and Bardeen) - Company AT&amp;T.</td>
</tr>
<tr>
<td>1951</td>
<td>• First UNIVAC computer delivered to the US Census Bureau. This was the first commercial machine to use stored programmes – instructions within the machine – Eckert and Maunchley (Kenney 1992).</td>
</tr>
<tr>
<td>1958</td>
<td>• Development of the first IC by J. Kilby in Texas Instruments</td>
</tr>
<tr>
<td>1959</td>
<td>• First commercially producible IC using planar technology by R. Noyce in Fairchild Semiconductor</td>
</tr>
</tbody>
</table>
| 1960   | • The Broadcasting Act – set up Telefís Éireann, the Irish TV service.  
• IBM 1401 first delivered |
| 1961   | • First Irish Post Office radio link opened from Athlone to Galway  
• DEC (Digital Equipment Corporation) introduced its first program data processor |
| 1962   | • IBM’s first removable Disk Storage |
| 1963   | • First Satellite in Geosynchronous Orbit |
| 1965   | • “Moore’s Law” first stated |
| 1969   | • ARPANET (precursor to the internet) introduced  
• AT&T released UNIX operating system and licensed it free to all. |
| 1971   | • First Microprocessor chip by T. Hoff in Intel |
| 1973   | • Sharp developed Liquid Crystal Display (LCD) technology |
| 1975   | • IBM introduced System/32 machine  
• Bill Gates and Paul Allen founded Microsoft |
| 1976   | • Version of Basic written for the Altair by Bill Gates and Paul Allen (Microsoft) |
| 1977   | • Apple, Tandy’s RadioShack and Commodore introduce microcomputers |
| 1980   | • IBM began Project Acorn to build PC |
| 1982   | • Sony and Philips introduced CD players  
• Compaq and Sun Microsystems established |
| 1983   | • First IBM PC |
| 1984   | • Apple Macintosh launched  
• Cisco was established |
| 1986   | • First commercial C++ compiler for applications by Irish company Glockenspiel  
• Sony and Philips introduced CD-ROM |
| 1989   | • Tim Berners-Lee develops core elements of the world wide web |
| 1991   | • Apple Powerbook |
| 1993   | • Mobile phone system, Eircell opened by Telecom Éireann  
• Sony Playstation introduced |
| 1994   | • Privatisation of the Internet- allowing commercial usage |
| 1997   | • First DVD players |
| 2001   | • Mobile phone licence to Meteor, Eircell taken over by Vodaphone  
• Apple iPod 1st generation |
| 2002   | • Licence awarded for 3G network to Vodaphone. O2 |
| 2003   | • iTunes Music Store and iPod (3rd generation) |
| 2007   | • iPhone |
This data in this table is taken mainly from Chandler (2005) for general electronics and software milestones and from Cox (2006) for technology developments in Ireland. Any other sources used are included in the references section. The following section reviews the development of the industrial sector over the five decades.

4.2 INDUSTRIAL DEVELOPMENTS IN ELECTRONICS AND SOFTWARE IN IRELAND

4.2.1 Introduction

There follows a chronological description, using examples, of the relevant companies who have formed part of the Irish electronics and software sector in the period 1960 - 2010. The chronology takes the dates of start-up or arrival of firms in Ireland to set a time series. The companies listed or described in the upcoming sections are intended to illustrate the types of industry and the development of the sector over time.

4.2.2 Development of Electronic Companies in Ireland per Decade

Begley et al. (2005) review the phases in industrial development in Ireland and find five phases of multinational involvement. These five phases roughly correspond to the decade breakdown (1960 to 2010). In the decade 1960-1970, they point to the liberalisation of the economy with low tax, low costs and generous grants as main advantages for attracting Foreign Direct Investment (FDI). General Electric and Magna Donnelly were examples of companies attracted to Ireland mainly as a low-cost manufacturing site.

1960 - 1969

The electronics sector grew from small beginnings in the late 50s – early 1960s. Outside of RTÉ, the ESB and the Department of Posts and Telegraphs, the main areas of operation were in the manufacture of radios and televisions for the home market by foreign owned companies (Committee of Industrial Organisation 1963). Protectionism and high import tariffs had encouraged these firms to locate in Ireland. Total employment in the sector was 1788 persons in 1960. Total value of goods produced was £ 2,670,000 with exports at
£260,000 in 1961. The firms were Pye, Bush, Philips, Brownlee Bros, Murphy Radios, Plessey and General Electric Ireland. The company ownership breakdown was approximately 44% British, 35% German, 14% American (Committee of Industrial Organisation 1963).

**Technico**

A successful indigenous telecommunications company, called Technico, was in operation during the early 1960s, concentrating on supplying exchange equipment for the Department of Post and Telegraphs. Established by Beckman, a German entrepreneur and Glaser, an Irishman with Swiss roots, they designed, manufactured, installed and commissioned telephone exchanges for a large export market (Power 2006). This was an early training ground for many of the telecommunications engineers, some of whom went on to establish Lake Electronics in the late 1970s (O'Toole 1987).

**GE subsidiaries, EI and ECCO**

By 1966, General Electric (USA) had established the first of two subsidiaries in Ireland. The first GE plant was called EI, located in Shannon, Co. Clare and set up to manufacture components for the parent company in the USA. It continues to design and produce residential fire safety products in Shannon, employing over 600 people but is now under Irish ownership following a management buy-out in 1988. In 1966, ECCO was opened in Dundalk as a semiconductor manufacturer and is credited with training approximately 36 people who went on to become CEOs and leaders of other companies around the country (McCambridge 2001). They were taken over by the Harris Corporation and subsequently by Littelfuse. The plant was closed in 2009 and Littelfuse sold the site in 2012 (The Argus 2006).
Jowen Electronics

In 1966 a small company, Jowen Electronics, was operating in Cork. They designed and supervised construction of large electronic display boards for export. O’Halloran (2009) suggested that a lack of investment in R&D, to keep ahead of the competition, was the reason that Jowen Electronics eventually closed in Ireland.

System Dynamics

Founded in 1968 by Tom McGovern, System Dynamics was the first Irish software company (Sterne 2004). The company designed bespoke software as part of its services but styled itself as a “technical consulting house”, supplying contract technical staff, working on application development projects and running training courses, mainly for IBM mainframe and later for DEC and Data General mini computers. In 1994, shortly after Tom McGovern died, System Dynamics was acquired by Arrival Holdings, a British company who scaled down the Dublin section. It returned to Irish ownership again in 1996 and is still trading (Sterne 2004).

1970-1979

In the 1970s, IDA expertise and government flexibility were added to the above advantages resulting in the attraction of manufacturing in more capital-intensive sectors. Wang, DEC and Nortel were cited as examples of new enterprises that came to Ireland in this decade (Begley et al. 2005). In 1973, Ireland became a member of the EEC and this access to the larger European market was an attractor for FDI. In the 1973 IDA plan, the electronic and chemical sectors were identified as high-growth potential areas where Ireland could be competitive and would not be undercut by emerging lower cost countries.

Digital Equipment Corporation

The mini-computer manufacturer Digital Equipment Corporation (DEC) came to Galway in 1971. DEC began as a hardware assembly and distribution facility. DEC employment in
Ireland grew to 500 in 1973, developed to over 1,000 by 1977 and reached 1,100 by 1981. It was to hold this level of employment until 1993 when the manufacturing operation began to shut down. DEC also built up a software competence and by 1993 it employed 350 people on the software side and the software group had been so successful that DEC added a high-performance software group during the year.

**Analog Devices**

In 1977, a US company called Analog Devices opened a subsidiary in Limerick to design and manufacture Complementary Metal Oxide Semiconductor (CMOS) ICs. It has over 1,000 people employed in manufacturing, distribution, sales/marketing, treasury and R&D operation in Limerick. Over 400 people are employed in R&D. According to IDA information, the company made a further €23 million investment in manufacturing in 2010.

**Lake Electronics**

Lake Electronics, a telecommunication company, was started in Dublin in 1979. This was seen by many as Ireland's most successful indigenous hardware electronics company. In 1981, the company employed 70 people, including 15 experienced, highly qualified professional engineers and had a projected turnover of £3 million with a 20% net profit on sales. In 1987, Lake Electronics was the “largest home-grown electronics enterprise in the country” (O'Toole 1987) with achieved sales of over £50 million for its telecommunications products. This company had customers in the USA, China, Britain and Europe. By 1987, 145 people were employed of which 130 were in two locations in Tallaght in Dublin and staff in Swindon had reduced from a high of 45 down to 15.

**1980 – 1989**

A consultation with the McKinsey Consulting Company resulted in the IDA Strategic Plan for 1982-1992 being formed. It signalled a change to focusing on industry that would “achieve high output growth using the best technology available, while maximising their
spending on Irish services and materials”. Electronics, computer software and other niche areas, such as healthcare and biotechnology, were identified as having the desired high-growth characteristic.

The 1980s saw Lotus, Lucent, Microsoft, Intel, EMC and Apple arrive in Ireland. Begley et al. (2005) indicate that the arrival of these companies coincided with a technically educated workforce. They also indicate that, by this stage, there was an accumulation of multinational management expertise, developed in the existing manufacturing base. Some of the companies who set up in Ireland were seeking for a presence in Europe to offset fears that they would otherwise have difficulty selling into “Fortress Europe”. This was used as a strategy by the IDA to encourage investment (McSharry and White 2000). At this stage there was some turn-over, in the form of arrivals and departures of firms, particularly in the low-tech sector. Also the focus shifted to attracting higher value manufacturing-related activities, such as supply chain management and customer services.

Apple

In 1980, Apple started to operate, in Cork, employing 19 people but this expanded quickly to 170. This was the IDA’s first major success from Silicon Valley. By 1988, there were around 500 people employed and by 1999 this figure had risen to over 1,000 people employed directly. By the year 2000, the company in Ireland shifted emphasis from manufacturing to services and the fortunes of the company were aided by the launch of the successful iPod, iPhone and iPad products. By 2010, Apple had 2,000 people employed in Ireland.

Sterne (2004) states that the IDA had successfully targeted about 80 electronics manufacturers by the early 1980s and estimated that these had about 14,000 people employed. He indicated that before the IDA began to give grant aid to software companies, computer hardware companies provided encouragement for software development. In 1981,
Triple A Systems launched a multi-currency banking product called Bankmaster that ran on an ICL minicomputer. ICL assisted Triple A Systems (which became Kindle and then was taken over by Misys) to sell the product into former British colonies in Asia and Africa and benefitted, in turn, by selling ICL hardware. DEC helped GC McKeown to sell into local government authorities in England and IBM assisted AMS to find international buyers for the Insight financial planning package which was so successful (selling over $10 million within three years) that the company changed its name to Insight Software, in 1983. RTS produced accounting and manufacturing software for international users which ran on IBM computers and by 1981 had successful sales in Iceland, Britain and Germany and grew to a worldwide network of 20 sales offices after four years. This according to Sterne (2004) established another characteristic of the Irish software industry – the ability to network and co-operate for mutual benefit.

**IBM**

IBM did not bring a computer assembly plant to Ireland although they featured high on the IDA radar. They tended to locate their factories near large supporting markets. However, they did have a small enterprise in Ireland in the mid-50s – mainly involved with punch-cards and a sales and support operation (mentioned in the original C.I.O. Reports 1963). In the 1960s, training of technical staff was carried out in the UK. O’Halloran (2009) reported that when he went to work for IBM, in the early 1960s, he was the only Irish person on the training course he attended in the UK. He indicated that IBM’s work culture was unique to IBM. As previously mentioned, Ireland’s first software company was a spin off from IBM. In 1983, IBM Ireland Information Services Ltd (IISL) opened in Dublin to design and test bespoke software. This operation was profitable and Sterne (2004) estimates their revenue to have been around $2 million in 1984. Following successful software developments both for IBM direct and product sales to other external customers, revenues were around $18 million and staff numbers had risen to around 100. However, despite success, the group lost out in 1994 when a corporate decision was taken to reduce the number of software
laboratories outside of the US. IISL lost control of the products they had created. These were taken over by an American software unit. Most of the employees were redeployed. In the latter half of the 1990s, IBM set up component manufacturing operations in Ireland and there was a change of direction on software when IBM acquired Lotus Development in 1995. Sterne (2004) reported that, in 2003, the Dublin software laboratory was working on core product for IBM in the area of component development for middleware that combines e-mail, instant messaging, document management and team collaboration.

**Micropro**

Micropro was an example of an overseas company that came, enjoyed success for a few years and departed before their tenth anniversary. Micropro was a Californian company that opened in Dun Laoghaire in 1981 following success of their product called ‘WordStar’ (Sterne 2004). They employed nine people by 1982 and, while they initially envisaged modification work being done in Ireland, the design team they hired, successfully planned and produced the first version of WordStar to work on an Intel x86 architecture. They expanded and hired a second team to localise and translate the software into European languages. Micropro eventually had 28 people employed, mostly in disk duplication and packaging, but this dropped to 5 by the end of 1985 as a recession hit the PC trade. By 1990, the company shut down the Irish operation (Sterne 2004).

The mid-1980s was associated with the closure of plants and job losses, including DEC, Wang and Mostek. Between 1983 and 1985, more jobs were lost than were created in the ICT sector. Over half of the job losses were in the Dublin region. Towards the end of the 1980s, employment in the sector had improved again and jobs created in ICT were more than compensating for those lost.

A 1984 survey to determine Ireland’s level of development in the area of software, estimated 250 software companies were present at that time. By 1985, the number of
companies had climbed to over 300, mostly working on business applications software for specific industries. Sterne (2004) indicated that most of these firms were surviving on very little capital and were usually short of money and mostly working on derivative products. However, by that stage some of the distinctive features of the indigenous Irish software sector were already set, such as: hundreds of small firms, a preference for software product over service and a willingness to look for export markets. The early signs of successful networking were also showing with the co-operation with successful large hardware firms (Sterne 2004).

In 1985 Lotus set up a software development centre in Dublin and Microsoft set up its European production and distribution centre a year later. After the arrival of Lotus, many other companies, such as Oracle, Symantec, Corel, Claris and Frame Technology followed. Novell arrived in the early 1990s. Lotus and Micropro were the companies that introduced localisation to Ireland (Sterne 2004).

**SMC**

In 1985, SMC in Cork was started to develop database handling ability for desktop PC’s. They worked on a project for Zenith. This was to give them their most successful software package, a management information system called MSS. By the early 1990s, SMC employed 60 people. In 1991, SMC was acquired by MF Kent Corporation. When a receiver was appointed to the MF Kent parent group, it was finally wound up in 1994. SMC was the seed company for many new technology based companies in the Cork region. These included companies Cadco, Qumas and PM Centrix (Sterne 2004).

Based on Córás Tráchtála figures for 1985, there were around 1,800 people employed in the software industry with 1,200 in indigenous software firms and approximately 600 in foreign-owned subsidiary firms (O’Gorman et al. 1997). Between 1980 and 1986, two further initiatives were to be successful for the IDA, namely, focus on a new International
Services Programme targeting, among others, data processing and software development. It resulted in the successful set up of IBM Software Centre in 1983, a Lotus Software Centre in 1984 and a Microsoft Software Centre in 1985 and the creation of thousands of jobs and a thriving software sector.

The latter half of the 1980s was to see a technically focused subset of the software industry develop. The software companies were producing development tools and high-tech communications functions for existing applications. Sterne (2004) identified this as the beginning of the third generation of Irish software development. Some companies in this area were overseas companies such as Merrion Gates Software, Retix who specialised in data communications, an IT centre for ICL and an IBM software laboratory. However, in this area, Irish software companies held their own with Baltimore Technologies, Captec, Generics and Glockenspiel.

By 1991, the number of people employed in the software industry had risen to around 7,800 and was roughly evenly divided between indigenous and foreign-owned firms.

1990-2000

In the 1990, the rising cost base, due to the success of the “Celtic Tiger”, led to staff shortages in many sectors but particularly in the ICT sector. This decade, however, added the advantages of access to, and greater co-operation between, third- level institutions and industry (Begley et al. 2005). Venture capital became more abundant for investment in start-ups. While many firms continued to exit, particularly in manufacturing, there were many successes as Dell, Xerox, Xilinx and SAP started up in Ireland. This transitioned into the “Knowledge Economy” from 2000 onwards. Successes in FDI included Google, eBay, PayPal, Cisco, Amazon and Facebook with customer service, supply-chain and headquarter functions. The profile and type of company also emphasised the increased reliance on e-
commerce and software development. Focus on R&D also increased. Innovation and flexibility in the workforce increased in importance.

Over the course of the 1990s there was an overall increase of around 450,000 in the total number of people in employment. The unemployment rate had fallen to around 5%. This led to labour shortages and skills shortages, with larger firms and computer and engineering firms suffering most (Forfás 2000). The worldwide value of personal computer hardware and software, sold was $70 billion, making it one of the top four manufacturing industries in the world (Cringely 1992) and it

"provided a firm foundation for an expanding Irish economy and contributed, more than any other sector, to the phenomenal industrial growth that took place and to the substantial foreign trade surplus that was generated" (Cox 2006).

Throughout the 1990s, Ireland was successful in attracting, annually, over 20% of the new US electronic companies investing in Europe (McSharry and White 2000). Between 1990 and 2000, a total of 85,712 people were employed in foreign-owned ICT companies (Power 2006) but there was a downside also. Wang and Zenith were driven out due to competition and closed in the early 1990s and DEC closed its Irish assembly plant in 1993 due to a consolidation move.

Dell

Dell set up in Limerick in 1990 and occupied the site previously used by Atari which had closed. By 2002, Dell's exports, at a value of approximately €7 billion, made up 7.8 per cent of all Irish Exports in that year (Tiernan et al. 2006). Dell used a direct-to-customer model, looked to keep obsolescence and inventory as low as possible, had a production operation with a focus on quality, cost and velocity (both time to build and time to reach the customer). They used a 'pull' system driven by customer orders and were one of the highest performing Dell plants world-wide (Tiernan et al. 2006). Production was transferred to
Poland in 2009 with the loss of around 2000 jobs but higher value added functions were retained and extended (Collins and Grimes 2008).

**Iona**

Iona was formed in 1991. It was a TCD campus company and its founding members had worked on European research projects in distributed object technology. Iona rushed to create a neutral multi-platform standard (Common Object Request Broker Architecture (Corba)) toolkit. The resulting product, called Orbix was released in 1993. It received the approval of the Object Management Group who had designated the standard. By the end of the decade there were many new start-up companies that had their roots in Iona. The subsequent rise of Java as the standard development platform was one of the reasons for the decline of Iona.

It was notable that while approximately half of the employment was in indigenous Irish firms, their share of the sales revenue was much smaller. O’Gorman *et al.* (1997) indicated that the higher sales figures arose due to value generated in R&D, marketing and management activities of the parent companies.

Three clusters were developing in the Irish software sector in the areas of telecommunications, computer-based training and software development tools or middleware. CBT Systems was the leader in the computer-based training arena and by 1991 was the largest Irish exporter of software with international sales of a few million dollars. With success in US sales over the next four years, CBT Systems’ revenue grew to $40 million.

Earlier successes for the company were in the areas of financial management, banking and telecommunications but the recent focus was on training computer users. The success led to CBT going public in 1995 and demonstrated the strength of Irish software development and
ushered in the fourth generation of software companies (Sterne 2004). Only a few companies made it to flotation on the stock exchange after CBT and this included Iona, Trintech, Datalex, Baltimore Technologies (after change in ownership).

**Aldiscon**

Aldiscon were successful in the telecommunications sector and developed management systems for text messaging on mobile phones. By 1994, they had two-thirds of the world market for short message service centres and had used early adoption of industry standards as a driver for success, in a similar way to Glockenspiel and Iona (Sterne 2004).

**Table 4.2 The Irish Software Industry Data, 1991 -1995**

<table>
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<tr>
<td><strong>Indigenous</strong></td>
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<tr>
<td>Employment</td>
<td>3,801</td>
<td>4,495</td>
<td>5,773</td>
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<td>Overseas Employment</td>
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<td>4,448</td>
<td>6,011</td>
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<td><strong>Total</strong></td>
<td>7,793</td>
<td>8,943</td>
<td>11,784</td>
<td>10.9 (average)</td>
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<td><strong>No. of Indigenous</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Companies</td>
<td>291</td>
<td>336</td>
<td>390</td>
<td>7.6</td>
</tr>
<tr>
<td><strong>No. of Overseas</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Companies</td>
<td>74</td>
<td>81</td>
<td>93</td>
<td>5.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>365</td>
<td>417</td>
<td>483</td>
<td>7.3</td>
</tr>
<tr>
<td><strong>Sales Revenue</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>(£ million)</td>
<td>150</td>
<td>236</td>
<td>386</td>
<td>26.7</td>
</tr>
<tr>
<td>Indigenous</td>
<td>1,580</td>
<td>1,756</td>
<td>2,611</td>
<td>13.4</td>
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<tr>
<td>Overseas</td>
<td>1,730</td>
<td>1,992</td>
<td>2,997</td>
<td>14.7</td>
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<tr>
<td><strong>Total</strong></td>
<td>3,310</td>
<td>3,748</td>
<td>5,608</td>
<td>14.1</td>
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<tr>
<td><strong>Indigenous Exports</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(millions)</td>
<td>61</td>
<td>116</td>
<td>226</td>
<td>38.7</td>
</tr>
<tr>
<td><strong>Overseas Exports</strong></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>(millions)</td>
<td>1,548</td>
<td>1,726</td>
<td>2,585</td>
<td>13.7</td>
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<tr>
<td><strong>Total</strong></td>
<td>1,609</td>
<td>1,842</td>
<td>2,811</td>
<td>15.0</td>
</tr>
</tbody>
</table>

The National Software Centre

The late 1990s saw the opening of a National Software Centre in Cork. A need was seen by the Cork Business and Innovation Centre and by leading local software veterans. Initially, it was intended that it would offset a shortage of office space that had high speed data links and that it would provide supported space for growing software businesses.

In examining the Irish software industry in 1997, O’Gorman et al. envisaged the industry as shown below in Figure 4.1.

The overseas side of the Irish software industry was involved in the production of mass market packaged software and some specialised or internal software development. The outsourcing functions crossed the divide between both the overseas and the indigenous sectors. The Irish sector was involved in product development in largely niche areas but some were also offering services or a combination of the two.

![The Software Industry Structure in Ireland](image)

**Figure 4.1  Structure of the Software Industry in Ireland**
Intel

Intel stands out as the major longstanding success story for Ireland. It chose Ireland as a location for its microprocessor manufacture amongst very stiff competition from other countries. It started in 1989 and by 1998 had 3,500 people employed in Leixlip and was opening “FAB-14” to produce its most current microchip.

The IDA saw success again as the American markets thrived. Ireland had recovered with a 7% growth rate in 1994 from a rate of between 2% and 3% in the previous three years. Low inflation and a falling national debt, following the government’s 1987 budgetary measures, were other positive factors for the country. Successes for the IDA, from this time, were Dell, Gateway 2000 and a Compaq customer service centre with 600 jobs. Hewlett-Packard established in Leixlip in 1995 to make printer-toner cartridges (both Compaq and Hewlett-Packard had originally set up in Scotland). In the Irish software sector, in 1994, Seamas Eivers co-founded Client Solutions. This later became part of the publicly quoted Horizon Technology Group. Eivers was one of the founder members of the National Software Centre in Cork.

As the hardware development grew, software and other computer support services began to arrive, such as Microsoft, Lotus (later a part of IBM), Oracle and Ashton-Tate. Ireland began to make progress on the software front with indigenous companies such as Iona and Baltimore Technologies reaching multinational status. Mostly, the software companies were operating in niche markets such as localisation, or computer-based training and technical documentation and, eventually, Ireland was the second largest exporter of software. Ancillary items for computers also developed in Ireland, with Hewlett-Packard manufacturing ink-jet cartridges and Verbatim and Atlantic Magnetics producing diskettes (Cox 2006, p.331). In 1996, IBM announced an expansion to employ 3,000 people in electronic components manufacture and customer support services. Dell, AST and Gateway chose Ireland as a base for European operations. Sun Microsystems - makers of work-
stations - came to Ireland, as did Oracle – specialists in database software. With the convergence of functions, during the internet boom in the 1990s, Ireland was successful in attracting 3Com, Cabletron and Bay Networks (later bought out by Nortel). On the indigenous side, Horman Electronics took on full system assembly for Apple.

Sterne (2004) points to a change in attitude, in the mid-1990s, in the Irish software sector. Engineers and other business entrepreneurs were more willing to risk investment in a start-up company. They were more ambitious and focused on international markets and the stock markets. This was a change from the previous generations and showed a confidence and a developed willingness to interact with external investors. However, Sterne (2004) claimed that, by 1997, less than $24 million had been invested in the Irish software sector and one-third of this was a single investment in Aldiscon.

Between 1995 and 2004, the Irish share of OECD exports of computer and information services and other business services grew from less than 1% to around 5% (OECD, 2006). In 1996, eight projects, each with over 500 jobs, were won by the IDA. Amongst them was the IBM Corporation with a 3,000 job customer-support centre for European IBM customers. The successful operation of the previous IBM 100-person Software Development Centre stood Ireland in good stead and led to the creation of 3,000 further IBM jobs, in line with the development by the IDA of their successful call centre packages and the trend towards e-commerce. In 1997, Seagate closed in Clonmel with the loss of 1,400 jobs in the manufacture of computer hard-disks. Collins and Grimes (2008) cite this as a wake-up call for other subsidiaries or affiliates - a realisation of vulnerability of manufacturing sites which had only production on site.

The IDA started to actively discourage large companies from locating manufacturing of certain types in Ireland, particularly if low cost was a key requirement, according to Barry and vanEgeraat (2005). They found that, per Forfás data, local sourcing in Ireland by
computer assemblers was of the order of 6 to 7 per cent of material inputs sourced but this rose to 27 per cent in the middle of the 1990s and finally to about 28 per cent in 1999. However, these figures included items bought from the local supply-chain which may have been manufactured in other regions and also included expenditure on full systems which had been manufactured under contract by manufacturers with local operations. They disputed that this was true vertical linkage production and proposed an average of 10% as a more accurate figure for parts and components sourced by assemblers in Ireland that were also manufactured in this country.

Most components were bought in from the Far East and some from the USA. Sourcing of enclosures, motherboard-back-panels, network cards, non-English language keyboards, digital/printed media, cables/interconnect, packaging and accessory kits were the most likely to be sourced locally within Ireland (and also Scotland) but, even here, there would have been competition from the Far East for motherboards/backpanels, network cards, cables, keyboards and monitors.

Barry and vanEgeraat (2005) found that the production activity in Ireland was very limited or had little value added – many were merely packaging media or language specific parts into a box. They cited bulkiness and component variety as main drivers in the decision to source locally. Bulkiness was related to packaging material and hence warehousing space, leading to high inventory costs and local sourcing allowed Just-in-Time to be employed to keep cost lower. With enclosures, some were sourced locally for similar reasons but, where only limited volumes were required, these then tended to be imported, as the volumes did not warrant the cost of developing a local source and costs associated with tooling. They also found that components with a high variety of options tended to be produced on a true Just-In-Time basis by local suppliers.
Sterne (2004) reported that when the National Software Directorate measured the growth of the software industry in a 1998 survey, it found that more than 550 Irish-owned software companies were in existence, employing an estimated 9,300 people, and that their exports were around €545 million. These firms were highly dependent on export markets, with less than 20% of their business coming from within Ireland, and the US was their biggest market. At this stage, about 40 firms had their own subsidiaries in the US and firms such as Iona, Trintec and Mentec had set up networks of offices there. The survey found that the computer-based training sector (with CBT Systems as the flagship company) had almost a third of the export revenues of the sector but only about 11% of the employment where the biggest subset of the sector was the “other niche product” sector with 17% of the employment and, also, 17% of the exports. At this stage, companies with internet-related software accounted for only 1% of the export sales. While some companies developed products for web content handling, global competition for this type of business meant that sales were difficult. Companies that targeted niche markets tended to be more successful. It was graphic designers and marketing consultants that benefitted most from the rush to build websites in the late 1990s. The services side of the industry benefitted from a revival, with the establishment of e-business consulting and systems integration firms such as Ebeon, Oniva and Digital Channel Partners, although these firms did not last for a long time period (Sterne 2004).

The latter half of the 1990s featured many acquisitions of Irish software companies. In 1997, Logica paid $82 million for Aldiscon and, in 1999, Euristix was acquired by Fore Systems for $80 million. Previously in 1998, Compaq had bought Digital Equipment Corporation and later, in 2001, Compaq and Hewlett-Packard merged (Sterne 2004). O’Gorman et al. (1997) report that, while there was a common perception of take-overs by foreign firms of the larger, more successful Irish software firms, in fact, just 5 out of the 24 largest companies had been taken over by 1996. The motivation for such entrepreneurs to sell their companies tended to be, at least partly, a desire to realise some of the wealth built
up in the company or a requirement for an injection of additional capital. The 1990 Census of Industrial Production data showed that 26% of industrial employment and 28% of industrial establishments were located in the Dublin area. The overseas software firms were mainly concentrated in the greater Dublin area. Further smaller concentrations of the indigenous software industry were to be found in Cork, Limerick/Shannon and Galway (O’Gorman et al. 1997).

OECD data in 1999 indicated that, of all OECD countries, Ireland had the highest proportion of high-tech companies represented in its manufacturing exports, with electronics accounting for more than a third of its export output (Green 2000). Green found that the electronics sector was dominated by large multinational companies but that there was a more even spread between overseas and indigenous companies in the software product and service sectors. These were mostly small to medium sized companies. In reviewing the decade, Forfás found growth in both the indigenous and overseas sectors in manufacturing and services, with particularly high rates of output and employment growth in software, electronics and call centres (Forfás 2000).

In 1998, the OECD defined the ICT sector for the first time and pointed to the increasing “ubiquity” of the ICT technology. ICT firms were playing an increasingly important role in economic development (OECD 2002).

2000-2010

In the early years of this millenium, competition from the Far East continued to impact on Ireland’s component production plants. MKIR Panasonic shut down Europe’s last remaining hard disk drive manufacturing plant which was located near Dublin. It couldn’t compete with Asia on pricing (Barry and vanEgeraat 2005). Volex moved cable assembly operations to Eastern Europe and Asia. They found that even before simple component-manufacturing had been affected, six enclosure and subassembly manufacturing plants
closed between 1999 and 2003, not just because of the move to low-cost economies but because of a falling off in business from local customers such as Gateway, Apple and Dell who were experiencing a global downturn in computers.

During the downturn in the global economy in 2000, employment in the ICT sector dropped off initially, only to rebound and then stabilise, according to (Collins and Grimes 2008). The downturn in 2001 and 2002 (i.e. the dot.com downturn) saw significant job losses in Ireland. In 2000, 55% of OECD exports of software goods was accounted for by Ireland and the United States. Ireland, as the European manufacturing and distribution centre for world software enterprises, sold over 40% of packaged software and 60% of business software in Europe (OECD 2002). Ireland ranked number one in the value of the software services exported in the year 2000 (OECD 2002).

The rise of the internet had initially affected the Irish software industry in how software products are distributed by downloading or offering of trial versions. Many predicted that the internet would push the industry back to a services model and away from the software package to such an extent that software would be just another web service. Data centres were built to provide for the expected rise of service providers with storage equipment and server racks, all connected to the internet and backed up using uninterruptible power supplies (UPS) to protect against power outages and data losses. While there was much hype about data centres, Sterne (2004) indicates that the main change in the Irish software scene was the arrival of a new mobile applications cluster. Mobile applications software overtook middleware, fixed network telecommunications and computer-based learning with a range of differentiated, internationally targeted products. Indigenous firms such as Anam, Alatto Technologies, Am-Beo, Cape Technologies, ChangingWorlds, Network365, Ossidian Technologies and Xiam all started at the end of the twentieth century and were operating at the start of the new century.
Even after the downturn in 2001, Irish software sales continued to grow. Sterne (2004) indicates that sales increased from $460 million in 2000 to $550 million in 2001. In 2002, the rate of growth slowed but the export figures continued to rise and start-up software enterprises were still increasingly looking to Enterprise Ireland for support. It was a difficult time for young companies who had just introduced their product as a spending freeze in the industry severely limited sales. The move from the Dublin area to the regions became less attractive. Sterne (2004) reports that those companies, who had floated on the stock market or accepted large venture capital investment during the boom, suffered most in the downturn and turnover of top executives at these companies was common place. Furthermore, this down extended to the hardware sector in that, Gateway, a PC hardware vendor, closed down its sales and distribution operations in Dublin in 2001.

The EGFSN (2008) reports that the peak employment in the ICT sector occurred in 2000/2001 when there were 80,000 employees in the sector. The following three years saw a fall to 64,000 people employed following the dot.com downturn. Employment in the sector levelled off in 2004 and began to rise again in 2005, with 70,000 employed at the time of issuing of the report in 2008. The downturn in Ireland in 2000/2001 was similar to that seen in the USA and elsewhere but other factors affected Ireland also. Ireland was no longer attractive for lower value-added investment projects such as had largely been attracted in the 1980s and 1990s. Indigenous companies were hit early in their life-cycle and suffered with increased competition in a reduced market place, a tough sales environment and caution on the part of companies to deal with smaller suppliers. The downturn was particularly steep in the telecommunications sector where Ireland had developed and specialised effectively in software development. The trend for “shift to services” affected software products particularly and this was another area where Ireland had developed software expertise. Also, competition for the IT services located in Ireland increased from places such as India, particularly for companies had not migrated to software product development (Forfás 2008).
By 2004, many of the top performing clusters in the Irish software sector had seen a downturn (Sterne, 2004). The e-learning and computer based training experienced cutbacks in corporate spending. The software tool developers experienced competition from collaborative type developments and open source software. Headway, a software tools supplier, went into receivership in 2004. Mobile applications were not as vital mid-way into the decade. The telecommunications software sector successfully repositioned itself to offer cost-cutting options and the companies Shenick and Interactive Enterprise were successful with vertical market applications.

Barry and vanEgeraat (2005) indicate that the overall ICT sector shrank in the first few years of this decade but overall employment figures suggest that displaced workers from ICT found jobs in other sectors. They identified the change in orientation of the FDI sector as a key development. That change entailed a shift away from manufacturing to services for the ICT sector. In their analysis of the top ten technology companies, they indicated that these companies accounted for 55% of the ICT sector in the country and about 25% of the total employment in IDA supported companies. Dell, Intel and IBM employed over 3,000 employees each, making them significant employers in the sector. These still had a significant number employed in production but were diversifying with higher numbers employed in non-production roles.

The 2008 EGFSN Report indicated that hardware electronics employed 35,000 people in 1999 but five years later this was down to 20,000. Software peaked in 2001 with 32,000 people employed but fell off thereafter until 2006 at a rate of 1.4% per annum. Between 1996 and 2006 employment in the manufacture of semiconductors remained quite stable with job losses being offset by expansion elsewhere. Semiconductors can be taken as an early indicator of ICT market trends as they are a vital, intermediate input into all ICT equipment (OECD 2006). Table 4.3 shows the numbers in employment in the sector, based on 2006 data from Forfás.
Intel opened a new IT innovation centre and re-started FAB24 fabrication facility work. They had decided in 2004 to build FAB24.2 which would be constructed in 2006 but this was against the general trend. The microcomputer sector suffered major job losses and closures both from the move of production to low cost economies and from failures due to competition within the industry itself (Barry and vanEgeraat 2005). They listed both Intel’s ceasing of assembly in Ireland and Apple’s shedding 450 jobs as i-Mac was outsourced and moved. This resulted in Horman Electronics, an indigenous Irish company, losing its system assembly contract with Apple. AST and Gateway closed due to market competition. By 2002 only two of the five microcomputer companies in Ireland remained in computer assembly and Apple’s assembly operation was reduced. Barry and vanEgeraat (2005) indicate that, between 1995 and 1998, a large number of component manufacturers from the low- and medium-technology sectors moved mostly to the Far East and closed their Irish operations.

Table 4.3  Employment by Subsector and by Company Ownership, 2006

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

(source:Forfás 2008, p.24)
Logitech, which at one stage made around 90% of the computer mice sold in Europe, closed and moved to the Far East. Manufacturers of keyboards shifted their manufacturing function eastwards, away from Ireland (Keytronics, Alps and Mitusmi) but held some distribution operations here along with a limited localisation capacity. Seagate moved the manufacture of hard disk drives to the Far East and closed their Irish operation. Applied Magnetics, who made disk drive components also closed. Intel and Apple both saw a shift of labour intensive manufacturing eastwards. March 2007 saw the closure of Motorola in Cork.

Collins and Grimes (2008), in their study of the top 10 technology companies in Ireland, note that those in the hardware sector were all in direct competition over certain market segments (Dell, Intel, HP, IBM and EMC) but that, since 2005, a trend for strategic alliances and co-operative agreements was noticeable. Also, they cite the reduced importance of local linkages with local suppliers in global concerns and gave the example of Dell’s Intel processors coming from the Philippines rather than from the local Intel plant in Leixlip. They point out, however, that these affiliates did still share a common local interest in the areas of costs, supportive business environment and quality of labour available. They note that in the five years from 2000-2005, Irish exports of services grew by 160% whereas product exports were only 6% – highlighting the shift from manufacturing towards service provision. These figures were backed up by the fall in hardware computer exports which fell by €14.2 billion between 2001 to 2003 (Collins and Grimes 2008). Exports of computer services, in contrast, grew by 15% between 2002 and 2003 to about $12.7 billion (Collins and Grimes 2008).

In 2010, Forfás published its report “The National Recovery Plan 2010-2014”. This plan prioritises the development of ICT sector as a key area of growth for the country and states:
"The ICT manufacturing sector in Ireland accounts for approximately 7% of manufacturing exports. The sector has experienced a decline in output over the last two years and some multinationals have moved their manufacturing activities to lower cost locations. At the same time, a number of these companies have increased their services operations here. The concentration of leading ICT companies remains high for a country of Ireland’s size and there are good prospects for recovery. The success of the IDA in attracting R&D projects to existing manufacturing sites will help anchor manufacturers and shift activities in Ireland further up the value chain. The tax environment remains favourable for inward investment and an improvement in cost competitiveness will also support medium term growth."

(National Recovery Plan 2010-2014, p.44)

Table 4.4 lists the top 10 Technology Affiliates operating in Ireland in 2005.
### Table 4.4 Top Ten Technology Affiliates in Ireland in 2005

<table>
<thead>
<tr>
<th>Activity</th>
<th>Date Established</th>
<th>€ million turnover 2005 (% of global turnover)</th>
<th>Employment 2005 (% of global employment)</th>
<th>Turnover /employee (€Million)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Dell</strong></td>
<td>1990 (1.0)</td>
<td>8,300 (14.3)</td>
<td>4,300 (5.4)</td>
<td>1.93</td>
</tr>
<tr>
<td>PC Manufacture, EU applications centre, business process improvement, sales support, treasury, tech support EMEA</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Microsoft</strong></td>
<td>1985 (1.0)</td>
<td>8,112 (20.4)</td>
<td>1,090 (1.8)</td>
<td>7.44</td>
</tr>
<tr>
<td>Sales and marketing, EU operations centre, product development centre, finance, HR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Intel</strong></td>
<td>1989 (0.1)</td>
<td>3,500 (11.6)</td>
<td>3,200 (4)</td>
<td>1.09</td>
</tr>
<tr>
<td>Semiconductor manufacture, innovation centre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>IBM</strong></td>
<td>1956 (0.0)</td>
<td>2,500 (2.6)</td>
<td>3,700 (0.7)</td>
<td>0.68</td>
</tr>
<tr>
<td>Business design, solutions, server manufacture</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>EMC</strong></td>
<td>1987 (1.1)</td>
<td>2,400 (30)</td>
<td>1,400 (7)</td>
<td>1.71</td>
</tr>
<tr>
<td>Information Storage Management</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Oracle</strong></td>
<td>1997 (1.0)</td>
<td>2,034 (20)</td>
<td>1,067 (2.3)</td>
<td>1.91</td>
</tr>
<tr>
<td>EU Product Development, world product translation, sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Apple</strong></td>
<td>1980 (1.1)</td>
<td>1,975 (11.7)</td>
<td>1,500 (6.5)</td>
<td>1.32</td>
</tr>
<tr>
<td>EU operations centre, store support, telesales, tech support, finance, HR</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Analog Devices</strong></td>
<td>1977 (0.1)</td>
<td>1,580 (70)</td>
<td>1,300 (16.8)</td>
<td>1.22</td>
</tr>
<tr>
<td>High performance integrated circuits</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Hewlett-Packard</strong></td>
<td>1971 (0.0)</td>
<td>1,460 (1.7)</td>
<td>1,660 (1.4)</td>
<td>0.86</td>
</tr>
<tr>
<td>European development centre, manufacture, sales and service support</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Xilinx</strong></td>
<td>1995 (0.0)</td>
<td>774 (9.5)</td>
<td>500 (14.8)</td>
<td>1.55</td>
</tr>
<tr>
<td>R&amp;D centre</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Note: Beside Date Established two values have been added. 0 represents no and 1 represents yes. The first digit indicates whether the Irish affiliate was established within 10 years of the corporation forming and the second digit indicates whether or not the Irish affiliate was the first EU subsidiary.

Source: Irish Times 2007, Datamonitor, Business Source Premier

The IDA website lists 50 ICT multinationals which have significant operations in Ireland. They divide them into three groups, namely: the first time projects, companies with expansion plans and new R&D developments in 2009, 2010 and 2011 per Table 4.5.
Table 4.5  Key ICT Investors in 2009, 2010, 2011

<table>
<thead>
<tr>
<th>First Time</th>
<th>Expansion</th>
<th>R&amp;D/Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electronic Arts (EA)</td>
<td>Microsoft</td>
<td>Intel</td>
</tr>
<tr>
<td>Quest Software</td>
<td>HP</td>
<td>HP</td>
</tr>
<tr>
<td>Maxim Integrated Products</td>
<td>Dell</td>
<td>IBM</td>
</tr>
<tr>
<td>LinkedIn</td>
<td>Google</td>
<td>AOL</td>
</tr>
<tr>
<td>Bentley Systems</td>
<td>SAP</td>
<td>Alcatel-Lucent (Bell Labs)</td>
</tr>
<tr>
<td>Aspect</td>
<td>eBay (incl PayPal)</td>
<td>Accenture</td>
</tr>
<tr>
<td>BSB</td>
<td>Citrix Systems</td>
<td>Analog Devices</td>
</tr>
<tr>
<td>Lumension Security</td>
<td>Facebook</td>
<td>PayPal (eBay)</td>
</tr>
<tr>
<td>Synchronoss Tech.</td>
<td>McAfee</td>
<td>Alps Electric</td>
</tr>
<tr>
<td>Big Fish Games</td>
<td>Activision Blizzard</td>
<td>Sophis Group</td>
</tr>
<tr>
<td>Webroot</td>
<td>Salesforce.com</td>
<td>Murex</td>
</tr>
<tr>
<td>GENBAND</td>
<td>Telefónica</td>
<td>Sajan</td>
</tr>
</tbody>
</table>

Source: IDA Information & Communication Technologies, Ireland, Spring 2011.

The IDA point to the retention of the 12.5% tax into the future (despite EU pressure), the track record, talent quality and availability and technology attributes as indicators of success. Enhanced competitiveness was an added attractor. The Autumn/Winter 2012 Information & Communications Technologies – Ireland, from the IDA, lists Intel, Analog Devices, Texas Instruments, Qualcomm, Infineon Technologies, On Semiconductor, Synopsys, Cadence Design Systems, Cypress Semiconductor, Microsemi, Maxim Integrated, LAM Research, Xilinx, Altera, Hittite Microwave, ZMDI, M/A-COM and Silicon Laboratories as the Multinational Semiconductor Companies in Ireland.

The IDA also point out that Ireland has a strong base in indigenous companies such as S3 Group, Powervation, Movidius, SensL, Decawave, Ceva, Duolog, Chipright and IC Mask Design. Many of the Irish companies are involved in IC design and product development as well as mixed-signal electronics. Irish ability to research in this area was also pointed out as a strength because of the availability of Tyndall, CRANN, MCII and CCAN research centres. Midas Ireland (a partnership of the microelectronics industries, educational and
research institutions) along with government bodies, promotes development of the microelectronics sector in Ireland. The microelectronic sector employs around 8,000 people and, as of 2010, was continuing to expand and develop.

The IDA indicate that nine of the world top ten software companies had subsidiaries in Ireland (IDA Newsletter Q2 2010) including Microsoft, IBM, Oracle, SAP, Symantec, HP, EMC, Adobe and Siemens. The IDA estimate that, between the indigenous Irish sector and the multinational involvement, there were over 600 software companies employing around 27,000 people, with annual software exports of around €24 billion. Cloud computing is identified as a strategic focus and the IDA indicates that HP and IBM invested in R&D in this area in 2008 and 2009. Microsoft opened its first “mega data centre” in Europe in 2009 to service the EMEA market. The company SuccessFactors announced a 40-person project in 2009. This company operated the Software as a Service (SaaS) business model. Two Irish software companies, Cape Clear and LeCayla had been acquired by multinational companies, Workday and Opsource respectively, in 2008.

4.4 SUMMARY

Begley et al. (2005) list five main reasons for investment in Ireland by multinationals, namely, corporate tax regime, government support, workforce characteristics, EU access and cost of operations. Grimes and Collins (2008) attribute the pro-business environment policy, adopted by successive governments and by government agencies, as a key driver leading to Ireland’s attraction as a location for FDI. They studied the top 10 foreign-owned technology companies in Ireland. They found that, other than having affiliates in Ireland, a further commonality was that they shared market spaces, i.e., addressed an EU or EMEA market as part of their global operations. Barry and vanEgeraat (2005) cited our corporate tax regime as a major factor in Ireland’s success in attracting FDI. They also noted that the trend for success in internationally-traded services and shared services, rather than hardware, in the years post the dot-com collapse but stated that the post millennium
negative trends for ICT subsectors were more likely due to the global downturn rather than any particular shift out of Ireland. The exception, they claimed, was the move of the computer assembly and peripherals operations to lower cost locations.

Alongside the five decades of multinational evolution and development, the indigenous Irish industry also took shape. Many Irish engineers in the 1960s found work with the ESB, the Department of Posts and Telegraphs and RTÉ. In the 1970s and 1980s, O’Gorman et al. (1997) state that rapid growth was seen in the high technology areas of computers, pharmaceuticals and medical instruments. By 1990, the indigenous side of these industries employed only some hundreds of people in each of these sectors (O’Gorman et al. 1997). Ireland developed a high number of indigenous software companies and this is one area where Ireland was identified as having sufficient successful activity for the formation of clusters (O’Gorman et al. 1997).

Also, the indigenous industry grew as the multinational element grew. Sterne (2004) divides software firms in Ireland into five separate generations. The first generation of companies began in the 1960s and early 1970s and focused on providing computer consultancy and services to support mainframe computers. Generation two, consisted of product development companies which coincided with the rise of mini-computer and PC industries.

Sterne (2004, p.23) indicates that, by the second half of the 1980s, the third generation of “technically elite” software companies was developing niche products in specialist areas. They were followed by software companies who looked immediately for available external investment and to trade internationally. This, according to Sterne (2004), was the defining characteristic for generation four.
Following the economic downturn around the year 2000, the ambitious companies, that had floated on the stock exchange or had accepted high venture capital investment, suffered badly (Sterne 2004). This led to generation five which focused again on vertically integrated products for specialist markets such as banking, insurance, regulation compliance and government applications. Success and development in the area of software had led to sufficient development in the sector for a successful clustering of software companies (Sterne 2004). In fact, development of software was one area where the Irish indigenous industry appeared to compete with the FDI software sector in terms of numbers employed.

“As the ICT industry reshapes itself to adjust to changes in technologies, delivery mechanisms and markets, emerging Asian countries are rapidly becoming leading producers of equipment, software and services” (OECD 2006b, p.4).

This section has given an indication of the levels of changes that have taken place in the ICT sector in Ireland. A time series for the Industry is given below in Figure 4.2. The four areas of technological development, government policy changes, technical education developments are then amalgamated to produce a combined Roadmap. This combined roadmap is included in Chapter 7 and is compared with the roadmap produced from the empirical data collected during this study. The following chapter examines the methodology and methodological choices for this study.
Figure 4.2  Time Series for ICT Sector Development
Chapter 5  Methodology

5.1  INTRODUCTION

This chapter considers the theoretical and conceptual parameters pertaining to the research design. The chapter reprises the objectives and research questions in Section 5.2. The philosophical choices made for ontology, epistemology, and axiology are presented. Next, a justification and summary of the implications of the choice of Critical Realism (CR) for this study is given. A section defining and explaining the main features of critical realist terminology is provided. An overview of the case study as a method is reviewed and a protocol for the research is presented. Data collection and issues pertaining to it are reviewed. Finally, a short summary of the methodology choices is presented in Section 5.4.

5.2  RESEARCH OBJECTIVES AND QUESTIONS

This study aims to examine the beginnings and, to explore the subsequent development of the electronics and software industry, in the Republic of Ireland, in the time period 1960 – 2010. Within the stated time frame, further goals of this research are to identify key developments in Irish technical education and to review how government policy affected the Irish electronics and software (now ICT) sector. Also, the effect of technology developments on the emerging industrial sector is explored.

Throughout this sectoral exploration, a primary goal of the research is to identify drivers and inhibitors for the sector over the time frame and to discover any relevant trends in development. The data collected are then explored to see if possible CR mechanisms can be identified.

Finally, an outcome based objective of this research was to see if recommendations could be made to inform future policy decisions and also managerial decisions.
5.3 CHOOSING A RESEARCH METHODOLOGY

5.3.1 Summary of Choices Made in this Thesis

In choosing a research methodology, it is usual to start with philosophical underpinnings and the researcher’s stance on ontology, epistemology and axiology.

"The research philosophy you adopt contains important assumptions about the way in which you view the world. These assumptions underpin your research strategy and the methods you choose as part of that strategy" (Saunders et al. 2009).

This study takes a critical realist view. CR represents a standpoint in its own right and not just a compromise solution between empiricism and idealism (Danermark et al. 2002). While CR is not an easy ontology to apply (Ryan et al. 2012), it was chosen to fit the aims of this research project. Ryan et al. point to a growing use of CR in the study of business relationships and networks, while Easton (2010) and Neergaard and Ulhoi (2007) list a range of disciplines which includes economics, sociology, criminology, geography, linguistics, religious studies, history, psychiatry, social work, ecology, environmental studies, law, information studies, media studies, interdisciplinary science studies and management where critical realism has been taken up.

Table 5.1 outlines the justification of the choice of CR for this research project. It was chosen in the belief that its comprehensiveness and depth would offer advantages over other paradigms in offering explanatory possibilities of the qualitative data collected to identify drivers for the Irish ICT sector. CR allowed the viewing of the Irish ICT sector as an ‘open system’ where the generative mechanisms that the research sought to uncover “operate in a complex interaction with other mechanisms, which either co-operate or work against the mechanism in question” (Danermark et al. 2002) thus allowing the complex and dynamic and interactive nature of the sector to be explored.

In line with the iterative process of systematic combining identified by Dubois and Gadde (2002), the “theoretical framework, empirical fieldwork and case analysis evolve simultaneously”. Easton (2010) indicates that the critical realist case method is particularly suited to the task due to the “cut and come again” possibility it offered. Concurrent to the
interviews undertaken to establish the case, an ongoing literature review was undertaken and historical documentation accessed to provide other sources of contextual and relevant data to inform the study of the sector.

**Table 5.1 Justification for the Use of the Critical Realist Approach**

<table>
<thead>
<tr>
<th>Criteria</th>
<th>Relevance to this research</th>
</tr>
</thead>
<tbody>
<tr>
<td>Research Questions</td>
<td>Critical Realist paradigm chosen to study process of change in the Irish ICT sector. Critical realism has been identified as particularly suitable for studying the process of change over time (Ryan <em>et al.</em> 2012)</td>
</tr>
<tr>
<td>Role of Prior Theory</td>
<td>Prior Theory is used to give direction to the search for drivers and to provide conceptual models and frameworks for comparison with the emergent and developing case.</td>
</tr>
<tr>
<td>Unit of Analysis</td>
<td>The unit of analysis in this study is the ICT sector in the Republic of Ireland defined as the foreign-owned and indigenous firms actively involved in the production and/or servicing of both hardware electronic and software products. The time scale for the study covers 1960 to 2010.</td>
</tr>
<tr>
<td>Measure of Quality</td>
<td>Paradigmatic and methodological quality Case study: Construct validity, internal and external validity and reliability</td>
</tr>
<tr>
<td>Mode of Representation</td>
<td>Aims for clear, explanatory statement of exploratory and descriptive research findings of drivers</td>
</tr>
<tr>
<td>Point of Focus</td>
<td>Looks to identify ‘events’ and ‘non-events’ within the unit of analysis and, through analyses of actions, decisions and perceptions, seeks to establish underlying ‘mechanisms’ or ‘drivers’ for these events in contextual setting.</td>
</tr>
<tr>
<td>Nature of Generalisation</td>
<td>Selection of ‘purposive’ experiential experts as representative of the case which is capable of analytical generalisation and not statistical generalisation as per Easton (2010).</td>
</tr>
<tr>
<td>Degree of Licence</td>
<td>Contextual information used to anchor findings of drivers through CR methodology, historical retrospective information and case study findings.</td>
</tr>
<tr>
<td>Prediction</td>
<td>Per CR requirements, prediction not possible but identification of mechanisms may lead to deeper understanding.</td>
</tr>
<tr>
<td>Sources of Data</td>
<td>Retrospective historical data from official and archival sources as well as empirical qualitative data from semi-structured interviews.</td>
</tr>
<tr>
<td>Basis of Knowing</td>
<td>Knowledge is always fallible and theory laden. “Different types of knowledge are appropriate to different functions and contexts;”(Sayer 1992). Reality is difficult to apprehend.</td>
</tr>
<tr>
<td>Ultimate Aims</td>
<td>Contextually situated discovery of deep underlying mechanisms, called drivers, which were, and are, capable of causing change in the Irish ICT sector.</td>
</tr>
</tbody>
</table>
According to VanDeVen (1992), in most studies, process can be taken to have different meanings. He identifies three most commonly used definitions: 1) as a logic that explained a causal relationship between independent or dependent variables, 2) a category of concepts or variables that refer back to actions undertaken by an individual or an organisation and 3) a sequence of events that describe how things change over time. This third explanation aligned with the research path of this project.

The time series, outlined in the literature review, gave a time dependant description of events that occurred in policy, education and industry. This provides a series of events that formed the basis of analysis, in conjunction with the interview material indicating the human actions, perceptions, decisions and relationship consequences. A study of these, using critical realist methodology, was begun in order to search out and identify 'causal mechanisms' or drivers of the industry.

In summary, this research adopted a CR philosophy and used abductive and retroductive reasoning in a mono-qualitative method supported by archival and historical retrospective data along with semi-structured interviews to build a case of the development of the Irish ICT sector in a longitudinal fashion. The data was analysed to yield CR mechanisms which we equate to the drivers of the ICT sector.

5.3.2 Preliminary Research

An overview of possible research philosophies, as well as a first look at relevant literature to inform the study, was the starting position adopted for the project. Initially, the focus was turned to the positivist and interpretivist philosophies. The positivist approach was ruled out on the basis of lack of a consistent and coherent dataset over the timescale involved. This elimination was taken after inquiring what information would be available from the Companies Registration Office and from the Central Statistics Office.

Qualitative research encompasses a wide variety of methods that can be applied in a flexible manner. As identification of drivers is a key objective of the research, the qualitative paradigm was initially chosen as being more likely to produce results in this area. Maykut and Morehouse (1994) identify the goal of qualitative research as the discovery of patterns which emerge after close observation, careful documentation and
thoughtful analysis and indicate that “what can be discovered by qualitative research is not sweeping generalisations but contextual findings”.

A four-strand time series of key events or happenings was begun so as to give a view of what was happening in the areas under exploration. These four areas were the ICT industrial sector, as defined, the technical educational sector, the relevant government policy changes and technological developments. This time charting was also intended to be an on-going and developmental process and had the advantage that it could easily be adapted and amended as new information became available. The time series developed are to be found in Chapters 3 and 4 of this thesis and comprises information gathered from the documentary sources. This “arraying of events into a chronology” is not just a descriptive but also “an analytic tool - to investigate presumed causal events” (Yin 2014, p.154) and helps the focus towards the case study's major advantage that it “can trace events over time” (Yin 2014, p.154).

A summary of the possible ontological, epistemological, axiological and methodological choices reviewed are shown in Table 5.2. This table summarises the four main philosophies of Positivism, Realism, Interpretivism, and Pragmatism.

Having reviewed the options per Table 5.2 Critical Realism was chosen as the best ‘vehicle’ for this research process. The following section briefly outlines Critical Realism as a philosophy and explains the terminology associated with it.

5.3.3 Critical Realism Explained

Critical Realism (CR) is an integrative meta-theory based on the works of Roy Bhaskar. It takes a transcendental realist ontology, and argues for a world “composed of objects (generative mechanisms) existing independently of human interpretation, knowledge, enactment or discourse” (Hedlund-deWitt 2012). The CR position represents an ontological realism, an epistemological relativism and a judgemental rationality (Bhaskar 1997).
Table 5.2  Comparison of Four Research Philosophies

<table>
<thead>
<tr>
<th></th>
<th>Positivism</th>
<th>Realism</th>
<th>Interpretivism</th>
<th>Pragmatism</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ontology:</strong> the</td>
<td>External, objective and independent of social</td>
<td>Is objective. Exists independently of</td>
<td>Socially constructed, subjective, may</td>
<td>External, multiple, view chosen to best</td>
</tr>
<tr>
<td>researcher's view</td>
<td>actors</td>
<td>human thoughts and beliefs or knowledge</td>
<td>change, multiple</td>
<td>enable answering of research question</td>
</tr>
<tr>
<td>of the nature of</td>
<td></td>
<td>of their existence (realist), but is</td>
<td></td>
<td></td>
</tr>
<tr>
<td>reality or being</td>
<td></td>
<td>interpreted through social conditioning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(critical realist)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Epistemology:</strong></td>
<td>Only observable phenomena provide credible data</td>
<td>Observable phenomena provide credible data, facts.</td>
<td>Subjective meanings and social phenomena.</td>
<td>Either or both observable phenomena and</td>
</tr>
<tr>
<td>the researcher's view</td>
<td>provide credible data, facts. Focus on causality</td>
<td>Insufficient data means inaccuracies in</td>
<td>Focus upon the details of situation, a</td>
<td>subjective meanings can provide</td>
</tr>
<tr>
<td>regarding what</td>
<td>and law-like generalisations, reducing</td>
<td>sensations (direct realism). Alternatively,</td>
<td>reality behind these details, subjective</td>
<td>acceptable knowledge, dependent upon the</td>
</tr>
<tr>
<td>constitutes</td>
<td>phenomena to simplest elements</td>
<td>phenomena create sensations which are open</td>
<td>meanings motivating actions</td>
<td>research question. Focus on practical</td>
</tr>
<tr>
<td>acceptable</td>
<td></td>
<td>to misinterpretation (critical realism)</td>
<td></td>
<td>applied research, integrating different</td>
</tr>
<tr>
<td>knowledge</td>
<td></td>
<td>focus on explaining within a context or</td>
<td></td>
<td>perspectives to help interpret the data</td>
</tr>
<tr>
<td></td>
<td></td>
<td>contexts</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Axiology:</strong> the</td>
<td>Research is undertaken in a value-free way, the</td>
<td>Research is value laden; the researcher is</td>
<td>Research is value bound, the researcher is</td>
<td>Values play a large role in interpreting</td>
</tr>
<tr>
<td>researcher's view of</td>
<td>researcher is independent of the data and</td>
<td>biased by world views, cultural experiences</td>
<td>part of what is being researched, cannot</td>
<td>results, the researcher adopting both</td>
</tr>
<tr>
<td>the role of values</td>
<td>maintains an objective stance</td>
<td>and upbringing. These will impact on the</td>
<td>be separated and so will be subjective</td>
<td>objective and subjective points of view</td>
</tr>
<tr>
<td>in research</td>
<td></td>
<td>research</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data collection</strong></td>
<td>Highly structured, large samples, measurement,</td>
<td>Methods chosen must fit the subject matter,</td>
<td>Small Samples, in-depth investigations,</td>
<td>Mixed or multiple method designs,</td>
</tr>
<tr>
<td>techniques most</td>
<td>quantitative, but can use qualitative</td>
<td>quantitative or qualitative</td>
<td>qualitative</td>
<td>quantitative and qualitative</td>
</tr>
<tr>
<td>often used</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: Saunders et al. 2009 Table 5.1 p.119
CR sees reality as stratified and non-linear. This stratified nature of reality is three-dimensional where the three overlapping levels consisting of the empirical domain, the actual domain and the real domain (see Table 5.3). The empirical domain consists of what we experience, directly or indirectly (i.e. it contains data or facts and is theory-laden). This is separate from the actual domain where events happen, although we may or may not experience them. This is separate again from the real domain where mechanisms and structures exist that may (or may not) cause events to happen. Sayer (1992) built on Bhaskar’s work and demonstrated how it can both provide a justification for case research and also provided guidelines for practice in social science (Easton 2010).

Table 5.3 Stratified or Domain Nature of Critical Realism

<table>
<thead>
<tr>
<th>Stratum in Critical Realism’s Depth</th>
<th>Referent</th>
</tr>
</thead>
<tbody>
<tr>
<td>The Real</td>
<td>Underlying generative (causal) mechanisms or structures that co-produce the flux of phenomena (events). These are themselves depth-stratified or layered (e.g. mechanisms of the inorganic world, the biosphere, and the sociosphere)</td>
</tr>
<tr>
<td>The Actual</td>
<td>Events (whether observed or not) (e.g., Big Bang, The French Revolution, a human action)</td>
</tr>
<tr>
<td>The Empirical</td>
<td>Experiences, empirical observations (e.g., what you see through microscopes or in historical documents)</td>
</tr>
</tbody>
</table>

Source: (Hedlund-deWitt 2012) Three levels of depth in Critical Realism’s Ontology. Note: the levels overlap: the real > the actual > the empirical, where > means co-includes or constellationally overreaches.

Sayer (1992, p.5) sets out 8 key assumptions of critical realism. These he indicates as ‘signposts regarding the nature of realism’ and they are listed as follows:

1. “The world exists independently of our knowledge of it.
2. Our knowledge of the world is fallible and theory-laden. Concepts of truth and falsity fail to provide a coherent view of the relationship between knowledge and its object. Nevertheless, knowledge is not immune to empirical check and its effectiveness in informing and explaining successful material practice is not mere accident.
3. Knowledge develops neither wholly continuously, as the steady accumulation of facts within a stable conceptual framework nor discontinuously, through simultaneous and universal changes in concepts.

4. There is necessity in the world: objects – whether natural or social – necessarily have particular powers or ways of acting and particular susceptibilities.

5. The world is differentiated and stratified, consisting not only of events, but objects, including structures, which have powers and liabilities capable of generating events. These structures may be present even where, as in the social world and much of the natural world, they do not generate regular patterns of events.

6. Social phenomena such as actions, texts and institutions are concept dependent. We not only have to explain their production and material effects but to understand, read or interpret what they mean. Although they have to be interpreted by starting from the researcher's own frames of meaning, by and large they exist regardless of researchers' interpretation of them. A qualified version of 1 therefore applies to the social world. In view of 4-6, the methods of social science and natural science have both differences and similarities.

7. Science or the production of any kind of knowledge is a social practice. For better or worse (not just worse) the conditions and social relations of the production of knowledge influence its content. Knowledge is also largely – though not exclusively – linguistic, and the nature of language and the way we communicate are not incidental to what is known and communicated. Awareness of these relationships is vital in evaluating knowledge.

8. Social science must be critical of its object. In order to be able to explain and understand social phenomena we have to evaluate them critically” (Sayer 1992).

Critical Naturalism

It is the critical naturalist viewpoint that allows the study of 'messy' or open system social phenomena. Blundel cited in Neergaard and Ulhøi (2007) pointed out the 'double hermeneutic' that social scientific enquiry encountered i.e. that of looking to generate explanatory knowledge about phenomena that are themselves 'knowing', in contrast to their natural science counterparts whose subject-matter is 'unknowing'.
**Open and Closed Systems**

Danermark *et al.* (2002, p.66) indicate that a closed system occurs when "reality's generative mechanisms can operate in isolation and independently of other mechanisms". While being able to close a system enables natural science experiments, creating this type of closed system is not possible in the social science field where people interact with and thereby cause changes in their environment. The ICT sector or unit of analysis for this study is an open system and no attempt was made to close the system or control variables. Instead the study looked for drivers for the sector and looked to identify causal mechanisms.

**Events**

Easton (2010, p.120) describes events as the "external and visible behaviours of people, systems and things as they occur, or as they have happened." Events are the means to understanding how entities form and reform through various processes over time. "Events occur when the mechanisms of these entities and structures become activated and exercised" (Ryan *et al.* 2012). A representation of the critical realist view of causation is shown in Figure 5.1. This illustrates how events (which occur in the actual domain) are the starting point for critical realist investigations. When an event is experienced it becomes an empirical fact and comes under the empirical domain (Danermark *et al.* 2002).

![Figure 5.1 A Critical Realist View of Causation.](source)

**Objects/Entities and Structures**

These are the basic theoretical building blocks used by critical realism explanations. They can be human, social or material, complex or simple, structured or unstructured. Examples
of this are people, relationships, organisations, attitudes etc. (Easton 2010). Real entities have emergent powers to cause events under certain conditions. They also have liabilities or susceptibilities to the actions of other entities or mechanisms.

**Mechanisms or Causal Powers**

Mechanisms exist in the domain of the real. The actuation or activation of mechanisms can (but may not) cause events to occur since activation of causal powers is not automatic and is dependent on the presence of conditions. These mechanisms can also be described as ‘generative’ (Neergaard and Ulhøi 2007) in that they give rise to events that we can experience. These mechanisms exist whether or not an event is produced. When mechanisms produce an event it comes under the actual domain and this is so whether we can observe it or not.

Many different mechanisms can be operational at the same time. To Danermark et al. (2002) the relationship between these mechanisms and their associated effects are contingent. Sayer (1992, p.116) indicates that the “same mechanism may sometimes produce different events and conversely the same type of event may have different causes”. Easton (2010) states that rather than take the word ‘mechanism’ at face value, that a better portmanteau term would be ‘deep generative processes and structures’. He points out that mechanisms are important as a rich source of explanatory devices. Danermark et al. (2002) indicate that causal laws must be analysed as tendencies not as universal empirical regularities.

**Emergence**

The concept of ‘Emergence’ is how CR approaches interaction between the different strata or domains. When properties of different strata or domains combine they give rise to qualitatively new phenomena or objects (Neergaard and Ulhøi 2007). The new objects or entities are emergent in that they are considered to possess new structures, causal powers and mechanisms that “depend upon, but cannot be reduced to, those of their constituents” (Blundel cited in Neergaard and Ulhøi 2007).
**Necessary and Contingent Relations**

Critical realists define relationships among entities as being either necessary or contingent. A contingent relation between entities can be said to exist when “It is neither necessary nor impossible that they stand in any particular relation” (Sayer 1992, p.89). Necessary relation, on the other hand, means that changes in one entity lead to changes in the other related entity. However, these changes do not have to be symmetric. Easton (2010) asserts as an example to illustrate this non-symmetry, that an organisation cannot exist without individuals but individuals can exist without formal organisations.

**Modes of Inference**

Danermark et al. (2002) describe the differences between the forms of inference. They use the word inference with two different meanings. Firstly, as in formal logic and secondly, as in thought-operations or “different ways of reasoning and thinking in order to proceed from something to something else” (Danermark et al. 2002, p.73). Distinct from the modes of inference are the research approaches which are most commonly associated with research strategy, namely, deduction or theory testing and induction or theory building.

Instead of deduction or induction, CR uses “abduction” and “retroduction”. This type of reasoning looks to explain events in the social world by looking to uncover the structures and mechanisms that are capable of producing them. Danermark et al. (2002, p.205) define abduction as “inference or thought operation, implying that a particular phenomenon or event is interpreted from a set of general ideas or concepts”.

Sayer defines retroduction thus: “This mode of inference in which events are explained by postulating (and identifying) mechanisms which are capable of producing them is called ‘retroduction’” (Sayer 1992). Easton (2010), defines it as “moving backwards” and asking “What must be true in order to make this event possible?” To Danermark et al. (2002), retroduction is about going from empirical observation of events and moving from this to conceptualisation of the transfactual conditions.
5.3.4 Case Study Method

Alongside the historical sectoral background research, a case study method was chosen to provide further ‘live’ data to answer the question as to how the ICT sector started and developed over time. It was also pertinent to achieving the second goal of identification of drivers and inhibitors for the sector.

Cases as methods are selected to explore and clarify different relationships between structures. In CR terms these relationships can be either necessary or contingent. Blundel cited in Neergaard and Ulhøi (2007) recommends that particular attention be given to spatial and temporal boundaries so that wider structural conditions are considered and he, too, points to an iterative study with continuous movement between “more concrete and more abstract” activities to arrive at a refined explanation. In other words a two pronged approach, one which looks at abstraction and theory conceptualisation and the other looks at fine details of the case material (Tsoukas 1989).

Protocol and Interview plan

Yin (2014) indicates that case study research should have a protocol and that this protocol should include the procedures and general rules to be followed as well as the instrument or questionnaire. The purpose of a protocol is to increase reliability of the case study research. As part of the Case Study protocol, an in-depth semi-structured interview plan was devised and a copy of this is included in Appendix D.

Figure 5.2 contains a summary of the Case Study Protocol for this study. Laforest (2009) was consulted as a guide to planning and conducting semi-structured interviews.

Yin (1989) states that the case study is the most flexible of all research designs. In fact, “maturation of industries” is listed directly by Yin (2004) as one of the areas where focus on a “case” allows a “holistic and real-world perspective” to be maintained (Yin 2014).
Section A: Overview of the Case Study

This research was sponsored by the Irish American Partnership and aimed at researching the Irish Electronic and Software Sector from 1960-2010. The research questions, driving the research, concern the development of the sector itself and the influences of government policy, education and industry over time to cause changes to the sector and vice versa. The theoretical frameworks and development of the case, as well as the theory and empirical data, were developed in line with systematic combining. This Protocol outlined the guiding principles for the research conducted.

Section B: Data Collection Procedures

Data was collected by reviewing available and relevant documentation to inform the literature review process and the time series or timelines for the various areas of interest to the case study. All data was collected by the researcher and sources of data are listed in Table 5.4 Data Sources. Table 5.6 summarises the range and experience of the people interviewed. Respondents were contacted initially by e-mail or by telephone and an appointment made for the interview. Where possible the explanatory paragraph was sent by e-mail and, where this was not done, time was spent before the interview in going through the research goals and objectives before the consent form was signed and the interview begun. All interviews were recorded with the permission of the interviewee. Following on from the interview, an e-mail of thanks was sent to the respondents and the e-mail indicated that the respondents could contact the researcher with further information at any stage and also a commitment was made to those who had expressed an interest to inform them of the outcomes of the research. A list was made of these people.

Section C: Data Collection Questions

Data Collection questions in the semi-structured interview plan are included in Appendix D.

Section D: Guide for the Case Study Report

In this instance all respondents were informed that the research report would be in the form of a Thesis Report, submitted to Cork Institute of Technology to fulfil the requirements of Masters of Business by research.

Figure 5.2 Case Study Protocol for this Study

Research questions are definable in terms of the questions; who, what, where, how, and why (Yin 1989; Yin 2014). A case study is particularly suited to exploring the how and the why questions. So this development of a case was not only of assistance in identifying how the Electronics and Software sector started up and developed in Ireland but it also addressed the question of what drivers contributed to the changes in the sector over time. These two core objectives are thus compatible with the case study method.
The unit of analysis, or 'case', for this single case study is the Irish Electronics and Software Industrial Sector (which developed into the ICT sector) from 1960 to 2010 and meets the criteria for a case outlined above. The issue of contemporary is met although access to and identification of people, active in the early 1960s is becoming more difficult. The case is also contemporary in that it was and still is an important sector in the Irish industrial landscape. It matches the second criterion in that the boundaries as to where the ICT sector begins and ends are indeed blurry.

Case study as a method is also compatible with a critical realist philosophy. Easton (2010) states that CR is compatible with a wide range of research methods and that case study research matches Sayer’s intensive research method. Yin (2014, p.17) indicates that case study method is all-embracing in terms of different epistemological stances including relativist, interpretivist and realist. Critical realist case studies feature in Easton (2010); Ryan et al. (2012); and Aastrup and Halldórsson (2008).

Yin (2014, p.51) lists five reasons for undertaking a single rather than a multi-case study. These are cases that can be defined as critical, unusual, common, relevatory, and longitudinal. The rationale for a single case study in this instance is the longitudinal nature of the study. Yin (2014) points out the suitability of a single longitudinal case study to "cover trends over an elongated period of time, following a developmental course of interest" (Yin 2014, p.53). The time constraints and single researcher nature of the study meant that a single case analysis was more achievable.

Yin further indicates that case study research tends to be exploratory, descriptive or explanatory but, again, the boundaries between each are not clearly defined. This case study is descriptive in that it seeks to describe the development of the industry sector and exploratory in that it seeks to identify drivers or mechanisms of change for the ICT sector over the study period. An explanatory study would require more triangulation and testing of the drivers than would be possible within the resources of this study.

The empirical evidence for this case was gathered from interviews with individuals and Yin (2014) distinguishes between the unit of data collection and the unit of analysis. He points
out that care needs to be taken that the unit of data collection does not distort the unit of analysis.

**Data Collection**

Data or evidence for building a case study can be collected from many sources (Yin 2014; Easton 2010). Yin (2014, p.106) identifies the strengths and shortcomings of six sources of evidence typically used in case studies. Direct observations, participant observation and physical artefacts are not included here. For the purposes of this case study these sources of data were documentation, available archival records and interviews.

Frequent meetings with a subject matter expert assisted with identification of suitable respondents and technical information about industry and educational matters. Also, in the early stages the researcher took part as a recorder in the BeWiser European Funded project policy round table morning session related to the ICT sector. To this end this preliminary research fell into the observation category. This early experience was useful in giving an overview of current topics of interest in the areas of academia, government policy and the ICT industry.

The evidence for this case study research was collected from documents, archives and from interviews. Documents best provide corroboration and augment evidence collected from other sources (Yin 1989). They provided details that corroborated data from other sources. Inferences can be drawn from documents but care is needed to further investigate for other evidence rather than treating inferences from documentary data as findings. Collection of documentary data was very flexible and was done at the convenience of the researcher. Potential sources of documentary data were official reports, administration documents, government agency reports, formal studies or evaluations related to the case and relevant news clippings from mass media, books and available, accessible archival material.

Yin (2014) also warns that over-reliance on documentation in a case study could be considered a weakness. The data sources that formed the case study materials and sources are listed in Table 5.4. Archival records are similar to documents. During this research, visits were made to the National Archives and the Library in Engineers Ireland in Dublin to search for relevant early information about the case. Where archival evidence was
consulted, per Yin (2014), the conditions under which it was produced were to be taken into account to reduce bias.

Interviews were the most important source of evidence. Yin identifies these as guided conversations rather than structured enquiries. "An interview is a conversation with a purpose" (Lincoln and Guba 1985). Kvale and Brinkmann (2009) call it “an inter-view, where knowledge is constructed in the inter-action between interviewer and the interviewee”. They identify seven stages of an interview investigation: thematising, designing, interviewing, transcribing, analysing, verifying and reporting.

Qualitative interviews last long enough to allow for “prolonged engagement” with the interviewee, establish trust and rapport and this is what merits the term in-depth (Maykut and Morehouse 1994). The range of interview formats is broad and can range from the unstructured to the structured. Semi-structured interviews were chosen for this study.

Table 5.4  Overview of the Multiple Data Sources for this Study

<table>
<thead>
<tr>
<th>Source</th>
<th>N</th>
<th>Description</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Subject Matter Expert</td>
<td>1</td>
<td>Consultation with a subject matter expert who had extensive experience in applied technical education from the early 1960s onwards was ongoing throughout the project. This expert was invaluable as a source of contacts for other experts with extensive experience both in and around the ICT sector.</td>
<td></td>
</tr>
<tr>
<td>BeWiser (EU funded collaborative project) Policy Round Table</td>
<td>6</td>
<td>Focus Group</td>
<td>Preliminary research. Researcher acted as a recorder at table where issues of relevance to the ICT sector in Cork were discussed. Also present were a facilitator, 2 representatives from Government policy, 2 Academia representatives and 2 industrial experts from ICT firms in the greater Cork area.</td>
</tr>
<tr>
<td>Documentation Sources</td>
<td></td>
<td></td>
<td>Archival documents, Industrial Survey Reports, EGSFN reports, IDA annual reports, OECD ICT reports</td>
</tr>
<tr>
<td>Semi-structured Interviews</td>
<td>15 participants</td>
<td>In-depth interviews, recorded</td>
<td>Analysed in Chapter 6</td>
</tr>
</tbody>
</table>
For the purposes of this study a semi-structured research plan was developed which looked to address the three areas of interest of government policy, technical education and industry development and this plan formed the basis for conducting interviews with all respondents. A copy of this interview plan is included in Appendix D. Also before each interview, to optimise the benefit from the interview, careful and thorough preparation was done and brief notes were reviewed on company profiles and organisational information. Kvale and Brinkmann (2009) list ten qualifications required to raise an interviewer to the level of crafts-person. According to these authors, these qualifications are: knowledgeable, structuring, clear, gentle, sensitive, open, steering, critical, remembering and interpreting.

**Recording of Interviews**

Two schools of thought prevail on whether audio recording of interviews is appropriate or not. On one hand Lincoln and Guba (1985) recommend "not tape recording unless there are legal or training reasons for doing so". In contrast, Patton (2002) considers it to be an indispensable part of the equipment for a qualitative interviewer. Yin (2014) lists four situations where the use of an audio tape is contra-indicated, namely: a) where an interviewee refused permission, b) where there was no specific plan to transcribe the interview, c) where the researcher is clumsy and unable to manage the recorder and d) where the researcher relies on the recorder to do the 'listening' instead of the active listening that is required for a successful interview.

As semi-structured interviews formed the main source of primary data for this study, interviews were recorded and this researcher found, in line with Maykut and Morehouse (1994) that the recording device faded into the background quite quickly once the interview was underway and it was a vital tool in maintaining the voice of the interviewed participants. Recording also had the advantage that the researcher was better able to concentrate on formulation of questions and on listening to the answers given, in line with active listening. All taping of interviews was done with the respondent’s consent. In the one instance where the recorder failed to record the interview, the researcher wrote up the interview and e-mailed it to the respondent for comments and changes and the agreed interview summary was used. Most interviews took place during office hours and either in the respondent’s work office, the Boardroom of CIT or, on occasion, interviews were
arranged in more public places such as in a hotel lobby or in a café. These latter locations were never the preferred option and only occurred when no other options were viable.

**Transcription**

The level of transcription used should match the requirements of the research questions and methods. Dresing *et al.* (2012) divide transcription into simple transcription and detailed transcription. Due to time constraints, simple transcription was used for this study. All recorded interviews were transcribed using simple transcription and guided by Dresing *et al.* (2012) who indicate that simple transcription is acceptable once it matches the requirements and methods of the research. All transcription was carried out by the researcher to aid in familiarisation with the interview data, and to learn about interviewing style and technique.

**Limitations of interviews and reduction of bias**

In discussing objectivity in qualitative research, Kvale and Brinkmann (2009) define freedom from bias as referring to “*reliable knowledge, checked and controlled, undistorted by personal bias and prejudice*”. A reflexive objectivity is required to review researcher’s sensitivity about prejudices held and requires being reflexive as to what the researcher contributes to the production of knowledge. Under inter-subjectivity, they differentiate between arithmetic and dialogical inter-subjectivity. Arithmetic refers to statistical reliability, for example, by coding interviews into quantifiable categories. Dialogical inter-subjectivity refers to where “the interview is a conversation and a negotiation of meaning between the researcher and his or her subjects” (Kvale and Brinkmann 2009).

In defence of the research interview against the standard criticisms, Kvale and Brinkmann (2009, p.168) point out that it is helpful to emphasise the researcher as the primary instrument for obtaining knowledge. This requires a high level of quality in the interviewer’s craftsmanship. Also while bias, if not acknowledged, can invalidate inquiry results, a recognised bias or subjective perspective can sometimes bring new dimensions to light and aid in multi-perspectival construction of knowledge. In answer to the effects of leading questions, Kvale and Brinkmann (2009) believe that research interviews often benefit from the application of leading questions as an aid to checking interviewees’
answers for reliability. Per Kvale and Brinkmann (2009), the decisive question is not whether the questions were leading questions or not, but rather, where the interview questions lead and whether new, valuable, and trustworthy knowledge is the result.

**Ethical Considerations**

Yin (2014, p.77) indicates that a good case study researcher should strive for the highest ethical standards. These he lists as responsibility to scholarship (e.g. not plagiarising or falsifying data), honesty, avoidance of deception and responsibility for one's own work. Also important in this area is keeping up with current related research, accuracy of work, striving for credibility and understanding, reporting any methodological qualifiers and limitations to one's own work.

Protection of respondents in the research is a particularly important consideration. This was accomplished firstly by submitting the research plan to the research review board of the Cork Institute of Technology to ensure that the research planned matched their ethical guidelines. Once this approval was received, protection of the human “subjects” was achieved by:

1. Gaining informed consent from all interviewees – all respondents were informed of the purpose and nature of the research and their voluntary participation was requested.

2. Assurances were given that no harm would arise to any individual as a result of the research study and also the participant privacy and confidentiality of those who consented was guaranteed via anonymity.

3. Every attempt was made to select respondents equitably so that no particular groups of people were unfairly included or excluded from the research.

4. In this instance, no minors or people belonging to vulnerable groups were interviewed, but care was taken that comments such as “you can delete this later” were respected.

For the purposes of this study an explanatory paragraph was given to each participant to outline the purposes of the study and to assure them of confidentiality and fairness. Interviewee conditions were included and this document doubled as the consent form when
signed by respondent and interviewer before any interview took place. A copy of this document is included in Appendix E.

**Quality Criteria**

Yin (2014) summarises the quality criteria for case study research under the four headings of Construct Validity, Internal Validity, External Validity and Reliability. These are summarised in Table 5.5.

**Table 5.5 Case Study Quality Criteria**

<table>
<thead>
<tr>
<th>Construct Validity</th>
<th>Use multiple data sources</th>
<th>Data collection Composition</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Establish chain of evidence</td>
<td>Data collection</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Have key informants review case study report</td>
<td>Data collection</td>
<td>Yes</td>
</tr>
<tr>
<td>Data collection</td>
<td>Data analysis</td>
<td>Research design</td>
<td></td>
</tr>
<tr>
<td>Data analysis</td>
<td>Data analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>External Validity</td>
<td>Do pattern matching</td>
<td></td>
<td>Open coding</td>
</tr>
<tr>
<td></td>
<td>Do explanation building</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Address rival explanations</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Use logic models</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reliability</td>
<td>Use theory in single case studies</td>
<td>Data collection</td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>Develop case study database</td>
<td>Data collection database</td>
<td>nVivo file</td>
</tr>
</tbody>
</table>

(source: modified from Yin 2014, Figure 2.3 p. 45)

The findings and conclusions of this thesis were reviewed by 3 respondents and 1 knowledgeable ICT expert who had not taken part in the research. All concurred that the findings depicted the industry as they knew it and found it a good representation of the industry development.

**Selection of respondents**

Where possible, the interview plan was e-mailed to the participants before the interview but in some cases where the interview came about by way of introduction, time was spent before the interview began going through the explanatory paragraph and conditions. The respondents are listed in Table 5.6. This table shows the interview number, the areas of
expertise of the respondent as well as a time-interval for when they started their working career. Figure 5.3 illustrates this same information graphically.

Table 5.6 List of Respondents

<table>
<thead>
<tr>
<th>Interview Number</th>
<th>Area of Expertise</th>
<th>Gender</th>
<th>Date of Interview</th>
<th>Work Career Started</th>
</tr>
</thead>
<tbody>
<tr>
<td>Interview 3</td>
<td>Education and Industry</td>
<td>Female</td>
<td>10/12/2013</td>
<td>1980-1984</td>
</tr>
<tr>
<td>Interview 4</td>
<td>Government Policy</td>
<td>Female</td>
<td>28/01/2014</td>
<td>1980-1984</td>
</tr>
<tr>
<td>Interview 5</td>
<td>Industry</td>
<td>Male</td>
<td>28/01/2014</td>
<td>1980-1984</td>
</tr>
<tr>
<td>Interview 6</td>
<td>Education and Industry</td>
<td>Male</td>
<td>29/01/2014</td>
<td>1985-1989</td>
</tr>
<tr>
<td>Interview 7</td>
<td>Industry</td>
<td>Male</td>
<td>25/02/2014</td>
<td>1965-1969</td>
</tr>
<tr>
<td>Interview 8</td>
<td>Education and Industry</td>
<td>Male</td>
<td>14/03/2014</td>
<td>1990-1994</td>
</tr>
<tr>
<td>Interview 9</td>
<td>Industry</td>
<td>Male</td>
<td>21/03/2014</td>
<td>1985-1989</td>
</tr>
<tr>
<td>Interview 10</td>
<td>Industry</td>
<td>Male</td>
<td>16/04/2014</td>
<td>1970-1974</td>
</tr>
<tr>
<td>Interview 11</td>
<td>Industry</td>
<td>Female</td>
<td>04/07/2014</td>
<td>1985-1989</td>
</tr>
<tr>
<td>Interview 12</td>
<td>Industry</td>
<td>Male</td>
<td>15/07/2014</td>
<td>1965-1969</td>
</tr>
<tr>
<td>Interview 13</td>
<td>Industry</td>
<td>Male</td>
<td>12/08/2014</td>
<td>1960-1964</td>
</tr>
<tr>
<td>Interview 14</td>
<td>Industry</td>
<td>Male</td>
<td>15/08/2014</td>
<td>1970-1974</td>
</tr>
</tbody>
</table>

Sample size is a much debated issue in qualitative research. Easton (2010) indicates that the sample size in any case study is not likely to be large enough to qualify for solid statistical analysis. He points to sampling mode as the defining factor of case research. This “sample of one” has both constraints and opportunities. Under constraints are the low (statistical) representativeness and generalizability of findings. The key opportunities are its ability to “understand a phenomenon in depth and comprehensively” and flexibility. Yin (2014) indicates that “control” in case studies is by the selection of the cases.

In this study, non-pre-specified within-case sampling (Miles and Hubermann 1994) or selection process was used to identify key “experienced and knowledgeable experts” (Lincoln and Guba 1985). Every attempt was made to maintain a wider context by also interviewing key people from as broad a spectrum as possible.
As the timescale covers five decades, a spread of people with relevant experience who have joined the sector at different times was targeted. Sampling over the spectrum of implementers of government policy (development agencies), educational influencers (people currently actively involved in an educational capacity) and people with relevant industrial experience were chosen. Some of the people interviewed crossed two of the divides in that they had both relevant ICT industrial experience and also professional educational experience. Also, under the banner of industrial experience, attempts were made to represent the hardware and software sides as well as indigenous industry and MNCs (multinational corporations). People with relevant industrial experience of ten or more years and who had top managerial experience were chosen. So it is “working knowledge of the contexts of the individuals and settings that lead us to select them for initial inclusion in our study” (Maykut and Morehouse 1994).

Of interest to this study was their starting stage in the timescale under consideration and their specialist knowledge of the sector through their work experiences in the areas of exploration. A pictorial representation of selection is included in Figure 5.3. The goal was
not to recreate random selection sampling but rather to represent a range of experience in and around the ICT sector as defined.

In line with Lincoln and Guba (1985), the selection was both “emergent and sequential” where analysis of collected data suggested other experts to be included in the research. Some snowball sampling inevitably also occurred where experts being interviewed recommended other people of influence who could inform the research project. A continuous ongoing process of sample selection, data collection and analysis led to an emergent research design (Lincoln and Guba 1985) in line with the “rolling” or “wave” quality described by Miles and Hubermann (1994), who identify nesting as a feature of within-case sampling and this nesting is also apparent in this study in that people interviewed worked directly in enterprises in the ICT sector, in Education or in Government agencies. Similarly, the ICT sector exists as a sector in the greater industrial sector which operates in this country and which may be affected by outside global events.

The other major point for within-case sampling was that concern for representativeness should have a minor role. This was met by interviewing people who could throw light on the question of how the ICT sector in Ireland originated or developed over time and answer the question of why the industry developed as it did. This search for the “why” and the “how” was undertaken with the dual purpose of adding to the description of the case and also to lead back to identification of drivers for these changes. Also the fact that individuals were chosen as the unit of data collection was continuously kept in mind in choosing candidates who would have special knowledge to assist in developing a clearer outline of the case.

Use of Qualitative Data Analysis Software

For the purposes of this study, a Qualitative Data Analysis Software (QDAS) was utilised. Yin (2014, p.125) calls this analysis tool CAQDAS or computer-assisted qualitative data analysis software and he points to the use of a database for storing and retrieving the evidentiary base as being key to increasing reliability in case study methods. Compiling data, disassembling data and reassembling data are the three areas where CAQDAS functions may be of use but Yin (2014) warns that, of these, the reassembly needs to be closely directed by the researcher and indeed that the researcher must be the “main analyst”
and "direct the tools" (p.135). He points out that the two key words were assisted and tools or, in other words, these tools cannot do the analysis (Yin 2014, p.134). Yin (2014) also lists the minimal conditions for use of computerized functions as being: a) when verbatim records are a central part of the evidence and, b) when there is a large collection of such data.

nVivo® was chosen as a suitable software package as it is flexible and well supported. Similar to other QDAS packages it allows tracking of ideas, indexing and coding of data with thematic or conceptual labels, the ability to add demographic data to allow comparison of subgroups, searching for patterns, development of visual models and charts and reports or outputs from the data (Bazeley and Jackson 2013). Also the use of software was chosen to:

1) To keep all research sources and documentation in one place.
2) To provide transparency/access to the research and thereby provide a research database necessary for reliability as per Yin (2014).
3) As a tool to "manage" the data.
4) To separate the researcher's report from the evidentiary base.

As per Yin (2014, p.124), this study used nVivo database to maintain a link back to the evidence for the reporting of interpretations and conclusions and to aid in maintaining a chain of evidence in the case study. Thus by maintaining evidence in the database, no original evidence is lost through carelessness or bias and at all stages the original data can be traced back to source and context. The positive advantages described above were the decisive factors in choosing to use CAQDAS and nVivo was chosen as a well-supported, widely recognised QDAS software package.

5.4 Summary

This chapter summarises the research philosophy and the methodology chosen. It states the practical experiences and concerns encountered while carrying out the research. This project chose a critical realist philosophy, used abductive and retroductive reasoning in line with CR. This study is a mono-method qualitative case study supported by retrospective historical and archival research and available sectoral and industrial information.
Semi-structured interviews with a purposive selection of ‘experiential experts’ added empirical data to form the case study of the ICT sector in Ireland from 1960 to 2010. Data to assist in representing the case were collected through reviewing historical documentation. Systematic combining was chosen to allow an iterative process where theory, empirical data and the case evolved simultaneously. The CR research spiral method per Ryan et al. (2012) guided the research. Case study as a method was then reviewed and the case study protocol was outlined. Selection of candidates for interviewing was examined and graphically illustrated in Figure 5.3. Data analysis and findings are presented in Chapter 6.
Chapter 6 Findings and Discussion

This chapter reviews the data collected in six separate sections. Five sections relate to the research questions asked. Emerging themes in the data are then explored in the sixth section. Based on available literature and documentation, the development of the ICT sector was reviewed in the literature review in Chapters 3 and 4.

6.1 Development of the Industrial Sector

Firstly, a brief review of findings from the literature review section is given and this is then followed with the presentation of findings and discussion from the empirical data.

There were four key economic reports that reflect the development of the electronics industry in Ireland are: The Second Programme for Economic Expansion (1963); the Telesis Report (NESC 1982); the Culliton Report (1992); and the Ahead of the Curve Report (2004).

"Trade liberalisation and state interventionism" are the "two main pillars of economic policy" in Ireland (Smith 2006). Where trade liberalisation has persisted throughout the five decades considered in this study, it is the nature of the intervention by the State that has developed with the changing circumstances.

This earliest report (1963) reflected a simplified view that the industrial base could be expanded only by attracting FDI to Ireland. The statement of industrial policy in the 1960s was "based on the understanding that such industry will supplement, but not supplant, Irish industry" (Second Programme for Economic Expansion Part II 1964, p.154). The attraction method was based on simple expenditure supports such as tax relief and grants. Under these policies, electronic manufacturing was attracted, as illustrated by the two GE subsidiaries.

The Telesis Report (1982) recommended a shifting of public expenditure to support internationally trading indigenous industry and a building up of skilled sub-supply firms. It also recommended a reduction in the level of grants offered to newly investing foreign firms (NESC 1982). FDI was no longer viewed as the only way to expand the industrial base. A two-pronged approach was suggested, the continuation of FDI but with
improvement sought to the linkages with and better support to develop, indigenous industry.

In the early 1990s, the City and County Enterprise Boards were established by the government to support indigenous industry and, particularly, start-up companies. Enterprise Ireland was established in 1998 to support the exporting indigenous sector. The indigenous support policy started with the aim of creating a climate favourable for start-ups and shifted, over time, to removing the barriers to growth and encouragement for upscaling by looking to meet each individual firm’s specific requirements (Tiernan et al. 2006).

The Culliton Report (1992) identified that industry development drivers were not limited to public expenditure support of industries but also involved many macroeconomic factors such as education. This report found “serious gaps” in the Irish system for education and training which were considered to be “a most critical element of policy”. The report 'called for a broadening of industrial strategy to include “overall macroeconomic and fiscal policy, the level and structure of taxation, the effectiveness of education and training and the provision of adequate infrastructure” (Culliton 1992).


"the transition from a production-driven, investment-based economy to one that is market-led and knowledge-based cannot be achieved by the enterprise sector acting on its own. The Government and state agencies, the education sector and the social partners will need to be mobilised to embrace the change and absorb it into their own structures and operational processes" (Enterprise Strategy Group 2004).

This shows the changing nature of the industrial landscape which now includes globalisation and a requirement for networking or cohesive co-operative development across many areas. This report lists the four essential conditions for economic prosperity as: Cost Competitiveness, Infrastructure (both physical and communications), Innovation and Entrepreneurship, and Management Capability. Expertise in markets, technology (particularly in product service and development), and education and training to build world-class skills and effective, agile government were all required, on top of the four essential requirements, to build sustainable industry in the country.
Four main generic patterns of industry development, namely, Gradual, Continuous, Discontinuous and Hypercompetitive development (deWit and Meyer 2010) were identified in Chapter 4. Initially, the industry development in the Irish electronic industry was gradual as it started from a very low level. It cycled from continuous to discontinuous development following development trends of computer technologies and global economic effects. It exhibited a cyclic nature associated with the electronics industry as many industries started up and closed down. This was generally in line with technological developments and global trends. As the country prospered in the early 1990s continuous development was seen. Around the millennium, some hypercompetitive development was seen until it was disrupted in the dot-com crash around 2001/2002.

In Section 6.1.1 below, the interview data collected are viewed to see how they answer the question of how the electronics and software sector in Ireland began.

6.1.1 The Early Electronics Industry

The data collected support the lack of a developed base in electronics in the 1960s (Interviews 7, 12, 13, 14, 15). "Up until 1964 the only jobs for Elec. Eng.[Electrical Engineering] in Ireland would have been ESB or P&T and suddenly [GE Subsidiary] EI had opened up in Shannon" (Interview 13). Comments such as this were reflected widely in the interviews. Some of the respondents had worked initially in the semi-state bodies and one respondent “couldn’t wait to get out of it” (Interview 14). In the case of O’Halloran (2009), initial work experience was in the P&T in modernisation of the Irish telecommunications network. The Committee of Industrial Organisation (1963) examined only 12 companies, who were active, in the “Wireless, Television and Telecommunications” Report. These companies were mostly manufacturing radios and televisions for the home market and the requirement for engineers was low.

By the late 1960s, the effects of free trade were beginning to be felt. Some new options in Ireland were appearing for engineering graduates. With the low base in industry, the indigenous Irish electronic sector was only beginning.

“At that stage [1969] then, I think, Telectron was about the only private company in Ireland. Telectron was actually a wholly-owned Irish company that was set up… Technico was a sister company and the same set of directors, work directors [board members] were
common – certainly a large crossover. But Technico was sales and did the sales of Telecron” (Interview 12). Telecron designed and manufactured telecommunications equipment. “Initially we bought in a lot of stuff and bought in designs from Telletra. We were supplying telecommunications and telephony to the P&T mainly and the odd sale to England or Wales or Scotland” (Interview 12).

The IDA policy of attracting overseas investment had begun to show results. “I finished up here [university] in ‘68 and I was just lucky that General Electric and Westinghouse came recruiting in the college that year” (Interview 7). The first electronic subsidiary of GE in Ireland was EI. This was GE’s first overseas subsidiary and it was set up in Ireland in 1963 “when the project came up they code-named it ‘The Emerald Isle Project’ and then when they came here they intended calling it General Electric but GEC in the UK owned the name for the British Isles so they couldn’t call it that. So they left it ET” (Interview 14). GE’s second subsidiary, in Dundalk, was called Ecco which stood for Electronic Component Co. and this opened in 1966.

Emigration also featured in the data collected. “All of my colleagues that were in the class with me, [there were] about 40 of them,... any of them that did stay in Ireland were working for the ESB, P&T, County Councils or various government bodies” (Interview 12) and “I graduated in ’83. There were about 100 in my final year but that was all engineering [disciplines]... and about 50-60% of them went overseas” (Interview 15).

6.1.1.1 Unions

Unions featured quite strongly in the earlier experiences of the respondents up to and into the 1980s (Interviews 6, 7, 11, 13, 14)

“EI was non-union when it was set up by GE in ’63 and then in ’68 some people wanted to unionise here and GE said no because it was a minority. It was a famous case. It was in the annals of Irish Industrial Relations. Anyway, there was a massive strike here... it was a very nasty one and it split the whole place between those who did or didn’t want to. The end result was the company had to recognise the unions and they did” (Interview 14).

Later, when GE opened Ecco, they “didn’t want to make the same mistakes in Dundalk” (Interview 13).
In Northstar in 1982, Respondent 11 found:

“a certain level of rigidness in the workers... There were unionised floor workers and non-unionised office workers. The non-unionised office workers had to work their tails off and those guys got to walk out of the building at four o’clock. If they didn’t, they got paid overtime” (Interview 11).

When AT&T took over Telectron, they “straightaway took on the union in Tallaght which was, as you know, no change without agreement... and only went back to work...on threat of shutting down” (Interview 13). In the ‘80s, “the anti-union thing was huge. This was life or death as far as these companies were concerned” (Interview 7). When EMC was started up “[My boss] told me ‘If there is any kind of union sniffing around here, I’m just going to close this factory and that is it’ (Interview 7). Later, in the 1990s, “It was all based on trust. No unions” (Interview 6). Respondent 10, who currently lives in the US, reported that from an American perspective, Ireland was perceived differently in the hardware and the software spaces. The software sector had the reputation of being “easy to deal with” where “in the hardware world, there was the reputation of being a little bit unionised and sometimes having a little bit of a problem”.

6.1.1.2 Initial Conditions for the Sector Development

Whereas IBM had a sales office in Dublin since the 1950s, the first mini-computer company to open a manufacturing subsidiary in Ireland was Digital Equipment Corporation (DEC) in Galway, in 1971. One respondent referred to GE as the first wave of development and identified the arrival of DEC and computer manufacture as the start of the second wave (Interview 7). From this it can be seen that there was an initial gradual development of electronics hardware manufacturing in Ireland during the 1960s (deWit and Meyer 2010). The initial conditions for the sector development were begun in the 1960s from a very low base. The work was in manufacture of components that were end-of-life in the USA and “normally you would only get the assembly of these products for GE” (Interview 14). Cheap labour and preferential tax were driving forces for investment. “The way it kicked off here was around the Shannon Free Zones and that kind of idea and manufacturing tax” (Interview 3).
As the industrial base in Ireland was low, initially, management came from home base (i.e. USA, Germany, France etc.) to run the Irish subsidiaries. “The plant manager [in DEC] when I was there was American. Most of the senior management were American” (Interview 10) and “they [GE] originally came in with all American Managers” (Interview 13). One respondent indicated “I was four years with Krups, which I kind of hated to be honest, because the German thing was so different from the US and that had been my previous experience” (Interview 7). There is also support for the notion that outside influence and development was what trained professional managers. “GE offered me a job in the [United] States on their Manufacturing Management Programme” (Interview 5). From this it can be seen that the early management relied on management staff from the parent company to head the Irish subsidiary. This changes with time to a situation where it is mostly Irish management but “It’s over to the Irish management to make the European thing run” (Interview 2).

This leads into a recurrent theme in the data of prior experience leading to seeding or spin-out effects as the learning and development from the past is carried forward to develop the new generation of companies.

6.1.2 Further Development in the Electronics Industry

This section deals with the development of the electronics industry after the establishment of a base in the 1960s. Seeding was a term that was used by some of the respondents to denote experience or training in one company or environment that then led to subsequent development of other new companies and skills. This seeding was also notable in that, from the references below in Figure 6.1, it was a continuous and ongoing process throughout the 50 years. References to seeding or formation of spin-out companies, both from indigenous companies and from the foreign-owned multinationals, were found in many of the interviews undertaken (see interviews 1, 5, 6, 7, 8, 9, 12, 13, 14, 15).

Respondent 5 believes that DEC had the advantage of training managers in the American way of doing business with monthly and quarterly reports and the rhythms and demands of US-style business. These habits and training or knowledge were then transferred to other companies when DEC closed down. And this was reflected by Respondent 6 who worked
in EMC around the year 2000 and found “the training under American companies like that is fantastic. It really develops leaders in people” (Interview 6).

DEVELOPMENT PROCESS - EVIDENCE OF SPIN-OUT COMPANIES

“Ecco was a gem really and it was a source of a lot of us guys who came up” (Interview 14)

“The next cohort of General Managers and so on for start-up companies, they came from General Electric because General Electric had a fantastic management training programme... and maybe, even in the 1970s, when you looked around Irish industry, the number of General Managers that had come from either EI or Ecco... it was very significant. The next wave was DEC” (Interview 7).

This was echoed on the Irish indigenous side by: “He left then afterwards [Telectron] and formed a company called Ashling. They made emulators” and Respondent 12 also mentioned a former Telectron employee who went on to become Engineering Manager in Analog Devices in Limerick (Interview 12).

“And I keep bumping into people that were working in Amdahl. So it was a very small seed group. And the same with Digital in Galway when they closed and it was the best thing that ever happened because they seeded” (Interview 15).

“Wang came in and so I applied there and I was taken on as part of the start-up crew for Wang, which was fantastic... the general manager was from DEC” (Interview 7).

“So the software industry in Cork, a lot of it came from one company which was SMC software manufacturing company which was bought by MF Kents. You know Client Solutions, PFH, Pepco, WASP and I could name three or four other companies and a lot of them came from SMC” (Interview 9).

“So Motorola closed and [company name] spun out of that... with the five best people” (Interview 13) and “so you have got examples like Motorola in Cork in 1998 and a number of start-ups came from that” (Interview 1) and “Motorola in Cork, right, look at Alcatel, even go further back to the earlier times when Wang were... [here] and Northstar and look at the people that came out of those companies and where they went. And all these people and the skills that were created. And what happened was what happened with DEC in Galway when they shut down. Galway now has a very strong industry coming out of the back of that” (Interview 9).

“And if you look at Baltimore Technologies and look at the number of people that came from that company to form their own and absolute leaders of industry today” (Interview 9).

“Those that headed up VMWare in Cork were from EMC... the guy who is now director of VMWare ... he was a technician in Bourns who moved into EMC as a technician and now he is heading up VMWare” (Interview 6).

Figure 6.1 Development through Seeding and Spin-out Companies
Also many individuals were mentioned as key figures in the development of the industry. Key figures such as Frank McCabe (mentioned in Interview 13 and 14), who in Ecco, "was one of the top management team... and later went on to become the manager of EI and later again then, managed Digital and ended up managing Intel". Many others were mentioned as key figures but the aim of this study does not include the evaluation of the contribution of individuals.

From a low base, the sector developed experience in technological companies and in the management of large manufacturing organisations. During the 1980s, research and development became a key focus. The data supporting this is reviewed in the next section.

6.1.3 Research-Based Development

In the late 1980s, Respondent 3 graduated with a Master’s and worked in a small research company called Farran Technology on very long-term research projects. This respondent considered that the research sector was "close enough to a university setting not to be really out there in the cold world". This appears to support the notion of a divide between the research that was taking place and industry. Later on, Respondent 8 reported joining a start-up company that had spun out from the Department of Electrical Engineering in UCD. In 1996, "they started to do consultancy projects for Analog Devices in Limerick and it bootstrapped. It is kind of a services organisation where you do projects for people and then the company started to retain its own IP and then decided to do a product" (Interview 8).

Prior to this, he took part in a joint venture "between Trinity College and Ericsson and Telecom Éireann and it was a research company doing your European projects and consultancy projects for various organisations". This would lend support to the development of better academic-industry links. It also references EU projects as a source of development of research in the country. In both of these areas, EU projects and early R&D companies, further data gathering and investigation would be required.

Next the evidence for how the multinational base developed is explored.
6.1.4 Developments in the Multinational Industrial Base

Begley et al. (2005) identified five phases of multinational development that roughly correspond with the five decades from 1960-2010. In the 1960s, the electronics industry featured branch plant manufacturing which led to the attraction of more intensive capital investment companies in the 1970s. In the 1980s, software began to feature and there was the benefit of a higher standard of education in the workforce due to improvements begun in the 1960s.

In the 1990s, the cost base in the country was rising and there were staff shortages, particularly in technical areas. However, there was much improvement at that time in cooperation between industry and the various educational institutions. The millennium brought in the knowledge economy and companies such as Google, Cisco, PayPal etc. arrived in Ireland. Against this background of FDI, the data gathered are now reviewed. By 1998, Molloy and Delaney were advocating that subsidiaries look to enhance their value to their parent companies by moving on the value chain. The following section reviews the data collected in this area.

6.1.4.1 Evolution within Branch Plants

Initially the electronics factories were manufacturing electronic products and these types of "peripheral manufacturing locations" were "likely first targets" for shutting down according to Respondent 5 who worked in DEC in Clonmel. This respondent indicated that, having worked in a variety of electronics companies (DEC, Logitech, Computer Products), the level of training and work culture depends on the profit margin. Where profit margins were high, company training tended to be good, such as in DEC. By contrast, Logitech was cost sensitive and completely production focused which was typical of consumer electronics. This was later echoed by Respondent 6 who, when working in Bourns Electronics, in the early 1990s, found a "highly competitive manufacturing environment, huge direct labour pool. You know, 600 people but very few engineers because that was indirect costs" and he described being lucky to get a second-hand PC there in the early ‘90s, again, down to cost controls.
One respondent reported that, around 1974, Frank McCabe, the Managing Director at the time in EI, convinced GE in the US to give responsibility for the R&D and the engineering, as well as the production of one product to the subsidiary in Shannon “Even though that would normally be kept by the parent” where

“They had to drive the cost down very quick and they had to make the transition from discrete components which it was at the time. They were the first to bring in the integrated circuit into the thing” (Interview 14).

This was a first indication of a move away from the branch plant manufacturing and an indication of the advance of technology and the use of ICs to reduce product costs. But this was also a tough economic time. In Ecco, which had gone from 2,000 employees back down to 900

“in 1974 the bottom fell out of the semi[conductors] and what happens in components – when they are scarce people... triple ordering and we all turn on extra capacity and then they cancel all the orders” (Interview 13)

and similarly, Respondent 14 reported

“We were doing a million transistors a day and suddenly we were doing ten thousand a day and I had the job of leaving go all these hundreds of people and it was my first exposure to that kind of thing”. (Interview 14)

Also by contrast “the big issue for Wang was, they couldn’t produce the stuff fast enough. I mean, it was totally out of control, with money no object” (Interview 7).

Over time, a competence in manufacturing appeared as evidenced by comments, such as:

“I ran worldwide manufacturing. I mean the biggest sin, the cardinal sin and the one that got you fired was if you could not produce the product at the end of the quarter. EMC had this huge hockey stick. So all the orders came in the last week or something so that is what we were always geared for” (Interview 7).

and there appeared to be a consensus that manufacturing in both Dell and in Bourns lasted “longer than it should have” due to manufacturing competence.

Some references to linkages between companies appeared in the data collected but, more particularly, to the transition to a value chain approach. “You’d have small companies that would start up and would grow in parallel with the multinational as a subcontractor or supplier to them” (Interview 7) and “They [Apple] actually had a supply base here at the
time. I remember we bought metalwork” (Interview 11). Similarly, according to Respondent 3 “the indigenous Irish sector, certainly in my awareness of it, would have developed in response to serving multinational needs”. [Bourns Electronics] “were suppliers to Apple and other companies” (Interview 6). Respondent 5 reported that DEC in Clonmel had a policy of sourcing locally where possible but according to Respondent 7:

“the issue might be that they never got to scale. They were small and they were supplying maybe one company but they never grew and became, let’s say, a worldwide supplier to that company. That just didn’t happen”.

This linkage or lack of linkage is supported in the literature in that, during the mid-1980s and early 1990s, the IDA developed a linkage programme to maximise the linkage gains from the base of foreign-owned companies located in Ireland and sought to link this FDI success to develop the indigenous Irish base. In the early 1980s in Cork, the Cork Electronics Industry Association [CEIA] was set up to promote electronics and link electronics businesses and third-level education in what was a difficult economic time in the region. CEOs from both multinational and indigenous electronics firms, third-level education representatives and government agency representatives all comprise the board for this association. They had already implemented a linkage programme by the early 1990s and nationally linkages were encouraged by the IDA National Linkages Programme (Power 2006).

Where, at one stage, there were companies subcontracting for the large multinationals, a transition to off-shoring of these supply activities to other locations was also found in the interview data. Also, Respondent 14 believed that it was a key strategic choice not to switch to contract manufacturing or subcontract work and to continue to manufacture their own product.

6.1.4.2 Value Chain Developments in this Industry

Respondent 11 reported that the Apple “replenishment system” started up around 1990 and “that changed the whole way they looked at production and then the BG Turnkey services became important”. By around 1992 “We were realising that the way to go wasn’t to be making your own stuff’ which eventually resulted in the printed circuit board shop being shut in Cork. However, Cork put up a fight and eventually the Corporate attitude became
"get rid of the boards and leave the rest there and they'll be fine. They'll figure it out". However, this respondent replied to a question on the invisibility of the Irish site in five separate popular publications about Apple and key Apple personnel with the reply "because it would be viewed as just a manufacturing site because it didn't make any decisions. All the decision making would be in Cupertino all the time" (Interview 11).

Similarly, EMC experienced a

"mad rush that everything had to be outsourced to China" (Interview 7) and "went through this evolution through difficult times where we ended up outsourcing or transferring a lot of our local supplier activity out to the Far East. TDI was one of the last examples of that" (Interview 6).

This respondent went on to give an overview of the process of EMC moving up the value chain.

"So they went from manufacturing to taking on a related activity which was logistics. So that was provision of spares and stuff. They shipped the product and then the provision of spares and managing a world-wide pool of spares logistics. That was then a bolt-on activity. That was the first additional function to manufacturing. Then they had finance. Then it became international finance. Then they had other activities like Customer service...and then you had about four different functions there and then you had software development opportunities" (Interview 6).

This corresponds well with Molloy and Delaney (1998) and their calls for Irish subsidiaries to move up the value chain, reported in Chapter 2. As a successful example, it resulted in the development of the "really multifunctional campus that it is today". EMC returned to profitability in 2003 after the dot.com crash (Interview 6). However, Respondent 6 also attributed success to the roots in manufacturing where "one of the unique things about EMC at the time was it was manufacturing the full product range for worldwide" and that this is what allowed it to become "that centre of excellence". The warning that subsidiaries needed to be mindful of competition from sister sites (Molloy and Delaney 1998) was also reflected. "And the leadership of American concerns. Those operations are so aware of the competitiveness between sister plants... and I think it brings out the best" (Interview 6).
The movement of focus from hardware to software and service was also reflected in the data. A competent base in manufacturing had been established (Culliton 1992).

“[Dell] Manufacturing was in Limerick probably ten years longer than it should have been. All the competitors were in Asia. And they were still delivering, they were still the most efficient plant in the network in Limerick at the costs that they were at and, on the back of that then, they built up 1,200 jobs in services so Dell have 1,200 or 1,500 people now in Limerick and nobody counts it. So the transformation has to be taken into account that you can’t stop the tide. The tide, once computers went to laptops, Limerick was always under pressure because the shipping costs just weren’t high enough” (Interview 2).

Respondent 9 stated that they benefited from outsourcing by “having an instant [design] team that were ready to go”. This company sold services to the large companies doing product development work for companies like Motorola, Apple and Agfa in Belgium and thereby benefitted from outsourcing. Similarly, Respondent 8, in the IC design start-up, started with outsourced contract work from large multinationals and went on to design their own products. The service work allowed them to build the design team.

According to Respondent 11, this change in manufacturing to outsourcing was “probably the biggest churn in the industry from the workers’ perspective”. There appeared to be a general consensus in the view that Ireland was not a suitable manufacturing location except perhaps in niche or higher value added markets. In contrast to this, Respondent 14 indicated that Ireland is still a site where Irish electronic manufacturing can and is successful and stated:

“We are totally self-sufficient, vertically integrated and everything. So and based here in headquarters, we have R&D, marketing and manufacturing and everybody is cheek-by-jowl and that is part of our strength” and that the company ran “a huge electronics assembly operation, one of the biggest probably in the country. We have four high speed surface-mount lines and we have about five high speed through-hole lines as well” (Interview 14)

Contract Manufacturing also was mentioned in interviews 2, 6, 11 and 13. Three respondents made reference to the success of the company PCH where the home base is in Ireland but where thousands are employed in China. Respondent 6 mentioned C&F
Tooling as another success. This company is based in Athenry but has facilities in many locations and “is a multinational and they have a large manufacturing base”. These are the types of companies that were recommended for Irish hardware outsourcing needs with the decline in hardware manufacturing within the country. These types of company correspond to the contract manufacturing and contract design manufacturing companies described by Sturgeon and Kawakami (2010).

6.1.5 Mentoring & Training in the Electronics Industry

The data also showed the respect and admiration of the respondents for the training and development that they received both from company training, on-the-job training and mentoring by individuals.

In Ecco, Respondent 13 stated “I got a lot of development from Jim” (Interview 13). He was also involved in setting up the first training programme and grant application in Ecco. And “I invented all kinds of training. That we’d send everyone to the IMI and we’d rotate people and send them to the States and we did all that and they gave us £100,000 [IDA grant]” (Interview 13). This training programme was prompted by the annoyance of the American general manager that they were “losing some of our experienced people” and the fact that the company was looking to grow by 300 people in that year. This course has been credited with producing a large cohort of managerial experience that seeded into other companies (McCambridge 2001).

In DEC in Galway, Respondent 10 stated that many of the workers had initially come from Honeywell in Scotland and “the Scottish people had experience in manufacturing. They had experience in electronics” and he was also impressed with the design engineer from America who outlined a set of steps to solve an intractable problem and “it was just so rigorous and his understanding was so amazing” (Interview 10). By contrast, according to Respondent 7, [Wang] were all in favour of training but thought that “we don’t have the time right now and we’re never going to have time”. He considered that both DEC and EMC had good management development within the companies.

Respondent 11 referenced the environmental learning benefit of working in a small set up: “It [Northstar in the 1980s] was an extremely good learning environment because it
encapsulated an entire electronics company on a small premises with a few people” (Interview 11). This all-round view then supported further career advancement for this respondent. The workplace as a learning environment was also referenced by two others as follows: “And I learned more in my four years at Apple than I have in any four years since” (Interview 3) and “There were great lessons in Apple” (Interview 13).

One respondent commented from the mentor’s side: “And I’d go troubleshooting. And every single time I showed him, he learned on that machine. He never came back to me with the same problem” (Interview 12). This respondent also told how, as electronics were still new in the country, he gave training to the AnCO person who then went on to train the production staff in a new rural IDA start up in the mid-70s.

Respondent 9 praised a senior manager who was good at selecting the right people “and then giving them the opportunity to develop because say the likes of Jim was always very good with people. Selecting people and letting them run with it” (Interview 9). Further evidence of this training effect is found in the following section which looks at the government policy and the third-level education contributions but training within companies appears to tie in to an open culture within the company and the chance for promotional opportunities and development within those companies.

DEC was widely known as an open company which encouraged development of their employees. Respondent 10 indicated that they had a process in Digital for giving someone who didn’t have an engineering degree a title of an engineer.

“And I quickly desigited a bunch of stuff and they promoted me to an engineer really quickly. So, sort of that way, the company was really unusual. You could not have done that in an English company” (Interview 10).

This compares well with the views of Respondents 6 and 7 who indicated how progressive the training policy was in EMC. “So they were upskilling employees all the way through, enabling them to take on new experiences and new competencies” (Respondent 6). This meant that “you could come in as an operator and move up. You could move up or you could be supported in your qualifications all the way through”. He also indicated that this commitment continued even when the company was going through difficulties in 2001 and 2002. “They never cut back on their training and development budget. They always
invested in people”. Also he stated that two leadership development courses were “mandatory for us all at director level [organisational managerial level] at EMC” and that training moved with the times in that the test technicians were retrained to suit the changing business times

“it was a highly intensive test environment and it was mainly technicians were…the main workforce. Then they were actually skilled to become customer service technicians. So they set up a product support engineering lab there which became customer service” (Interview 6).

Similarly, Respondent 14 in an Irish owned company stated:

“A lot of our management team, now nearly retiring, but they came in with their Leaving Certs and they came up through that and [there is] still some of that... So we encourage people to come along and do that” (Interview 14).

The Electronics and Software sector evolved into the IT sector and the ICT sector over time as technology developed and these industrial sectors converged. The ICT industrial sector did not develop in isolation.

6.2 DEVELOPMENTS IN GOVERNMENT POLICY, IN TECHNOLOGY AND IN TECHNICAL EDUCATION

This section reviews the data collected to answer the research question on the contribution of government policy and technical education to the development of the ICT sector.

6.2.1 Government Policy

In general, the government agencies, (the IDA, Shannon Development and Údaras na Gaeltachta, and later in the late 1990s, Enterprise Ireland) were the interface of government with the industrial sector. Attitudes toward these government agencies were mostly positive in the data collected. There were some negative comments about the agencies as a counterbalance. However, data in this area is limited to one interview with a respondent from Enterprise Ireland, one interview with an IDA respondent and one respondent in the County Enterprise Board (now the LEOs). Other opinions expressed are from the industrial respondents or respondents with both industrial and educational experience.
Respondent perceptions of the role of government in the development of the sector in general were mixed. For example, Respondent 6 felt that “Leadership development and leadership competence at all levels in Government is really, really important” but that “You don’t have that kind of leadership behaviour, ability, decisiveness, get things done because it’s a skillset that doesn’t seem to trickle through that career path”.

Respondent 7, who started his career in the mid-1960s, pointed to similarity of arguments over time. When the government first looked to attract outside industrial investment,

“So the thought processes, at the time, were to try and attract in industry and then when we had the industry in, then train the people to match the industry. So that was where the breakthrough came. That this wasn’t going to work. You had to train the people first and you had to have the pool of trained labour available and you could use that then as a magnet to bring in industry and that was the driving force behind the regional technical colleges” (Interview 7).

Later he was involved with the Hunt Commission, which looked at Research development within the country. He compared the government argument then with the earlier arguments about training for industrial development. He found little difference.

“The Hunt Commission [reported 2011], the big issue was PhDs and it was almost exactly, it was a carbon copy of the argument. The Department of Finance... was defending the Department of Finance thing that [we should] get the industry in first and the research activity and then you generate the PhDs and we had to try and convince him, it’s not going to work” (Interview 7).

The argument is the same between government and industry as to which is needed first to encourage the development of industry. The detail of the argument has moved on with the different decades. Where, initially, the challenge for government was to provide suitably trained people for industry, later the focus had shifted to the development of higher skills to allow more continuous development. R&D was identified as the path that would provide more sustainable development.

There was also a view that, “Irish entrepreneurs and Irish business look to government way too much, way, way too much” (Interview 2). This view was supported by Respondents 14 and 9.
Overall, Respondent 13 felt that "the State... just maintain the edge that they have had in competing" and he indicated that in the choices it has made, the State has generally been progressive. He saw the establishment of the Regional Technical Colleges (now the IoTs) and the creation of the research educational infrastructure as key developments. The Business Expenditure on Research and Development (BERD 2011/2012) report states that 14,000 persons are engaged in R&D activities. Two-thirds of these are employed in medium and large enterprises and 10% of all R&D staff now holds a PhD qualification.

6.2.2 Government Agencies and their Development Policy

Agency: The IDA

The first government agency to be involved in developing an electronics and software base was the IDA. "The IDA in its young days was vibrant" (Interview 13). This respondent had great respect for the IDA. When an issue came up with a multinational, the IDA executive directors "picked up the phone" and sorted it out. He was of the opinion that: "It evolved, I won't say seamlessly and the IDA spotted the companies and they are out there like vultures. They are looking at the companies that are appearing on radar". Similarly for Respondent 7, who found "the IDA was always helpful. There was no question about it that the whole set up was geared toward American foreign direct investment and American companies coming in".

From the data, the importance of tax incentives was seen. For example, "we appear to be holding on tooth and nail to our corporate tax structure and maybe that's an important piece of our fabric or infrastructure" (Interview 3) and "The IDA incentives were really, really important. And the whole corporate tax rate is so important too for [the] survival and the thriving of Irish operations" (Interview 6). Respondent 1 indicated that, initially, "about thirty years ago [when] the nature of State intervention was essentially employment grants" and that other factors such as available talent were more important than State grants nowadays (Interview 2). Currently, grant aid is unavailable for overseas companies locating in Dublin or Cork and "can be more of a complication than an incentive". The counter view was posed by another respondent. "They only came for the tax. They didn't want the engineers although they’d swipe them if they could" (Interview 12). This is countered by Respondent 13 who believed that it was the availability and quality of...
engineers "which are a scarce commodity in the [United] States" which helped the FDI drive. This corresponds with the IDA survey and interviews carried out in the 1980s and reported in Chapter 3.

Where linkages were viewed as important to maximise the benefits of FDI, particularly from the 1980s onwards, the IDA respondent pointed out "We’re coming under a lot of pressure from the Minister... but it’s not our job to tell Irish management they should use Irish companies" (Interview 2).

FDI was a consistent strategy by the IDA throughout the time covered in this study. Although FDI was a continuous and on-going policy, it appears to have generated much debate and argument as to how to optimise it and whether it was, in fact, hindering the development of the indigenous sector. The next section examines the data collected in relation to FDI as a driver for the industry.

**Agency Policy for IDA: Foreign Direct Investment (FDI)**

Early IDA targets for FDI were large manufacturing sites, as evidenced by the arrival of GE and DEC. However, the IDA currently advise that many of the top ICT companies are already here in Ireland. This corresponds to Respondent 2’s comment that the IDA Emerging Companies Division looked at "companies that are under 200 people, under 20 million revenue globally" and that the days of getting 2,000 employed in one location were gone. Further to this "even when I was in the ICT division, we’d always have dealt with smaller companies. We just wouldn’t have targeted them in as focused a fashion".

Initially, throughout the 1960s and early 1970s, the branch plant or subsidiary was the main staple of FDI and there was criticism that these jobs were associated with industry churn. This is juxtaposed with the current comment of one respondent:

"If you looked at the investments that we are getting in, if you looked at LinkedIn and if you looked at Google, for a lot of the stuff, look at the functions, not the name of the company. So Facebook is a technology company but they are not doing technology here".
The IDA respondent pointed out a change over time in that the more recent FDI companies "want to build a market and you can’t get away from that. So many people talk about companies investing in Ireland. Companies no longer invest in Ireland".

Not all respondents had continuous experience of success. In the early 1980s, Respondent 15 praised the IDA backing of Trilogy even though "they imploded before they opened". He believed that "they developed a lot of skills" and Respondent 12 had experience of being in an IDA backed start up where "there were eight people working in the factory before Christmas...and we got it going, but by March it was gone belly-up, gone".

Expansion in Microsoft in Ireland was partly influenced by the IDA’s offering extension on tax breaks if Microsoft "would extend the number of people with Masters and PhD degrees that are required to do the jobs there" (Interview 10). This provides support for the rising importance placed on R&D by the IDA.

Respondent 15 worked in Telecom Éireann around 1996 and recalls that the IDA were particularly helpful when he needed to source local Irish places who could assist with good plastic extrusion and reported that the places they recommended "were good in their day". This respondent also recalled that:

"we had about four people in the US office and they worked closely with the IDA. So they were, at the time, looking at the call centre space as a lot of jobs... So if you look at the companies that they brought in at the time, Gateway 2000 and Dell. So, Gateway 2000 had about 1200 people in a call centre" (Interview 15).

At a later time, this respondent went on a mission for the IDA to Geneva when the IDA were looking to "see if they could save any jobs" in Digital and this would support the IDA policy change where the attitude to job retention became as important as new FDI projects.

Respondent 7 pointed out one counterproductive element of the goals of the IDA.

"So they were goaled on new jobs. So if you had a company that was in trouble or in danger of going out of business, if they managed to save that company, they got no credit for that. So it was actually in their best interest if the company is in trouble. We’ll close down that company and bring in the next crowd who’ll hire all the same people and we’ll get credit for that" (Interview 7).
This was reflected also by the experience of Respondent 14 with Shannon Development:

"I failed to get any funding from the Government... They should have been even more motivated to keep the place open than I was" but "they couldn't support us because we weren't closing down...If we had closed down and opened it up six weeks later, they could have supported me" (Interview 14).

One other respondent had a bad experience in a regional start-up company and found that the attitude, when things were going wrong, was "if we don’t know, we can’t be blamed". These experiences occurred during the 1980s.

In 2008, Respondent 2 reported that the IDA “changed our strategy around that period”. They reviewed where investment was coming from and found that well over 80% was US investment and advised that “a diversification and a recognition developed that we needed to understand Asia better, not only Asia... the BRIC countries” and that this led to an IDA goal that 20% of investments won should be from non-US and non-European countries. However, he did acknowledge that other European countries were still a good source of projects and jobs for Ireland. This IDA respondent also pointed to the change in policy over time as follows: “It’s not about companies now it’s about skills. So if you are working...in an IDA company, it’s about building skills that are transferrable” (Interview 2).

Respondent 13 who had come up through the GE training system believes that “the ideal factory would be a Nissen hut at the end of a runway. If we get any hassles on taxes, labour, unions – we are gone” and indicated that he had attended a meeting where the corporate attitude was “Close it anyway” about a production plant of which no one in the corporate office was sure of the status. He believes that status, as a subsidiary, is always fragile, especially when the functions can be replicated elsewhere in a cost effective manner.

A current difficulty of the IDA in matching the skill base in the country to the FDI requirements was pointed out by Respondent 15. “The IDA are caught on a tight rope. There is a shortage of skills in ICT now but they cannot go and shout [about] this because they are trying to attract companies”. From an IDA viewpoint, “Given the skill base that has been built up in Ireland over a long number of years, a lot of that skill base was built on the back of IDA companies” (Interview 2). Similarly, from outside the IDA, Respondent
15 commented “Because of our [country] size, we have to choose and I think the IDA have played a blinder in choosing” and he quoted Napoleon who is reputed to have said “Always have lucky Generals”.

Some respondents were also wary that FDI should not be the only pillar on which the ICT sector was based. “We are way too dependent on foreign direct investment and we kow-tow to it in too big a way” and this respondent was of the opinion that the US Chamber of Commerce was an effective lobby group that “we are afraid of them every time” (Interview 14). This respondent, if offered a choice between “Boston and Berlin” would choose “the German industry model” which “was more sustainable in the long run...They don’t have a Dell, they don’t have a Wang that came and went and left the city demolished” but he also pointed out that “we had no option but to take all the jobs in Limerick”. This reality that the electronics industry was a necessary choice and the essential nature of this foreign direct investment was also referenced by Lee (1989).

**Agency: Local Enterprise Offices**

One respondent from the CEB (currently LEO) indicated that small enterprise came into focus when “In 1992, a White Paper was actually drafted... and the findings were pretty shocking to the Government... and they realised that no one was actually looking after the micro sector”. This prompted the setting up of 35 Enterprise Boards in 1993. At the start, in one CEB, “there was one guy running around with no office and about 40 files under his arm”. However, this respondent confirmed that technology start-ups were few in the microbusiness area and that the incubation centres in the Colleges were fulfilling this role. This respondent also noticed that software development start-ups were more prevalent than hardware development – especially in the micro business area. However, the comment that a White Paper shed light which led to action is also a common and continuous process throughout this study, as indicated by change after the early OECD report into education, the Telesis report, the Culliton Report etc.

“Then you had the establishment of Forfás in 1994 which brought that independent analysis that fed into Government” (Interview 1). The complexity of environment had increased to a level where government agencies looked to independent analysis to inform policy decisions and changes.
Agency: Enterprise Ireland

"In 1998 then... it was felt that ... – the nature of Irish-owned companies, the supports that they require are different than multinationals" (Interview 1).

The founding of Enterprise Ireland (1998) is a key government decision that sought to focus and build the Irish indigenous industrial base. However, this requirement to strengthen and develop the indigenous Irish sector had been an ongoing debate from the time of the Telesis report in the early 1980s. Also, at this stage, Ireland was more prosperous economically than before and there were changes which led to a more complex environment. This had implications for Enterprise Ireland, as illustrated by the comment, "there are some very complex types of companies out there and the nature of the support that they require from the State is also complicated" (Interview 1).

Respondent 1 described Enterprise Ireland as “navigating” around three interlinked areas of “legislation... two is the policy bit and three [is] State Aid” and the state agency seeks to encourage “continuous change in the company”. He described a whole company approach of support which he later described as a “partnership mechanism” or support structure: “since 1998, [is that] we look at the business plan of companies and we will provide a whole range of supports, not just in the particular area such as R&D for example or management development” (Interview 1) and “It wouldn’t begin and end with the company gets R&D and we walk away. We’d be trying to ensure that they continually improve”. This respondent described the balancing act of trying to put supports in place to ensure that good things can occur without displacing existing activity.

From an entrepreneur’s point of view, development support for the indigenous industry began around the time of the dot.com boom: 

“And then with the whole dot.com stuff there was a huge interest in it. The support structure that came at the individual level in the start: the incubation centres, the accelerated programmes like the Enterprise Development Programmes. That was one thing that was necessary to help people realise and give them a support structure to start a business. Now they weren’t great but they were a good start and then Enterprise Ireland coming in with certain supports to help people along. And
there was various funding and structures there with European funds as well of course” (Interview 9).

This continuous support and development of the indigenous industry then led to a more positive business environment.

“As it is today, there are twenty to twenty five accelerator programmes in the country... And that whole structure. Enterprise Ireland are paying for the facilitation of these things and pulling them together. I think that’s great... If you want to start your own business – this is the place to start” (Interview 9).

Another respondent indicated that, as regards money spent on investing in jobs, “Enterprise Ireland is the biggest Angel Investor in Europe” (Interview 2).

Agency Policy for LEO and Enterprise Ireland: Entrepreneurship Policy

Investment in the Irish indigenous industry led to a focus on entrepreneurship as a means of industrial development for this sector. Qualities for innovation-led entrepreneurship include “experience with multinationals, relatively well educated - as in Degree and University or IoT and some type of technology background” (Interview 1). From the point of view of an entrepreneur “you need a healthy dose of naivety to start any new venture because you never foresee everything and you wouldn’t have started if you had. So angel investors, they put a good filter at that level” (Interview 9). This entrepreneur graduated in 1989 but he started his “first company in ’94”. He had grown up in a family business and had always wanted to start his own business.

One other respondent had worked in an entrepreneurial technology start-up, in the area of IC design which eventually:

“took on venture capital and everybody went on the product. But at that time, you are doing a better deal with the venture capitalists... you are a real company.
You’re really successful. You already have skills. You already have a proven track record in the area so you are doing a much better deal” (Interview 8).

The focus on entrepreneurship appears to have had an effect on the mind-set of people and their willingness to back their business ideas by starting up themselves.
Increasingly, we are seeing students coming out that will go into an incubator company and they are a different animal to somebody who wants to work in a multinational or the civil service” (Interview 15). The policy aim in Enterprise Ireland was expressed as follows:

“And I suppose it is that regardless of age, that people look at entrepreneurship as a potential career... it’s trying to ensure that they have the capability if they go down that road that they make as much of a success of it as possible or that they would fail at least a bit quicker and then we could bring them back into the fold again and bounce them on” (Interview 1).

However, like FDI policy, entrepreneurship policy also had its negative features. Some respondents pointed out pitfalls or were critical of Enterprise Ireland. One respondent pointed to the difficulty of maintaining optimism amongst employees in such government agencies. “Fellows that have been in EI [Enterprise Ireland] too long get cynical and have heard it all before. You have to be careful of that in a semi-state body” (Interview 13).

One respondent, an entrepreneur, mentioned two dangers in current entrepreneurship training. The first was where “the metric becomes filling the seats as opposed to quality” and “you wonder how did they get on the programme” (Interview 9). He pointed to the tendency to fill these entrepreneurship vacancies regardless of quality. He was also critical of creating “a false impression” by bringing in “the shining stars” as demonstrators or role-models for would-be entrepreneurs and he thought that “where people can explain what the graft is and are still on the graft, there is a bit more reality to it” (Interview 9). He pointed out that there can be an abdication of the risk involved “The problem with these accelerator programmes, being investor ready and all that, [it] means that someone else is going to take the risk on you, as opposed to you need to take the risk on yourself”. He believed that these programmes are sometimes not necessary. In other words; “the accelerator programmes are too much about planning and not enough about doing” (Interview 9).

Problems with getting existing companies to scale were mentioned by a couple of respondents. The experienced entrepreneur is “growing my business and employing as little people as possible - but I’m not an Enterprise Ireland client. They won’t support me, yet” (Interview 9). Also, Respondent 2 commented:
“An awful lot of the Irish start-ups are really good quality ... But it’s the next stage then. It’s what happens when you’ve got the proven idea. How do you scale it up? That’s where the problem is. My view is, it’s a funding thing. Others would say it’s an ambition thing” (Interview 2).

However, this is a primary focus of Enterprise Ireland as evidenced by the comment: “We [Enterprise Ireland] want to get them on a growth path in terms of scaling as that can generate the jobs. Essentially, all our activities are focused on economic impact for the State” (Interview 1).

He described in detail the different programmes available at the different levels of scaling for the Irish companies looking to export.

Selling out too early was mentioned also. “If you look at Enterprise Ireland and what they are doing. They do great work in building start-up companies but we sell out too early” (Interview 2) and “One of the issues we [Enterprise Ireland] have is, I suppose, is the extent to which companies might sell out too soon” (Interview 1). The view was also expressed by Respondent 14 that: “the psyche of the people involved as well. I think there’s far too much prevalence of people who start a business, they get great support in doing so. They bring it to a certain level and then they take the fast buck and are gone.” (Interview 14)

and he believed that “we have got to try and maintain our businesses in Ireland and stop this quick buck. I think the government can, definitely, if they can give entrepreneurs a break that they can realise some of the value of their business without selling it out” (Interview 14).

The government has also supported electronic industry development with direct training measures and this is examined in the next section.

6.2.3 Government Policy on Training within Industry

Government has continually focused on the importance of education. This section looks at the data concerning training within industry and outside of the third-level institutions. The government first looked at support of training within industry to support rapid expansion and reduce skills shortages.
In the early days of GE subsidiary, Ecco, the government first agreed to pay for training and “they gave us £100,000” (Interview 13). This respondent described this as a huge amount of money at that time and the company developed a training course and this course is credited with training many managers who subsequently went on to many other start-up companies (Interview 13 and McCambridge 2001). McSharry and White (2000) confirmed that investor worries about skills availability was often offset by the training grants on offer and he called this “a potent weapon in the IDA’s armoury”. Half or more than half of these grants were eligible to be reclaimed by the IDA under the European Social Fund (ESF) after 1973. He identifies that it was AnCO (then FÁS, now Solas) that would interact with the company to draw up formal training plans. In a rural IDA start-up, in the early 1980s, “I had an AnCO guy there, very nice guy... he didn’t know what electronics were... so I showed him how to do all the stuff” (Interview 12) and this person, once trained, went on to train the other staff.

The training focus shifted to developing leaders and there were two references in the data to the “Leadership for Growth” programme. This programme sought to change “the behaviour of CEOs” (Interview 1) and “was [one of] the initiatives that I, thankfully, benefitted from” (Interview 9). This was a custom-built programme with Stanford University, USA and they set out “aspirations, leadership ability and strategic business ability” (Interview 9) and “they have raised the aspirations of so many individuals in this country by what they have done. Now, they are running similar programmes, less cost, at a lower level, in Cambridge University and there’s great feedback from those courses” (Interview 9).

Respondent 4 mentioned The “Genesis Enterprise Programme” and named two successful software entrepreneurs who had benefitted from this programme and started successful companies. This respondent indicated “By the year 2000, the emphasis had swayed very heavily towards the development of skills for the owner managers” (Interview 4). Following the leadership training, entrepreneurial supports came into focus. Where much improvement was noted in funding, according to Respondent 9, “the State aren’t stepping in with sufficient funding [for entrepreneurial start-ups]. Now it’s an awful lot better than it was but it is still lacking” (Interview 9).
The debate of whether entrepreneurs are born or made also featured in interviews 2, 9 and 14. "I'm not too sure you can teach entrepreneurial risk taking. It's either in you or it's not. Doing a course on entrepreneurial skills to me is a contradiction" or "The best entrepreneurs in the world never went to school" (Interview 14) and "I think entrepreneurial studies doesn't make someone an entrepreneur" (Interview 9). One respondent felt that not enough was being done at an early enough stage and "they need to bring an element of entrepreneurship into courses, every course.... I am talking about a module" (Interview 2).

The development of incubator spaces attached to Universities and IoTs was considered the important first step by Respondent 1, who gave the example that:

"you have the New Frontiers Programme in CIT... that allows companies to incubate. We would fund that in conjunction with the IoTs around the country. If they come out of that there is the opportunity to go for funding from ourselves what we call the Competitive Start Fund... and the next step would be HPSU [the High Potential Start Up]..." (Interview 1).

With the move of manufacturing out of the country, one respondent saw research centres as providing an in-country resource to support hardware development. "If you develop, I suppose, centres like Tyndall, or MAC is still in operation in UL, they could do hardware development - so you're outsourcing it."

Respondent 1 summed up the Government policy approach as follows:

"In any economy you will have discrete pillars. You will have the foreign-owned base; you will have an Irish-owned base. You will have a government base. You'll have customer. You just need that to be balanced and just because one is growing it doesn't mean that you are doing it at the expense of the other one. And that is the way that I see it and I think you are just continually expanding the base. Within those pillars then you are going to have to generate and try to create complementarity across them" (Interview 1).

The next section looks at data collected about the changes in technology over the five decades.
6.2.4 Development in Technology

"The technology has changed, the programming languages have changed, the tools have changed but the underpinnings are the same as what I got taught."

(Interview 8).

Over time there was a decline in the importance of the hardware as opposed to the software side of development. As evidenced by earlier points, the initial industry was mostly hardware manufacturing which looked to graduate to higher functions of marketing and research and development activities to improve the subsidiary status. With the arrival of the PC, the software industry began to grow. Many respondents indicated that currently there was a stronger software base than hardware base in the country and most indicated that starting-up in the hardware area was more difficult than for software.

Within the data, technology featured in most of the interviews (Interviews 5, 6, 8, 9, 11, 12, 13, 14, and 15). Technology development found in the data reflects the move from hardware to software and supports the move from a simpler environment to a more complex environment (Duncan 1972). This is supported by the career comment from Respondent 13, "...rate of change and that is the thing that sets apart a career in electronics. That all my career, from day one [mid 1960s], the rate of change has been phenomenal". Where the simpler environment of the 1960s-70s is described below, comment from Respondent 11 reflects the current environment:

"The lifecycle of a product is so short now and in fact, there is probably more engineering time goes into a product than there is the life cycle out in the market place before the next one comes along" (Interview 11).

6.2.4.1 Technology Development

Respondent 12 described his early days of working in Telectron, on "one-off type jobs" where the profit margins were relatively high. "The cost of the materials was one third. The other third was manufacturing, overheads and design etc. and the other third was profit... So the selling price was three times the cost of the materials" (Interview 12). He also described the typical early manufacturing site which had
“a load of girls manufacturing stuff... They were tuning coils and I mean it was a seriously efficient flow. They put stuff through pretty darn fast” but “There was no auto-routing and there was no software whatsoever. The first of that began coming in around the time when I was leaving” (Interview 12).

Even here change was continuous as evidenced by the comment “Pulse Code Modulation arrived with a vengeance”. Branch plant type manufacturing was also apparent in the “early days in Apple. I was actually quite ashamed of what I was doing up there. All we were doing was putting a printed circuit board into a plastic box” (Interview 13). In Ecco, “we had signal transistors. That’s where I started off my time on the signal transistors – process engineering and then I went into supervision” (Interview 14) and “they had radio products, they had tuners and things from the beginning and we were also the biggest operation here at the time when I came down [in 1981]”.

“And the factory [DEC] was fairly big. When I got there, there were 500 people working there already. So it was a large place and the different production lines and we worked on the PDP11s [midi computers] which were the new introduction at the time. [We] fixed them. You got your own oscilloscope and your own little place to sit. So it was a fantastic environment” (Interview 10).

Respondent 9 left college in the mid- to late-80s. He had an interest in programming from a young age and he identifies the change in technology where a photo now takes up as much or more memory than he had on his first PC.

“I used to program on the BBC [microcomputer] and you knew exactly how little memory you had. The first PC I bought had 40 Megs hard-disk space. Megs, right! I have photographs that are bigger than that now” (Interview 9) and later “I developed on the Macintosh and I developed on the PC and the challenge you had had to do with memory allocation” (Interview 9).

There was also a naivety in those days as reported by Respondent 10:

“We’d get stuck waiting for a part. We had young fellows fixing a part that was only worth five bucks. A whole load of stuff like that that we always thought was great. We were learning a lot but it wasn’t always very efficient” (Interview 10).

There was also a resilience and ‘can-do’ attitude as reported by Respondent 12 who worked in Telectron: “And it was amazing what you can do when you have nothing and if you have
to do it". He also described making his own test equipment for initial testing of a telecomm product and indicated that, in Teletron, they did not have time or resources to pursue patents for their work. Respondent 14 describes how one hardware product that was brought to Ireland around 1974, subsequently developed through the years.

"So they were the key [technology] steps. We took the initial product and we got the size of it down and we got the integrated circuits designed in and now we are bringing intelligence to the things" [because ] "the PICs [processors] are now available for a couple of cents. So you can give intelligence to these things now" (Interview 14).

6.2.4.2 Hardware versus Software

Much of the interview data collected featured a comparison between hardware and software. A summary of these differences is shown in Table 6.1. This table was generated using the respondent comments shown in Figure 6.2 below. In general, the data support the migration from hardware manufacture to the development of the software sector and the rising importance of the services sector. "So manufacturing is tough. Software is where it's at" (Interview 2).

<table>
<thead>
<tr>
<th>Advantage/Disadvantage</th>
<th>Hardware</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set-up Costs and Investment</td>
<td>Higher</td>
<td>Not as High</td>
</tr>
<tr>
<td>Cost of Mistakes</td>
<td>Higher</td>
<td>Typically not as high and easier to fix</td>
</tr>
<tr>
<td>Stock Market Evaluation</td>
<td>Lower and longer return</td>
<td>Higher and faster return</td>
</tr>
<tr>
<td>Ease of product release and distribution</td>
<td>Harder and longer (delivery mechanism still needs physical delivery)</td>
<td>Faster and easier to distribute</td>
</tr>
<tr>
<td>Development time</td>
<td>Longer</td>
<td>Shorter</td>
</tr>
<tr>
<td>&quot;Critical Mass&quot;</td>
<td>Harder to achieve</td>
<td>Improving</td>
</tr>
<tr>
<td>Ease of imitation</td>
<td>Typically harder</td>
<td>Typically easier</td>
</tr>
</tbody>
</table>

Further comments by respondents which relate to hardware and software are listed in Figure 6.2.
"I borrowed a Spectrum 81 or a ZX80 ... and I wrote some simple stuff... and the following summer of that year, my father helped me, half and half, in buying a BBC micro Model D. That was 1983" (Interview 9).

"the difference, so we were doing actual integrated circuit design [late 1990s], so designing chips... the difference is that in a chip a bug costs a half a million to fix" (Interview 8) and "the amount of effort that goes into developing a hardware product because once you go into high volume manufacturing ... when you make a mistake it is hugely costly" (Interview 9).

"The huge thing was stock market evaluations. And stock market valuations of software companies were astronomical whereas in hardware companies - they never rated hardware companies. So if you wanted your share price up, you had to get yourself, somehow or another, classed as a software company and convince the market that you were a software company” (Interview 7).

"It's easier to get your product out there with software. So there are now the android platform, the iPhone platform. It is the distribution mechanism for your software to get it out there quickly – whereas distributing physically is more challenging” and “there are much more regulatory requirements, check boxes, that have to be met with hardware so that is time consuming. So the development times or cycles are much longer in hardware than in software” (Interview 8).

"The problem when you are doing a product, it is a much larger piece of work [compared to service work] and the timescales are much longer so the management and estimation problem is worse” and “the worry I would have for any start-up whether hardware or software, you've got to get a bunch of things lined up right. You've got to have a good idea, you've got to have good execution but you also have to have something, some intrinsic value or technology or competency that makes it very hard for other people to copy. What I would see with an awful lot of the software start-ups is there is nothing there that you can’t copy” and “the community in the hardware space, in the IC design space, is quite small and there aren’t that many places to float around “... and “while it appears to be improving in the software space, we have struggled with the critical mass thing. And the critical mass thing, that also includes investment and VC and stuff” (Interview 8).

"The current focus is probably on things that are less expensive to set up. So you are not going to have an indigenous Irish chip manufacturer, where you could have an indigenous Irish designer because you can buy whatever the modern equivalent of the Cadence tools [are] not too expensively and set yourself up but you can’t build a fab” (Interview 3).

Figure 6.2 Respondents’ Comments Relating to Hardware or Software

However, Respondent 8 summarises the differences between hardware and software companies:

"I think there will always be many more software start-ups than hardware start-ups because of the costs. But I think a very large percentage of software companies are going to die off very quickly.

So if you are looking at the long-term, your odds are probably better in the hardware space than in the software space because the barriers are higher. But in terms of your exit price, I think the high user stuff is currently being valued
much more highly in the software space. So your big buck VC wins. What they are looking for [is to be found] in the software space and not the hardware. They don’t want – it’s going to take ten years of expensive investment to get a product out and even then we’ll make a profit but not a massive one. It’s not the sort of bet that the VCs prefer.

But as a country maybe the ten year company that’s going to be here in twenty is what you want rather than gee whiz. Two founders make millions and head off to somewhere low tax” (Interview 8).

The next section reviews the data collected concerning the developments of technical education in Ireland and looks to answer the research question on the contribution of technical education to the industrial sector.

6.2.5 Developments in Technical Education

“Well, it’s very hard in an engineering degree to pull out one aspect. Everything knits together. That’s the whole point. It’s a mesh of neurons” (Interview 15).

A short reprise of the findings from the literature review from Chapter 3 follows here. The OECD report “Investment in Education” was not impressed with the Irish education system as they found it, in the early 1960s (Barry 2007). This OECD report focused on inequalities in levels of participation and the ability of the educational system to meet the future skills needs to allow economic growth. The OECD investigators found that 42% of primary school leavers transferred to secondary school, 29% transferred to vocational school but 29% had entered the labour market directly.

It was the arrival of industry that prompted changes to third-level education. The late 1960s saw the setting up of AnCO for industrial training and apprenticeships. In the late 1960s, the decision was made to set up a network of Regional Technical Colleges to support industrial needs. Accreditation was required for the awards of these new colleges which led to the setting up of the NCEA. Alignment of the apprentice training, the RTCs/IoTs and the
universities awards was a long process and eventually led to the setting up of a single framework under the NQAI in 2003.

In 1978, the national manpower committee was established to liaise between the IDA and the Department of Education to align industrial upcoming requirements with educational outputs. This alignment of technical education output to the needs of industry was ongoing and led to a review of skills needs by the Expert Group for Future Skills needs in 1998. This group now regularly reports on skills requirements.

6.2.5.1 Development in Third-Level Technical Education

Technical education in the 1960s was either at degree level in the University or at certificate level in the few technical colleges or through the apprenticeship route. The technical colleges relied on the City and Guilds for standards. The development of the Regional Technical College network in the 1970s added a layer of technical training to this at certificate and diploma level, initially. However, the historical development of education covered in chapter three shows that there was much uncertainty as to how best to develop technical education.

One respondent graduated in Electrical Engineering in 1964 and he recalled in the late 1960s the excitement of his university’s receiving radar equipment from the USA. “[They] flew it in in a big transporter to the airport and gave it to us. Two boxes and you opened the two boxes up and you had a whole radar system”. The class size was small, “there were only eleven in my class... and probably six of them went out to Shannon”. This contrasts with his recollection of class in the RTC (now IOT) where “we’d get twenty engineers in, well maybe 25 and we’d have twenty of them by the time they finished”, but following rapid expansion, driven by the government requirement to have more skilled people, the numbers exploded. He attributed a dropping in the standard of the engineers produced to this sudden increase in numbers.

Respondent 7 who also graduated in the 1960s found that: “the other huge difference is that almost all the students now get work experience. So when they come into industry they are way ahead of where we were” and “lifeskills is the big win, I think, and also the ability to work with people because so much of your academic career is individual work” (Interview
8). “90% of the students, undergraduate students, now have a placement opportunity” (Interview 6) and

“Internships are now becoming more important... but certainly Computer Science here still doesn’t have a placement programme. I think they had for a short period at the end of the 1990s but it was discontinued” (Interview 8).

“[Engineers’ Ireland] Accreditation started in 1982...and was primarily for the universities. The IoTs really only came in, in the late 1990s (Interview 15). This statement supports the upgrading in the IoTs to support degree programmes. It also supports wider consultation with the profession to ensure relevance of material in the engineering courses. It also points to the slow development of an over-arching evaluation system which has evolved into the current QQI (Quality and Qualifications Ireland). QQI is a state agency established in 2012 to oversee and co-ordinate the functions previously carried out by the Further Education and Training Awards Council (FETAC); the Higher Education and Training Awards Council (HETAC); the Irish Universities Quality Board (IUQB) and the National Qualifications Authority of Ireland (NQAI). Respondent 3 also pointed to the involvement of Engineers’ Ireland.

“Even the change in the Engineers’ Ireland review criteria 2000, 2005 and 2010 is very significant and had a big impact all over the country in the sense that it built in the requirements for things like communicating with the business environment. It built in the requirements for ethical considerations around projects. It built in the requirements for Project Based Learning without calling it that” (Interview 3).

This is also supported by Respondent 6’s comment “we have a lot of programmes that are accredited by professional bodies, like Engineers’ Ireland. So we are being driven and we are striving to drive our courses to meet those needs of the professions” (Interview 6).

Problem based learning was referenced by Respondent 15:

“There’s a little more technology in the classroom. For example, we’re seeing, in terms of process, we’re seeing problem-based learning coming in. So nearly all engineering programs would be 20-30% problem-based learning type methodology. There’s a lot more work placements so what we find is if students go out and do work placement in their penultimate year, then the final year they really consolidate the academic materials” (Interview 15).
He reported a shift from “putting in the hours” or “time served” to outcomes of education as expressed as attributes and levels of accomplishment of those attributes.

“And if you look at the engineering standards for accreditation and engineering courses [and] how they have changed over the years. If you go back 10 years or so ago, maybe slightly more, their whole focus was on the one year, two year, three years. It was all how many hours you spent at the books and not so much what came out of it” and now “They formed [an organisation] called the International Engineering Alliance and they developed exemplars for engineering education across a number of dimensions. So we have 13 graduate attributes which you should learn when you’re in an engineering course – to different levels....So what is coming out is a more rounded graduate. It’s not just a techie which is an advantage they have over when I was in engineering” (Interview 15).

Change is also continuous in technical education and Respondent 6 summarised the differences between the IoTs and the universities as follows:

“The higher education sector in Ireland is going through changes. But it...has had its real strengths in the dual roles of the Institutes of Technology and the Universities. They are very complementary... look at the CIT website... its mission is about meeting the needs of industry and our (University) mission is about research-led teaching and basic research and they are very complementary” (Interview 6).

However, in this process of change the key points, or matching to industry needs and the importance of research, are emphasised. The next section reviews the data on linkages and networking between third-level education and the industrial sector.

6.2.5.2 Improvement of Linkages and Networking

Development of Linkages Between Industry and Education

There was reference to the difficulty of interaction between the Education sector and Industry.

“They [the government] had put funding in with Science Foundation of Ireland into the Institutes and the Universities and I suppose there was an awful lot of work had
to be done but there was nothing coming out. There was no commercial reality on it” (Interview 4).

Respondent 2 uses the word ‘forcing’ to describe the interactive process between colleges

“I suppose the policy of the government has been quite good on this in forcing the colleges to collaborate with industry on projects. You know, the funding is linked, if they don’t collaborate with industry they won’t have access to the funding so it has linked them in. It has forced the colleges to work with companies. Companies are really looking at that now and getting full value for their interaction with colleges. Colleges have learned to work with companies as well. So you look at Tyndall or you look at Crann. You look at the major centres. They really know how to work with companies and how to get good value out. So I would say, probably not important for attracting in companies but certainly important for keeping companies” (Interview 2).

This disconnect between research capability and small business started to be addressed.

“The Institutes of Technology and the Universities, recognising that there is a lot of talent within those organisations that could support business and I think the government, to be fair, has really had their eye on the ball on that one and they have recognised that we are really not bridging that gap” (Interview 4).

Development of Linkages between Educational Institutions

Respondent 5 indicated that linkages and interaction between Universities and IoTs were small. He also suggested that the industry attitude was that there was no reason to outsource “bread and butter work” to others. In more recent years, this interaction had improved and was very beneficial.

This lack of co-operation both between third-level institutions and between third-level education and industry was supported by the comment:

“So it@cork was started under Cork BIC. I was heavily involved and I was the chair of the industry-colleges linkages committee at the first stage. Trying to get CIT and UCC to talk and then to talk to the industry, you know. It was a no-win situation” (Interview 9).

This contrasts with more recent times where Respondent 1 found “UCC and CIT are really,
really good and very linked in with the types of companies that we [Enterprise Ireland] work with, as well as the foreign-owned'. Respondent 2 indicated that it would be "very hard to point to two [multinational] companies working together. You'd have two companies working together but with a college as an intermediary".

In more recent times, respondent comments became more positive. Such comments as, "Tyndall played a big part" and "the one place that I came across at the time and they were really good, was the Microelectronics Application Centre in Limerick" (Interview 15), support this positivity. Even more recently, linkage is now actively sought by the third-level sector.

"In practice, here in CIT Extended Campus and on the customer relationship management system, we probably have more ICT partners than we have in any other sector, although pharma-chem is probably coming close" (Interview 3) and

"There's a great guy based out in the Rubicon...And [he] knows all the new technologies if you want something done... open source, new ideas all the time, to solve different problems, the ability to be able to piece all these things together to solve bigger problems, that's there." (Interview 9).

Entrepreneurship and research are also developing links as evidenced by the comments:

"Ignite is a graduate business innovation centre to enable graduates to set up companies" (Interview 6) and

"If that [research] funding hadn't been put in place a decade ago we wouldn't be in a position to do things like innovation vouchers now where you link up IoTs and the Universities with small industries and we wouldn't be in a position to fund what we call "Innovation Partnerships", which brings the third-level with the multinational, with the SME, so there is continuous improvement required and we need to get more out of the substantial funding that's been put in place. But I think that whole area has been improved as an infrastructure – the research" (Interview 1).
6.2.6 Current Educational Developments

Initially, the industrial base was low and so the requirements for training were estimated to match a simpler working environment. "There is a base now, you see. Industry was an unknown quantity when I was coming out of college but now, there is probably a whole choice of jobs" (Interview 13).

"There's much greater availability of electives and choices so you can do language options with your engineering degree or you can avail of entrepreneurship modules and there are university wide modules that students can choose. So it's much more toward that model of catering for diverse needs" (Interview 6) and "On-line learning is in there and the whole CPD (Continuous Professional Development) and lifelong learning" (Interview 6).

Respondent 15 pointed to our obsession with getting qualifications and that this was not in line with production of "Silicon Valley" type of entrepreneurship.

"That's where we are fixated on the qualification. I must get that qualification. Now we are starting to see movement on the lifelong learning. A lot of places, like the Institutes of Technology more so, are providing more evening classes and things like that. I think the MOOCs (Massive Open Online Courses) will shake them up a bit" (Interview 15).

Further challenges are ahead in developing technical education in line with lifelong learning and on-line learning. However, "Our challenge is to produce people with open minds" (Interview 13) and this respondent also indicated the need to move with the times for education. "The thing that we need to watch most carefully is that you can't keep producing the same engineers for that business because the future is uncertain and it's full of opportunity". The IDA respondent pointed to flexibility as the key attribute but also warned of the dangers of subjecting education to the demands of industry.

"And there's a big danger for colleges and for economies to try and second guess what will be needed in five years' time. Companies have the luxury of changing that goalpost... So companies have that luxury to be able to say 'Oh, you need to produce this and you need to produce that'. Colleges need to produce people that know how to be flexible" (Interview 2).
The data contains references to the low level of technology in the early days. There were few places on the existing college courses. There are references to borrowing of equipment or donations of equipment from industry. This contrasts strongly with one respondent’s reports of looking at software research in Irish universities around 2000 and finding that some was beyond what their multinational needed or industry required.

"And we looked at the work that was going on in Limerick... and said that’s a bit too far on the academic end. And then we looked at some of the stuff that was coming out of Trinity... I actually went and met with a couple of those guys and then they all left and started a company” (Interview 10).

6.2.7 Potential Inhibitors to Future Industry Development

The problem with Mathematics was mentioned by many respondents, particularly those who had worked in or with third-level education. Problems with variability in points for entry to third-level engineering courses and the influence of parents were also mentioned as possible future inhibitors.

**Mathematics in Engineering**

Mathematics was mentioned as an area of difficulty for engineering students by many of the respondents. Within this group, Mathematics was mentioned on many occasions by those who had involvement with third-level engineering education. Maths is seen as a necessary tool to enable other subjects to be studied at an appropriate level. “You need that [Maths] for the other three. You need that for Electronics, analogue or digital. You need it for Control and you need it for Communication” (Interview 12). Respondent 15 believed that “if you can just do beermat calculations, on the hoof, in the middle of a meeting, you can get a feel for things and it stops you going all directions. It is just a thought process”

One respondent "got through Maths because I have a fantastic memory – not because I really understood it all and I found out later that those are very different” but other respondents found that Maths was seen as a negative factor in selection of engineering courses and in fulfilling the requirements while on the courses. Respondent 8 finds there is a weakening in Maths ability over time and “I put an equation on the board and half the
class switches off and it’s a one-line equation” and that many do not even get as far as taking the course as

“the most frequent question on the open day stand is how much maths is in Computer Science and you answer the question honestly and there is a large percentage walk away from the stand and say ‘it’s not for me’” (Interview 8).

Respondent 12 attributed weaker mathematics ability to a drop in standards with time.

“Once honours maths went out as a requirement, and by the way, honours maths has been diluted three times in my family’s lifetime. I’ve had kids in the secondary school for... seventeen years and in that much time the standard dropped three times” (Interview 12).

He pointed to a rapid expansion in the number of places which was driven by Government and Industry and the points dropping and “the standard coming in was so low that the maths guys can’t bring them to the level that they need and, of course, what we have is a pass degree”. This corresponds with the comment by Respondent 8 in a class where the points range was large for course entry,

“But I suppose I would be talking about the bottom end of our class. The mathematical ability was definitely very poor and part of that is a general reduction [in standards] and part of that is reduction in points” (Interview 8).

One respondent pointed to a benefit and a disadvantage involved in the move to Project Maths for the Leaving Certificate and the implications it will have for engineering.

“There is a move to Project Maths which means that, from an engineer’s perspective, the students are missing some really fundamental stuff going in now – matrices, differentiation, vectors. They don’t know what a vector is” [but] “the upside, the Project Maths students now, if you give them a problem, they’ll have a go at it using what they know, whereas in the old rote system if it didn’t fit they wouldn’t do it. So at least we have moved on from that” (Interview 15)

and he pointed out a change where “A big improvement that nearly all the colleges and institutes of education have made, is in the first semester, they do something like creativity or bridging studies for maths”.

However, Respondent 8 believes that there is
“a large percentage of students who think they can’t do mathematics or else don’t like mathematics or else genuinely can’t do mathematics that are completing their Leaving Certs at the moment” (Interview 8).

Respondent 7 indicated that this is not a uniquely Irish problem.

“There is all that concern about ...not enough of the kids are doing maths and the science subjects and all that now but that’s a concern ...almost a concern about the western world. Every one of the countries has that problem, including the US. And the US the way they’ve handled that problem ...they’ve encouraged students from Asia and you know around the world, to come to the States and they do their degrees and..., some percentage of them carry on and they end up living in the States. They stay on and never go back to their own country and that’s how ... they’ve resolved that issue. And we probably wouldn’t have that option so we probably have to get more of the kids into the Maths subjects” (Interview 8).

Related to the Mathematics is the CAO entry points required to do engineering. This has varied greatly over the fifty-year period 1960 to 2010.

**CAO Points**

“I wanted to go to UCC and study Electronics but I didn’t have enough points, or whatever, to get into the Engineering and they offered me a position in Arts and I’m the least artistic person in the world” (Interview 10). Respondents with experience in engineering education were asked what happens when the points go down for engineering courses?

“If the points go down, our experience is, an intake with lower points, they do struggle and need more bridging studies in year one. Otherwise they fall out of the system” (Interview 15). Respondent 12 commented that he would be unwilling to “foist an ignoramus” on his friends or colleagues in industry and he associated the drop in points with the push by government and industry to increase places on engineering courses.

“And I remember at the time saying, that as a percentage of the population, there are so many people that are potential engineers, the rest are wannabes and they cannot and I mean, cannot and certainly, will not, take the education. And I am not being elitist. I am just stating a fact. So either we dumb down or...sorry, we didn’t reduce down, we went up. So we proceeded to have the dumbing down now. So the average level of IQ went down and down and down. And we, I did anyway,
certainly, I fought a losing battle. I had guys that I failed..., that failed electronics”
(Interview 12)

An industry view, as expressed by Respondent 14, was quite bleak. “But to me, a 300 point engineer isn’t an engineer. He hasn’t got the capability and we did see some of them”. In the situation of points fluctuation, Respondent 8 reported that it is the bottom of the class not the top of the class that changes. “If you look at the points as well, you know, the points dipped an awful lot and have picked up again in the last four years” (Interview 8) and

“there are people who love computer science and they just want to do it and they’re not worried about what their points are, they are not motivated by that. So we have people from nearly 600 points to just got over the bar/the threshold. So as the points came up the people up at the top of the class aren’t any different than they always were. What’s happened is the weakest student is getting better” (Interview 8).

**Parental Influence**

Seven of the respondents referenced parental influence in the choice of engineering as a career. One respondent mentioned his parents’ disappointment when he failed to get points to do Engineering at university and chose to a course of study as a Technician.

One respondent credited his mother who “spotted an evening course that was taking place over four or five evenings... And I went to that. So they showed me the basics of programming”. This was an early driver for his career choice (Interview 9). On the negative side, Respondent 15 has experience of Irish mammies “on the phone... enquiring about engineering for her son. What age is your son? Eight, or What age is your son? Thirty-eight! We’ve got both and that’s not unique”.

Respondent 11 pointed to high Leaving Certificate points required as being an indicator of attractiveness for parents “I don’t know what requires the most points at this stage but I’m guessing that most parents will want their children to do that”. Three respondents (Interviews 15, 7 and 6) mentioned that the dot.com crash around 2000 gave cause to parents to advise their children against choosing ICT or computing as a career and a considerable drop in numbers doing these courses was seen. One respondent mentioned
conservative attitudes such as "parents and career teachers who still say if you have the points you should do the professions like medicine and law" (Interview 8). One man indicated that, in advising his children on engineering, he himself was unsure as he thought different colleges would suit the different abilities of his children

"The first fellow I was pretty sure that this [IoT] was the place to bring him. The other fellow I wasn’t too sure... he was a more academically capable individual, not so much hands-on and certainly had the IQ and the Maths".

It is revealing that an engineer, with experience of the education system, had trouble identifying the correct engineering choices available for his children.

The next section addresses the research requirement to identify drivers for the ICT sector.

6.3 Determinants (Drivers and Inhibitors)

The literature review, in Chapters 2, 3 and 4 focused on the theory of development of an industry and examined the Irish context for development of an electronics and software industry. A full list of the drivers, determined from the empirical data, is available in Appendix F. For the purposes of this section, Determinants (drivers and inhibitors) are subdivided into five categories: Global, National, Industry, Firm and Individual- these reflect the different environments discussed in Chapter 2. Some of the determinants could feature in more than one category. When asked to identify drivers for the industrial sector, one respondent replied that it was "very hard to isolate them... because you see you have the international context as well which is very different then to what it is now".

6.3.1 Global Determinants

Many respondents mentioned global influences. Global events, such as the opening up of new developing countries and the dot.com boom, were mentioned as drivers that were outside of our control but which had an influence. Globalisation as a process was mentioned in relation to the changes in education where modules were introduced and the change from terms to semesters in third-level education was viewed by one respondent as a form of globalisation. Globalisation and speed of globalisation were mentioned in the report Ahead of the Curve in 2004. "Ireland cannot depend on the past drivers of growth to sustain and promote further development. These drivers will have to be replaced, modified

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or reinvigorated. Irish business leaders and policy-makers must be alert to these developments and create rapid response mechanisms to defend against new threats and to exploit new opportunities” (Enterprise Strategy Group 2004, p.14).

The fact that we are English speaking was mentioned by many respondents and this is no doubt an important facet for FDI and for modern communications. The OECD (2006) reported that 32% of internet users are English speaking. English speaking as an advantage or driver was well referenced in the literature (Barry and vanEgeraat 2005; Grant 2013; Ryan and Giblin 2012). One respondent pointed to this as a declining advantage as “people are less afraid of that” (Interview 10). Foreign languages were also mentioned. The respondent from the IDA indicated that few Irish people had foreign language skills to a high enough level required for industry (localisation requires native-speaker language skills along with cultural knowledge). However, he did not see this as a difficulty as our attractive location meant that we can bring language talent from Europe. He mentioned that many new start-ups in the software localisation space would look for a mix of nationalities but that in this type of start-up, a considerable percentage of the staff would be Irish. “So you are pulling from Europe, you are not pulling from Ireland alone” (Interview 2).

Membership of the EU and being in the Eurozone were also mentioned by many respondents as drivers and accessing the EU market was seen as offsetting the small scale of the Irish home market. This more global view of markets was also vitally important for expanding Irish companies, according to the Enterprise Ireland respondent.

Overseas experience was seen as a factor in development. Many of the people interviewed had overseas experience. The GE training schemes were initially carried out in the United States. Respondent 10 reported how multicultural the early Digital Equipment Corporation experience was and how this had contrasted to his upbringing where he would have encountered very few foreigners. This openness to and acceptance of people from overseas was considered vital by the IDA respondent. Broadening of an individual by exposure to a multicultural industrial context was seen as a big positive by Respondent 6. Ireland benefitted from returned emigrants in Digital (Interview 10). A list of skilled qualified people, willing to return to Ireland, was also mentioned by McSharry and White (2000) in
the IDA’s efforts to attract Intel. The IDA respondent mentioned this also: “The cross-pollination is unreal at the moment. The number of people who have been over and back, that’s really positive for Ireland.”

The Irish-American connection was also a positive driver in much of the FDI from the United States and was mentioned by two respondents in relation to the location of EMC in Cork. It was also mentioned by the IDA respondent who identified it as a driver, particularly in the early stages of encouraging FDI into Ireland in the 1960s and 1970s. Related to this, Respondent 5 argued that management training under the American systems made Irish companies familiar with the American style of doing business. Respondent 2 mentioned that Irish people are familiar with American culture from Television and that this means a cultural understanding exists when dealing with Americans. This cultural affinity was also mentioned by Grant (2013) and Begley et al. (2005).

### 6.3.2 National Determinants

Being a small peripheral island nation with a small home market was seen as negative or a limitation. In many respects, these negatives were somewhat offset by the technological changes of miniaturisation and improvements in communications and logistics. The small open economy, while vulnerable to global changes and increased competition, was also capable of the flexibility required to suit fast-paced industries, according to Respondent 13. Another advantage of this national characteristic was that “we are a fishbowl. You know, it’s a good way of getting pollination of ideas” and “crosspollination between companies” (Interview 15). This respondent saw Ireland as good for networking because of the small size. However, scale and size were seen as reasons for a niche approach to manufacturing and for selectivity in research areas. Also, scaling for indigenous companies did not occur according to the data collected, but here, again, globalisation has meant that some successful Irish companies are now multinational in their own right.

Government policy was mentioned as a driver for the industry, particularly the policy of foreign direct investment. References were made to the supports of the IDA and Enterprise Ireland for the sector. Tax was mentioned by most respondents as a driver and was the first one that came to mind in many instances.
Time zone was a newer driver which came into play with the effects of globalisation and Ireland’s location as a crossover time zone between the United States and Asia. This driver was mentioned by two respondents. The IDA respondent said it is currently a good selling point for the IDA, particularly as they look to broaden the FDI base.

Unions were mentioned as an inhibitor, particularly in respect of the early development of the industry in the 1960s and 1970s. There appeared to be a bias against unions from the American firms in the electronics sector that came here. GE had serious difficulties when they refused to recognise the unions in the 1960s, as recounted by Respondents 13 and 14. Strikes were a regular feature on the Irish industrial arena in the 1970s. By the 1980s, Respondent 7 was informed that the factory would be shut if there was any hint of union involvement and he lived in fear of an employee demanding his rights to union representation. “No unions” was a comment by another respondent in relation to working in EMC. Respondent 10, who currently resides in the United States, gave the outside view that

“With the software world Ireland has a very good reputation of being easy to deal with. In the hardware world, there was the reputation of being a little bit unionised and sometimes having a little bit of a problem” (Interview 10).

Costs were initially a positive driver in the 1960s but this changed as Ireland became more prosperous. Where some of the electronic manufacturing had held out “longer than it should have”, eventually cost became the reason for the move of much electronic manufacturing overseas. “It went in the end for cost pressure” (Interview 6). Around the year 2000, government began to focus on competitiveness (Ryan and Giblin 2012). Wage agreements were not mentioned in the data gathered but featured in Collins and Grimes (2008).

Many workforce characteristics were mentioned as drivers - “easy to get along with”, “Good for bonding with customers”, “Can-do attitude”, “Willingness to travel”, “the ability to network and create linkages” and “employee loyalty”. Ireland’s reputation was particularly mentioned in the data as a positive driver. Also, Ireland had a reputation of being a place that “can actually do stuff” and that technically “we are well perceived internationally”.

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A more recent driver was the development of the investment infrastructure and venture capital availability. Funding was mentioned by the state agency respondents but also by some of the respondents with industrial experience, particularly the entrepreneurial respondent and a respondent who had worked in a technology spin out company. In the literature, O’Riain (2004) identifies the period around 1998 as a time when venture capital become more available in Ireland. This more entrepreneurial climate, with good start-up companies, was identified as a driver both to drive the domestic economy and as an attractor for foreign investment.

6.3.3 Industry Determinants

Many industry-level drivers were also identified within the data collected. Some comments reflected the turbulent environment of the electronics and software sectors. “Speed to market” was identified by some respondents; “the only advantage in software is time” and “it is about getting your product to market first” and also in responding to the market “so we can respond very quickly”. So the sector was very much identified as being market driven.

Respondent 14 indicated that they had survived only because they undertook continuous product development and research to continuously upgrade and adapt the product for the changes in technology and in the market. He also mentioned a unique product offering and the firm was continuously looking to add value to the product.

Vision or Ambition was identified by three respondents, one, at an industry level, one at a personal level and one, in the “Leadership for Growth programme”. Respondent 14, in an indigenous Irish company, said “There is no reason why we cannot become the next Glen Dimplex and that’s the ambition”. Respondent 13 reported that he had decided “by the time I am 35 to be managing a factory... I made up my mind and that was on a piece of paper under my pillow”. Respondent 9 indicated that ‘Aspiration’ was the first goal to be worked on in the Stanford ‘Leadership for Growth’ programme he attended.

The need to move up on the value chain became a driver as electronic manufacturing came under pressure and three respondents had experience of this within two large
multinationals. Another respondent (Irish-owned company) felt that remaining vertically integrated was a strength. He would be reluctant to split the activities even though they had expanded and had overseas subsidiaries.

**Production and Operational developments** were also seen as drivers. One respondent mentioned the adoption of *worldclass manufacturing* and Japanese techniques as a reason for success. Another mentioned Lean Manufacturing as a success driver and “Kaizen” had particularly “played a key role in” their continued success.

The types of company and *company culture* within the industry were also seen as drivers. ‘Open’ and ‘developmental’ were two words used. This was certainly the case with DEC and Respondent 10 recalled that this openness contrasted with a more restricted and hierarchical structure in other existing industries in the country at the time. These companies had good training and *management development*. Digital was a

> “very open company and I think those kinds of companies really made an enormous difference in Ireland. So it was very different than the traditional world. And Digital, the opportunity there was infinite” (Interview 10).

These new companies were then the source of management for further incoming investing companies and, in some cases, for starting up Irish technology companies. Respondent 13 commented that, during his time in GE subsidiary Ecco, “at least 50 CEOs in Ireland who had worked for me at one stage”. This shows development a capable managerial cohort who led or started up other companies.

### 6.3.4 Firm Level Determinants

Many firm level drivers were also identified in the data. Company culture was already mentioned in relation to DEC and Respondents 6 and 7 also found this to be the case with EMC. “Open” was the word chosen to describe these types of company. *Cost versus profit* was identified by Respondent 5 as the key in determining the culture of the firm. Where profit margins were high, the company culture tended to be open and progressive. Where cost was key and margins were low, the culture tended not to be so open or developmental. He differentiated between consumer electronics and components, subassemblies and full products. Companies that were supplying a complete product to the
customer tended to have more margin than the sub-assembly and component manufacturers.

“Communication” was mentioned by two respondents as an important company driver. Respondent 14 believes that it was important to communicate well with employees and particularly so, in difficult times. Respondent 6 attributed some of EMC’s success to good communication,

“you had many functions but I think the walls between the functions,...the silos weren’t that great, there was definitely a good flow of information across. You know that was just the nature of it but being close to the customer was always seen as very important” (Interview 6).

This “customer focus” and closeness to the customer was mentioned as important by Respondents 1 and 15, also. Respondent 15 recalled that Telecom Éireann were flexible and looked to match the customers’ expectations in small matters as well as big and he recalled “If their customer was calling from Germany they got a German ring tone, not Irish, and they were the little things you needed to do.”

Other firm level drivers included “hiring the right kind of people” as “people are the most important asset”. Respondent 14 indicated that they had survived only because they undertook continuous product development and research to upgrade and adapt the product for the changes in technology and in the market. He also mentioned a unique product offering and the firm was continuously looking to add value to the product.

6.3.5 Individual Drivers

“Glaine ár gcroí ‘gus neart ár ngéag, Is beart de réir ár mbriathar.”
Osborn O hAimheirgín

“Personal relationships” were identified as a key driver in many instances. Respondent 11 said “all business is personal”. Respondent 6 felt that things “happen through people and through personal relationships”. One respondent indicated that a CEO with Apple always looked for the key personal relationship within supplier companies and he asked other staff to do the same. ”Who was the number one person in that company that will be your go-to guy so when it all falls apart, they’ll take the personal responsibility and make it right for
you” (Interview 11). This also manifested in the relationship with the Irish subsidiary. “He trusts her to run the ship and a tight ship at that. She does run a tight ship up there” (Interview 11).

In the case of EMC, Dick Egan, a co-founder of the company, reported it was Larry Poland, Head of the Department of Electrical and Electronic Engineering at CIT who had a big influence on the EMC decision to locate their first subsidiary in Cork and that “personal relationships and whatever rapport Larry formed with Dick, it seemed to work” (Interview 6) and “He [Dick Egan] was very impressed with Larry” (Interview 7).

This personal relationship benefit could percolate throughout an organisation. “I saw it more in Apple than anywhere else, where the supervisors on the floor would be asked their opinion on how to do something and they eventually had a level of personal vested interest … They still worked rigidly on their hours but they were more willing to give of their time for something once they were brought into it, so to speak, … it wasn’t a them and us thing. Now we are all in this together and we have to make it” (Interview 11).

It is interesting here how a more personal relationship to the work then translated into a better team environment. This improved environment was also reported by Respondent 14 whose company “is known as a very friendly company/place to work for and a nice place to work and that's because we treat the person, very much the full person”. When hiring engineers as an Operations Manager, Respondent 7 “was always just look[ing] for more of a personality fit. So let’s say the hiring manager or supervisor, I depended on them to make sure that technically the person was actually qualified to do the job they were hired to do and I was always more interested then in ‘ok will this person fit in with the thing?’”

In reviewing start-ups to support in Enterprise Ireland, “it just comes down to those two things the project and the person”. This respondent saw a requirement for both to be evaluated. “Well, what’s the project? But the project can change and adapt and then there are the people. And once you’ve got some sense of the person, you can tell fairly quickly if they have that dedication”.

The ability to take risks was also identified. One respondent when asked about his career
compared himself to a classmate who had joined a semi-state company directly out of college and had also been extremely successful in his career but "he never met Steve Jobs" and he indicated that industry was, to his mind, the more exciting career choice. One CEO indicated that he had come through the multinational experience but, he had "taken a chance and gone off and done something uncomfortable ... It is easy to take the next easy shilling and go in and work"

6.3.6 Technology Determinants

The developments in communication and the speed of communications were identified as a "huge enabler for industry" by Respondent 15. In the late 1960s, one respondent "began doing this switching for ordinary telephones as well, using solid state instead of the ...relays because relays began to cost a fortune because of the copper". He recalled working in a rural IDA start-up in the late 1970s when the phone system still required an operator. The operator "was listening in to every word we said". He told the story of getting a tip-off from the operator when the boss was planning a surprise visit and not telling them in the factory before-hand. The operator had heard the call he made to book accommodation but was surprised that there was no subsequent call to the factory to let them know he was on the way. Respondent 15 described adapting the telephone system in Telecom Éireann to adapt to the needs of incoming call centres in the late 1990s. Respondent 9 indicated how business was global in the software space and that communications meant that overseas partners could be found without the need to travel and meet in person.

Alongside this, technology drove improvements in logistics and delivery mechanisms. This was an inhibitor for manufacturing but a driver for the more knowledge-intensive software and services which could make use of newer business delivery mechanisms. "The tide, once computers went to laptops, Limerick [Dell manufacturing] was always under pressure because the shipping costs just weren't high enough" [i.e. it became cost effective to ship to Europe from outside of the EU] (Interview 2).

Legislation and regulation were drivers for one company. The introduction of regulation in a particular area gave their product the means to avoid becoming a consumer electronic product, susceptible to cost competition from overseas. Alongside continuous upgrading of
functionality in the product, to meet modern market needs, the product was also differentiated by quality and, by the service offered in supporting the product. As the product was a life-safety product, this combination turned out to be a winner for this company. Regulation and standardisation were notable features of the technology industries and had caused large effects in the PC industry, networking and telecommunications sectors.

High quality product was also identified as a driver. High reliability and stringent testing were mentioned as drivers too. These were perceived as being more important in certain applications, and in hardware more than software. “The cost of screwing up and being late is really, really bad. So the hardware people have built methodologies and, particularly, simulation and testing” (Interview 10). Respondent 14 found the testing of software for reliability a particular challenge.

“it’s a scary thing in our product because we are in a life-safety thing. In a hardware-only solution, well if the hardware is designed and tested properly it will survive. If you have a bug in the software programme and suddenly after five years the [product] shuts down, because it comes across something in its life - business wipe-out type of thing. So software scares me from that point of view” (Interview 14).

This contrasted with the early days in Teletron where Respondent 12 reporting testing for “noise. ...we had no way of testing these kind of things but what we knew was, if we bring a radio in, an AM radio, and put it on the longwave, right, and go walk into the room, put it down, have something on, a bit of, news or that – and turn on the power supply, turn off the power supply. Oh, s***! Right, a perfect test” (Interview 12).

He did state that before product release the product was noise tested “rigorously” using the appropriate noise detection equipment. The IDA respondent identified quality as an important driver for the Irish manufacturing space. One respondent compared the telecommunications sector with the computer sector and found that the difference was “reliability was just way higher. You lift off the telephone, you get dial-tone – end of story”.

Reliability was also an issue for EMC who were competing against IBM in the electronic
storage market and

"so the testing that's done is very extreme. So that's what we were doing with EMC. But that was also because our huge competitor was IBM and you know the thing in the industry is 'nobody ever got fired for buying IBM'. So the EMC sales guy going in, had to try and convince this customer that he wasn't risking,...his job by buying EMC and so the reliability was huge. So, there was the performance of the product, that it had to be twice as good as IBMs product and then just quality and reliability had to be - that it wasn't going to break down at some critical time for that customer" (Interview 7).

To get this level of reliability "the testing was extreme" but eventually the move to outsource for cost saving came in here too. Cost overtook these drivers and resulted in the moves to off-shoring and the advent of the value chain approaches.

R&D – Research and Development

The incorporation of research and development in the industry was also seen as a driver. R&D “is in the blood” (Interview 14). This respondent saw it as a vital ongoing process without which they would not have survived. "As our features are equalised, obviously the prices are eroding and that's where the pressure is on R&D to be ahead on the next feature. So we are constantly looking for the next thing to be ahead on and we have done a bloody good job of it over the years". Respondent 3 compared a research environment with the industrial environment.

"The Apple experience was completely different. I worked in a very small Irish research type company which, I only realised later on, didn't really grow people very well. [It] didn't give people responsibility and authority or didn't allow you to make mistakes" (Interview 3).

The Enterprise Ireland respondent reported that "If you look at it from a research perspective, there has been a huge amount of funding gone into research over many years". This indicated an ongoing importance of R&D, as identified by the government. However, he pointed to a low starting-base here also and that development of this base had taken time and was currently situated in the measurement of outcomes in the form of spin-outs.
“The debate sometimes about the research agenda and the research we have now is usually linked out to spinouts. But we didn’t actually have a research, a sufficient research environment/mass for an industrialised nation twenty years ago or thirty years ago” (Interview 1).

He pointed to spin-out companies being used as an indicator of successful use of research funding but also

“from the start-up perspective, it’s important that that capability, that funding is in place, not only for the start-up but to facilitate IoTs and third-level generally to reach out to companies at all stages of development” (Interview 1).

Appendix F has a list of drivers found in the empirical data and the interviews in which they were found. Where possible these drivers are linked to the literature. The next section identifies development trends and then reviews the data to see if any possible critical realist mechanisms can be identified. This meets the requirement for this study to identify trends in the data.

6.4 Development Trends

Some managerial and social development trends appear in the data collected. Some, such as the move to the value chain and the development of Irish management expertise, have been discussed in the previous sections. Some other trends identified are reviewed below.

Firstly, twelve respondents with direct ICT industrial experience were interviewed. Of these, eight had changed function out of direct engineering roles in industry and were working in other related areas. Four respondents were working in the third-level education sector and four were consulting and/or mentoring businesses and start-up companies, as part of their current activities. One respondent had taken up a role in a national engineering organisation. This would indicate that where engineering is often a starting base, other opportunities may offer advancement or greater perceived benefits to the engineers at later stages of their careers.

“The first 25 years I was in Multinationals, came back from the [United] States and then became involved in helping Irish companies. And then, the most exciting phase was the last ten or fifteen years – helping Irish software start-ups.”
6.4.1 Perceptions of Education

There appears to be a change in how education is perceived now as opposed to in earlier decades. In the early 1960s, where numbers attending third-level education were low, one respondent “would have become an engineer himself, an electrical engineer, by winning a scholarship to UCC and that’s the only way he could do it” (Interview 6) but according to Respondent 12, there was a more relaxed approach to results than is found with the points race of current times.

“You weren’t worried. All you had to do was get honours. There was no good getting 90%. There was no good getting 100% or anything like that” and “you do exams – that’s it. Big deal! They weren’t any problem” (Interview 12).

Devaluation in perception of examination achievement which includes the Leaving Certificate and also higher educational levels appeared in the data. “Now when I did my Leaving Cert, if someone got an ‘A’ there’d be a halo around them. Now you know, ‘A’s are ten-a-penny” (Interview 15) and at third-level “PhDs are ten-a-penny now” (Interview 12). Similarly, from the same respondent, concerning falling education standards, “we are now talking about building on a bit of sand really. Okay, the smart guys, they will go off and do a Masters. A Masters was a huge thing to do in my time” (Interview 12).

Perhaps the introduction of free education and the increase in expectation of studying to third-level has led to academic achievement being viewed with less respect. In contradiction to this, Respondent 15 felt that Irish people placed too great an emphasis on getting a qualification and “that’s where we are fixated, on the qualification. I must get that qualification”. This would appear to indicate that while there is a drive or feeling of necessity about education, this same education is not, perhaps, as esteemed as it had been in previous decades.

6.4.2 Employment – Job-for-Life versus Tour-of-Duty

Respondents appeared to have a strong emphasis on “finding a job” and engineering as a means to being employable. This appears to have shifted to a mind-set of “skills” and accumulation of “transferrable skills” necessary to meet the needs of software and
networking companies of the more recent decades. It could be described as a shift between working up in the job and walking in to the job with a skillset. Where GE and DEC were good for developing their people, now “People [employers] want them oven ready, I suppose, work-ready” (Interview 15) and “the ideal type of employee would be a self-destruct employee, that after about five years [they’d] self-destruct” (Interview 13). The IDA also changed the goalposts away from jobs to wealth creation, as referenced by the literature in Chapter 3.

Respondent 2 indicates that the fear of losing a job was a big driver for Irish people. “You lose a job it’s a big deal. Getting another one isn’t that easy” in comparing Irish people to other nationalities, the cyclical nature of the economy and the industry appear to have had an effect. Where this attitude was seen as an advantage for Ireland by the IDA Respondent, another respondent felt that this type of perceived “instablility” in jobs in electronics and software where

“From a job perspective, I mean that’s the reality, the industry has the ability to be very agile, cause it’s driven by market needs” and that “To articulate that mind-set as a point of attraction is quite difficult” (Interview 6).

After graduating in the late 1980s, Respondent 6 felt that “We came out looking for jobs and the conditioning by parents and by career guidance teachers is about what job you can get, not about what job you can create” and talked about “the imperative of being able to get a job”. When Digital and Amdahl were shutting down

“they were just shedding people. And I landed back in Ireland right at that time. So ... I was looking for a job for probably a good six months. I was unemployed with a PhD in my back pocket and my international experience and everything else. And that was a hard time now, I must say”,
Respondent 6 admitted.

In general, the job for life has been replaced.

“The idea of being in EMC for thirty years – that’s kind of gone. What you’ll find is you’ve an executive that has been in EMC for a while, they’ll pop out to something else... They might have three or four things on their CV. So they are way more attractive” (Interview 2 – IDA)
but on the other hand Respondent 11 knew one lady who had made a thirty-year career in Apple and had started as an operator and worked her way up.

“However, I think if you are a person who can adapt with the changing times in a company and you bring a company along with that, you can have a job for thirty years. However if you are going to get stuck in and set in your ways and say ‘Well this is the job I came in to do and I am not going to do anything different’, that’s it, you are never going to last”. And Respondent 3 reported that “And I have always felt like that about working life, that when it’s time for a change you move on” (Interview 11).

With this change, the drive for companies to do their own training appears to be diminishing so the level of duty of care of an employer to the employee has changed and appears to have shifted to the third-level educational sector.

6.4.3 Individual versus Teamwork

Respondent 12 indicated, at the end of the interview, that to him the biggest change in engineering over his career was in the shift in emphasis from the individual engineer to teamwork and teamwork skills. He indicated that, at the start of his career, problem solving was trusted to the individual engineer and, while he reported getting great support from colleagues, the ultimate responsibility to get the job done rested with him. He thought that, nowadays, greater emphasis was placed on teamwork and commented “You don’t have to be able to do it yourself, you only need to know somebody who knows how to do it” and this point was also made by Respondent 4,

“20 years ago they might have built a prototype you know. They might have done the hard-core stuff. But then they started to do, what I consider, think smarter and that’s where they would find somebody to build that core for themselves and pull that design together” (Interview 4)

Respondent 14 felt that there was a reduction in the level of ambition in young people starting out and stated “I think the things that we find hard to engrain into people are the energy and drive that I think was there in my era. They seem to be … not as ambitious maybe” and he described regularly checking in with his manager to see what opportunities were coming up, for which he would be eligible to apply. And he stated that:
"We have managed to pick up the right kind of people along the way, but we would still be thin on the ground on management and leaders and are constantly looking for those people, you know, to get the next generation through and it’s probably one of the disadvantages of being so lean as well. We haven’t had the next layer coming along … but, as well as that, we are hit by this lack of drive and ambition in younger people”. Also “we have guys who are well experienced engineers in manufacturing and design and so on but … no ambition whatsoever to take on people responsibilities. They run a mile from it” (Interview 14).

This raises the question of whether there is a trade-off between individual ability and team skills. Are team players less likely to be personally ambitious and try for leadership positions? Perhaps, however, these leaders have taken the option to try for the entrepreneurial start-up companies and are less likely to be found in Irish manufacturing industries?

The emphasis on teamwork was mentioned by Respondent 6 in relation to a major multinational’s hiring policy:

“he [the General Manager] took on people who played team sports … they will work together as a team in the workplace. They’ll be used to give and take, coping with disappointments, dealing with success, playing a role, competitive instinct – there’s so many things there and it really worked” (Interview 6)

and similarly, Respondent 8 found, working in an IC design start-up company, “Very exciting industry, super team and really very good opportunities. It was around the time of the dot.com boom” (Interview 8).

Also, Respondent 2 mentioned teams in relation to moving up the value chain “How do we get another function in here and how do we do that as a team. So it’s the idea of working in a team”. Teamwork in education was referenced by Respondent 8

“we had a final year team project in UCD … but you really don’t do a whole lot of working properly in teams and it is great to have done some of that before you graduate because when you graduate is when you make your first life decision”(Interview 8).
Respondent 13 felt that Irish teams were hard to beat and that “I’d much rather be hiring a team in Ireland. I could hire a team in Ireland that would match or beat anything I could hire in America”.

6.3.4 Was there a Change in Confidence Levels?

There were mixed opinions about the development of confidence. Some felt that we had grown in confidence as a nation. “I do see a change over time where Ireland seems to be thinking a bit bigger” (Interview 11). This respondent felt that “something had clicked” and that a kind of “get-with-it” thing had occurred within the previous decade. It was echoed by “I’ve definitely seen a big difference. People are thinking bigger” (Interview 4).

Respondent 14 found we lack confidence in ourselves as a nation. “We are a small country and I believe we don’t have enough confidence in ourselves, you know. That’s fundamental.” He believed that this was one reason why we are so determined to hold corporate tax low,

“I think [where] government policy could be different is on the much talked-about corporation tax. I think we could be at 15 or 20% and still be competitive because we’ve a lot more going for us and that’s where we are back to the confidence of what we are. We seem to doff the cap to the foreigner and give him the cheapest thing” (Interview 14).

And also, in the area of manufacturing, he felt that there had been a general loss of confidence as “Software was put too much on a pedestal” and that this confidence needed to be regained in manufacturing.

Respondent 15 identified the late 1980s as a confidence turning point. He identified a confluence of development across the various sectors of education, country finances, industry and skill built up and other intangibles such as:

“in 1988, the Euro [football] finals and you know, you can’t underestimate, that does lift the mood and a lot of it is confidence. You talk about market sentiment and market confidence, consumer confidence and that’s what they are, they are intangibles. But they have an affect and now you pull all those together and I think that’s what brought us into the 1990s” (Interview 15).
An improvement in confidence in later generations was identified by Respondent 2. "So I wouldn’t say Irish people are the most confident. Now, I do think there’s a generation, younger than us all at the table, that I think are very confident and I would be very hopeful that they will have changed that attitude" but he did admit that this developing confidence had taken a knock after the dot.com downturn. However he also said “But the youngsters that are good now are so much better and more confident and way more”. Respondent 8 also mentioned confidence in relation to students but in this instance he was pointing to a cohort in more recent classes which had a high level of confidence that was not matched by substance or knowledge content and he pointed to a change from his day,

“whereas I think going back to when I was coming through, it was the other way around. We were scared to look our lecturers in the face and … we didn’t know what to put in the slide and but we actually, our content was good, you know” (Interview 8).

Entrepreneurship has benefitted from this increased confidence according to some of the data.

“But I think we are educating a generation that at least will have the confidence and the wherewithal to spot a gap and know how to go after it. And I think engineering is good for that. ‘There’s a gap now. I want to fix that.’ I mean, I have looked at a lot of projects down here over the years and there would have been some amazing ones” (Interview 15) and

“I think there is this new trend where people are much more willing to do that. And I think 20 or 30 years ago, people wouldn’t have done that. I think they would have looked for the job from somebody else. ‘When are you getting me my next job’ and ‘What company are you bringing in now? What company are you stopping from leaving the country to give me my job?’ Whereas I think people are much willing now to [say] ‘yeah, I can make jam so I am going to make a jam company’” (Interview 11).

However, according to Respondent 6, there was still progress to be made in changing attitudes around failure. He stated:

“And that’s the whole thing about Ignite [incubator centre], for example, if you
don't succeed, it's part of the process of becoming successful. There's huge learning in that and it's ok and it's fine and it's part of the process and you get there. But I think in Ireland, I think there's more to be done to create the conditions for successful business entrepreneurs and ... I think there are many organisations working that way but I think there's a ways to go” (Interview 6)

He made reference to a successful technology start-up that had relocated to the States and he queried why in a modern age of communications they felt this was necessary for their business.

The next section looks to see if any critical realism mechanisms can be proposed.

6.5 Possible Critical Realist Mechanisms

According to critical realism, mechanisms exist in the domain of the real which underlies the empirical and the actual domains. The actual domain is where events occur which are driven by underlying real structures with their associated mechanisms. These mechanisms may or may not be acting, depending on the state of other mechanisms or conditional circumstances. Figure 6.3 reprises the diagram of a mechanism from Chapter 5.

Figure 6.3  A critical realist mechanism – a reprise

This section reviews this study's data with a view to identification of potential mechanisms, per the final research question posed in this study.
6.5.1 Demonstration Mechanism

"When people are free to do as they please, they usually imitate each other"

Eric Hoffer (1902 -1983)

The data in this study has pointed in some instances to a demonstration effect mechanism. Where, trivially, this may be expressed by the expression “nothing succeeds like success”, this perception of success driving other successes was found. Nowhere was this more evident than in the data collected from, and about, the IDA. Respondent 13 had an overview from the early 1960s, and he attributed the success of a small country in the development of the ICT sector to “that ability of the IDA to build on success stories” (Interview 13), a plus point in selling Ireland as a location. The IDA reference sells for this very reason.

“In the IDA] We reference sell all the time. There’s a reason there. We want people back in Silicon Valley being very, very clear that Facebook, Linkedin, Google, all these companies … are in Dublin. So that when they look at Europe, Dublin forms part of that due diligence straight away” (Interview 2).

He did state that this was the foot-in-the-door step and much work had to be done subsequent to this to get a company to commit to an Irish subsidiary. This respondent also mentioned that “There are very, very few executives that are brave enough to go out and do something new because they have to go back and sell it to their board” (Interview 2) and this ability to point to well-known competitors who were already operating successfully is a huge sales aid for the IDA. This Respondent was celebrating winning a successful new technology company for Limerick and pointed to a herd mentality. This announcement would

“satisfy the politicians but also satisfy our targets. But the other side is, the next person that’s selling Limerick will have a much easier time because of that company going in. Because the herd mentality is going to kick in” (Interview 2).

At a personal level, a success demonstrator mechanism was reported by Respondent 11.

“[The] IDA board came to Cork once and they were meeting all the companies in the area. … I had become an EI [Enterprise Ireland] mentor. The background that I had come up through all of this, and was well known and trusted by them and now I
was the Chairman of the Board of [a Telecom Start-up]. And [this company] had just raised €15 million in funding and was going to be the bright new future. And we had really got the best venture capitalists in the world. And that was a success story. It was where my kind of experience, helping young people who didn’t have [it] … we raised €30 million in venture capital funds in [the company] and spent it all.” (Interview 11)

A demonstration effect mechanism can also work in the opposite direction. This is in line with a critical realist view that the operation of critical realism mechanisms depends on the other conditions present as to how they operate. A demonstration mechanism appears in multinationals’ choices to outsource and off-shore value chain activities which had a negative effect on manufacturing. Respondent 11 reported that, in Apple, the fact that other people were outsourcing appeared to have an influence on Apple’s choice to outsource also and this led to their printed circuit board-shop being shut in Ireland.

“We started seeing it in I suppose in about 1992, you know. You look at all the other companies and you realise – all these guys, they are not making stuff. Everybody else is making it for them. Everybody else is going to China or Taiwan. I remember even going to Vietnam to have a look” (Interview 11).

This respondent also stated: “Well what is everyone doing? Everybody is outsourcing all their manufacturing – oh Jesus, we better do it too” (Interview 11). As Respondent 7 recalled, “there was this mad rush that everything had to be … outsourced to China. And I was arguing against it, this business of 100% outsourcing and putting all your eggs in one basket over there.” This ultimately resulted in many multinational subsidiaries losing manufacturing to other sites in Ireland.

Porter (1996) recognised that strategy development in business where uncertainty was high, due to the rapid rate of technological progress, could lead to imitation and hedging by companies. This was particularly the case in high-technology industries where this imitation period often lasted longer than it should.

6.5.2 Patriotism Mechanism

In discussions about the start of the industry and how it began, patriotism appeared to feature in some cases. Respondent 10 reported that on a visit to Taiwan he was reminded of
the early days in Digital in Ireland

"the technical people there and this was Taiwan, it wasn't mainland. But they were phenomenal and their focus, they knew. And it reminded me a bit of early days.... Ed had a tremendous pride in being Irish and he wanted the Irish plant to be a showcase for Digital. And it was really important and the work had to be done right because we were Irish and we did it right and that was really important" (Interview 10).

Respondent 12 reported being delighted when they successfully tendered for a Telecom job in the UK where there was a major error in one part of the specification data. While he suspected there was an error and pointed it out, management asked him to see if he could meet the specification as published and he did. On inspection by the dubious customer who had since realised the error on the specification, this Respondent enquired if "they told you the Paddies were bluffing", which they confirmed. He took great pleasure in showing them that "the Paddies" weren't bluffing. His company was delighted when they subsequently won that tender although he ruefully pointed out "We didn't get the next one".

Patriotism was used in the early days of the IDA to motivate its staff in attracting jobs to Ireland. "Killeen's pursuit-of-excellence also reflected a strong sense of public service. He viewed the IDA's industrial development role as a form of practical patriotism" (McSharry and White 2000, p.194) and later, when Padraic White was IDA director, he also referenced this patriotism driver. "A competitive nationalism has been part of the organisation's success from day one. IDA staff talk of playing for Ireland against other countries, and during the difficult, recessionary 1980s, I encouraged the staff to recall that they were serving the country, not just holding down a job" (McSharry and White 2000).

A type of co-operative patriotism which operated between Irish management of multinationals was described thus:

"even in EMC, but before that, in Wang, we had this kind of understanding with management of other multinational companies around the place that even though we competed at the global and corporate level, that at the Irish level we could all, kind of, co-operate and help one another. But that was an unwritten kind of agreement. It was just an understanding" (Interview 7).
A similar form of co-operative patriotism was reported by Respondent 2 who described one multinational who has

"a couple of different functional areas. They don’t have a site lead, a traditional manager lead. Each of the leads, in the verticals, report straight back into the US. So basically, over time, they had two issues. Firstly, if this person here had a problem it was going straight back to the US. Secondly, if there were opportunities over here, this person here never heard across... So they decided... we are going to talk before anyone reports back up. If there’s a problem here then let everyone here come together to solve that problem because whether it impacts on me today, probably no, but if [company] becomes a site where there are problems then it’s not good for any of us “ (Interview 2) and “Problem sites get shut down” (Interview 2).

The IDA also tapped into this unofficial network according to Padraic White of the IDA “And they relied on friendships with local managers of foreign industries to give up some of their free time and join in the selling effort for Ireland over lunch or dinner (McSharry and White 2000). This was corroborated in the data collected where Respondent 12 recalled going out to lunch, with the IDA and the head of his IoT department, to meet with prospective industrialists. This cohesion of purpose was also identified in the Telesis Report (NESC 1982). “There is undoubtedly in Ireland a degree of common purpose regarding industrial development that is rarely found in other countries” (NESC 1982, p.27). These quotes indicate that a mechanism is operating for a greater patriotic good amongst the drives for individual and company success.

Respondent 14 recounts how he chose to stay on and fight for his company when it was threatened with closure. When asked why he would do this when he had the option to move on, he stated,

“I could have walked out of it. I was an MD. I was a well-qualified engineer. I could have walked out to another multinational, no problem” but “my motivation really was the people here” and “I felt I had a responsibility, as the leader of the operation, to try to keep it open. I really felt that I had a duty to these guys” (Interview 14).

He was critical of the entrepreneurial start up culture where
"there's far too much prevalence of people who start a business, they get great support in doing so, they bring it to a certain level and then they take the fast buck and they are gone...and then the Americans come in and they buy up the thing, they close it down and it's gone and it's a big loss to the country. I think we have to install a bit more patriotism in people for a start, but I don't know how you can do that" (Interview 14).

He wondered whether there was a means where these successful start-ups could be held in Irish ownership.

"I think we have got to try and maintain our businesses in Ireland and stop this quick buck. I think the government can definitely, if they can give entrepreneurs a break that they can realise some of the value of their business without selling it out, whether that's through making it easier to list on the stock exchange or giving whatever I don't know" (Interview 14)

Other respondents were of the opinion that when entrepreneurs sell up they often start other businesses and that there is no loss to the country in this.

6.5.3 Technology Mechanism

In the data collected, many people pointed to a technology mechanism whereby what we can do is continuously extended by technology but alongside that our understanding of the workings behind that technology appears to reduce. Expressed more simply, we can do more but know less, or we understand less about the workings of the technology that we use as the complexity and functionality of this technology increases. This translates into the user rather than doer culture. "Technology, from the coming of the electric light to television, was something that happened from outside, and to which one contributed little beyond consuming its products" (Lee 1989).

Early technology was accessible. It was hands on and visible. With miniaturisation and the ability to fit more functionality onto a single IC, this discrete, accessible nature disappeared. Technical information about products was readily available from manufacturers in the 1960s but this no longer appears to be the case. Respondent 12 has noticed a change in the availability of technical information. "Now okay, we did the internet and I looked up everything I could but .... The crowd that made it, they wouldn't give me a
circuit diagram. They wouldn’t give me anything” (Interview 12) and on another repair he found “a 300 page book of instructions for it. It’s amazing! You actually can’t get the circuit diagram of a television nowadays” (Interview 12).

On trying to repair a welder he also hit a blank wall in trying to get a circuit diagram from the supplier but with his experience

“again without a circuit diagram and I could reverse engineer that totally”.

Sometimes, “people in England will give you information. They’ll say ‘oh yeah’, and especially if I get a guy my own age, well sorry, a guy, an older fellow that knows back, the good old days, that’s used to having these things …they’ll send you the information and they’ll say ‘look’, they know you are fixing one of these things. You are not going to put them out of business. You are not going to do anything to them and that you’ll … well fix it as well, like you know, whether they give it to you or not” (Interview 12).

Respondent 9 wanted to adapt software for his application and contacted the company who refused to give him the information he requested on the basis that “it’s our IP and we are not going to give you that”. Respondent 9 figured it out anyway and “in three days we had it done”.

Respondent 12 distinguished between a user and a more fundamental understanding that is often required to solve problems,

“…the people who are educated to do the macro and use the equipment, very often have no more education than how to use the equipment. They don’t understand what it does. And they don’t understand how the thing they are examining works and that’s why they need this equipment. Okay, so they are not going to question their test gear” (Interview 12).

While Respondent 12’s descriptions were mostly about hardware, other respondents spoke similarly about software. Development systems now allow software development by learning how to use a software package such as Visual Basic (VB). A software entrepreneur stated,

“The problem with the VB programmer and the problem with some of those programmes and prototyping stuff is they [users] don’t understand what’s going on

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beneath and they'd be able to do standard basic stuff but with anything complicated
it's a muck. So you will not be able to build a solid performing system with that
mind-set. So you still need technical architects and that technical architect's role is
still [of] key importance to get the best out of systems” (Interview 9).

This corresponded with Respondent 8’s comment about some computer science students:
“But the thing is that, they are producing software that they don’t understand and
because they don’t understand it, it doesn’t work properly and they never, they
don’t have the capacity to fix it because they don’t understand it” (Interview 8).
Respondent 8 pointed out that this was a percentage of the class, not all students and that
“It is graft, it is work. The good ones do it, right. The good ones do the work,
understand the stuff and deliver good quality software” but “the problem is there’s
a large percentage not doing the graft and just skimming along the whole way
through” (Interview 8).
The proliferation of information that is now available via the internet may well be making
this skimming process easier.

User sophistication but technical ignorance gives rise to difficulties in understanding when
choosing to study in a technical area.
“What is very hard to explain to people is the gulf between being a computer user
and a computer programmer. So they are all computer users now but they don’t
know what a computer programmer [is]. So I think that is part of the difficulty to
sell – they don’t know what computer science is” (Interview 8).
Respondent 15 echoed this thought also.
“And I think there is a world of distinction where people lull themselves into, and I
think people become somewhat disillusioned when they go to do computing courses
and realise that programming is very different and you need formal methods and
algorithms” (Interview 15).

According to Porter (1990), it is the capacity to deploy technology and not mere access or
use of technology that leads to competitive advantage.

The research questions have now been reviewed in the light of the data collected. The next
section looks at some emerging themes in the data.

6.6 EMERGING THEMES IN THE EMPIRICAL DATA

This section looks at emerging themes in the data. The first of these is a brief exploration of the characteristics of an engineer. Then some reasons why the respondents in this study chose engineering are reviewed. There follows some of the opposing discourses in talking about engineering and engineering as a career which can be seen as emerging themes from this study.

6.6.1 What Characteristics make an Engineer?

In a search of the interview transcriptions, the following words all occur alongside the search word “engineer”. They are not listed in any particular order: Manufacturing, nanotechnology, quality control, principal, qualified, good, complete, dumb, electrical, electronic, reverse, professional, production, design, test, chartered, supplier quality, hands-on, clever and smart. Also in reviewing the data collected, people considered the following attributes as being identified with engineering. Solving problems, way of thinking, discipline, very risk-averse, flexible, adaptable, skillset, academic, logical, analytic, good at math, see problems, diligence, ability, mental prowess, naïve, skilled and enthusiastic. These words are illustrated below in Figure 6.4 in a word cloud (generated using Wordle format).

In the early 1970s, Respondent 10 had qualified as a Telecommunications Technician with a National Certificate and Diploma in Electronics and “had [used] a PDP-8 or something but there wasn’t [any] real computers [there] so I hadn’t taken any formal programming” but he found “the course was a fabulous introduction for what I ended up doing in DEC”. This respondent recalled seeing “the fellow in the radio cabin or the engineers [on ships in his hometown] with all these amazing boxes with knobs and switches and I wanted to be that guy”. He also recalls building his own radio as a young teenager “We bought a valve radio from someone called HAC, which was an English company, and [we] soldered it all up and we built all that stuff”. 238
In the early 1980s, one respondent chose engineering “prompted by a lack of knowledge of anything else... I was 17. I wanted to do something new and different. It was about that, honestly”. At that stage, the engineering degree in UCG was in its second year of existence and was prompted by the success of DEC in the area (Interview 3). Respondent 4 believed that the few people who did engineering from her school had grown up “in environments where there was a family business”. By contrast, Respondent 9 “started programming when I was twelve” even though “there was nothing in school” to support this interest. This respondent recalled

“my father used to have war with me about it... but I wasn’t playing games”. He persevered writing code and “was looking at other people’s programmes and what they wrote and how they did it and solving certain problems and I used to read books and magazines so when I went to college, they were putting names on all the things that I had learned from other people’s systems” (Interview 9).

Two respondents indicated that they weren’t particularly good students which is supported by their evaluations “I was a mediocre student” and “I mightn’t have done well marks-wise because I would be in the library learning the stuff that I was interested in and not always the stuff that was on the course”. This does not seem to have hindered their subsequent careers as one worked for multinationals in Ireland and in the US and one followed his ambition to develop his own businesses and became an entrepreneur.
Two respondents pointed to a gender difference in selection of engineering.

“Some boys know they are going to be an engineer from the time they are five and it’s the path they go on and they are pulling things apart and they are interested.

But girls don’t tend to have that same drive” (Interview 13)

and in the realm of science

“the girls end up gravitating to Biology and that sort of stuff” (Interview 10). He described trying to encourage his own daughter to try electronics but discovered that “she’s not as excited by a flashing light as I am”.

One lecturer believed that currently “we get a lot of students that want to do something in computer games and get drawn into computer science because it is related to the X-box in some way”. The next section looks at the working environments found by the respondents.

6.6.2 ICT Working Environment

Table 6.2 summarises brief descriptions of the working environments found in the data gathered. There appears to be a mix between positive and negative attitudes: a balance between the pressure of a fast-paced environment versus the relishing of the same thing.

Table 6.2 ICT Sector Environment

<table>
<thead>
<tr>
<th>Interview</th>
<th>Time</th>
<th>Descriptions of the Sector Environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>11</td>
<td>Early 1980s</td>
<td>“everybody was leaving or sick or not taking anymore” in Northstar</td>
</tr>
<tr>
<td>14</td>
<td>1980s</td>
<td>“there was this never say die spirit about the place that I bought into” in EI and also “the job was survival” and “it was always in closure mode that we were going on”</td>
</tr>
<tr>
<td>2010</td>
<td></td>
<td>“We know our people and we do take care of the full person, if at all possible” and “a very friendly company”</td>
</tr>
<tr>
<td>5</td>
<td>1980s</td>
<td>[Logitech] was not as supportive a workplace as DEC had been</td>
</tr>
<tr>
<td>13</td>
<td>Career from 1960s</td>
<td>“I rode that wave. It was skiing downhill and it still is exciting” and “…rate of change and that is the thing that sets apart a career in electronics. That all my career, from day one, the rate of change has been phenomenal”</td>
</tr>
<tr>
<td>7</td>
<td>1970s</td>
<td>“he came under such pressure he quit” HR manager in Ecco</td>
</tr>
<tr>
<td>10</td>
<td>1970s</td>
<td>“the design engineer at Digital was king” and “everyone was equal”</td>
</tr>
<tr>
<td>6</td>
<td>1990s–mid 2000s</td>
<td>“Nobody clocked in… It was all based on trust” and “a good fit for me” and “always going the extra mile” “in a leadership position … you are available all the time” and “flat organisation, very open door”</td>
</tr>
</tbody>
</table>
The next section explores the data with regard to engineering education and identity. Alongside continuous, rapid technology change, various debates or opposing views of engineering feature in the data. Examples of these debates are the academic versus the practical, the management engineer versus the professional engineer and the generalist versus the specialist. These opposing discourses go some way to explain the confusion of identity associated with engineering and with the current difficulties of making ICT visible and attractive to study in third-level and as a career option. This identity issue was a feature in the Journals from the 1960s that were accessed and it also featured as a main issue at a recent round table event.

6.6.3 Academic versus Practical

Engineering has a requirement for theoretical understanding and a practical ability to get things done. Where the academic side had traditionally been catered for in the degree courses of the universities, the practical was catered for through the apprenticeship system initially. The addition of the Regional Technical colleges added a layer to this academic and practical system that was designed to produce trained personnel suitable to work in industry. However, this tension between academic ability and practical or hands-on ability has continued to be a debate in the technical sphere. Respondent 7’s comment illustrates this as an ongoing debate:

“...you see from the education perspective you had this problem or discussion or whatever within colleges now that are they just producing people, cannon fodder for industry or are they educating them for some broad .... That debate goes on - we’re not going to solve that” (Interview 7).

One respondent found difficulty with “the theoretical guy who I didn’t really understand what he was talking about. Later, I caught up on that stuff” (Interview 10). Respondent 12 stated “I was seriously academic” and later on he declared “I’m not sure which I’d have gone to if I had a choice between the two [IoT and university]. I didn’t know how hands-on I was when I went to UCC.” This indicates that the early university degrees were more academic than practical. Support for this was also found in the comment of Respondent 3 who graduated in 1984:

“Having spent a lot of time in the education sector myself, it is clear to me that my undergraduate qualification... was wonderful, analytical, theoretical experience. I
loved it because it was very Physics orientated ... I don't think I had the skillset to look at it at the time but it was very theoretical and there was no harsh reality of the world at all” (Interview 3).

Respondent 6 found that in tough economic circumstances when a production job was available a PhD was surplus to requirements “Production stuff, the lingo and that's what got me the job. The co-op was so important. The PhD and everything else didn’t matter”.

Respondent 15 believes “It’s a personal view – we’ve become far too academic. Even look at the grade inflation, the points’ race. We’ve just become too focused” and Respondent 9, who sometimes mentors for Enterprise Ireland, advised an entrepreneurial student who wanted to develop a website and develop his business from this, “to go out and prove it in a manual fashion”. This resulted in the young person “nearly falling off his chair because he had to do something. So it is very easy to be developing something in a lab”.

A social hierarchy was also associated with this viewpoint of the university engineer, the technician and the apprentice. The academic appeared to be more socially desirable than the hands-on. One respondent thought that we were happier to develop down the software route as

“we don’t like to get our hands dirty. We...were never a manufacturing race [or] nation, if you think about it. We don’t have those doing skills... that type of thing.

It’s a mentality, a view, perception”. 

Another respondent was disdainful of being offered a visit from an ‘engineer’ to fix his Sky Box “You’ll probably send me down a technician.” He pointed out that the use of the word engineer was not tied in to a degree or qualification and he felt that mostly they were “technicians, if they are that. They are television fixers”, however, on the other side of the argument of engineers versus technicians:- one respondent stated “I have guys who are just technicians and they make as big a contribution”. Respondent 15 reported that in Telecom Éireann “Now the organisation was hierarchical. Engineers and technicians were worlds apart and didn’t talk”.

Respondent 15 described the process of apprenticeship and technician training.

“I suppose if you look where the technician would have come from historically, it would be the equivalent of somebody ... [who] would have done an apprenticeship. Now apprenticeships here are very narrow but if you went ... as a trainee technician, into
Telecom Éireann or the ESB, typically that would be two years. They did their own training. They don't do that anymore, but they would do their own training and it would be a two-year gig, block release with the college and on-the-job…. That would be a level VI now when you look at the level of content. And then the practitioner was hands-on. But what's now happened, people are being insulted to be called technicians, I think, but if you look where technicians have gone. In Intel, you know, their technicians are level VII minimum. So, industry uses different terminology to academics which blurs it further”.

He went on to say that development of an ICT apprenticeship was perhaps a missed opportunity for Ireland and pointed to the successful German apprenticeship model.

6.6.4 Generalist versus Specialist – The Broad and Narrow

Another opposing discourse was the generalist versus the specialist. Many respondents described their primary engineering degrees as broad or “good fundamental grounding” (Interview 5). One respondent indicated that the biggest change since the 1960s “particularly for Computer Science, is the breadth” (Interview 10) or “an engineering degree gives you a breadth of skills and it’s not just technical ones” (Interview 15). Respondent 6 described his engineering degree as “intensive” and particularly when he compared it to his brother’s leisurely nine hours of lectures in studying another discipline.

On studying to be an engineer in the mid-1980s:

“It did involve meeting a lot of deadlines, assimilating a lot of information. It was challenging and I think if you managed to get through that and there were an awful lot of things thrown at you across a wide range of subjects from Fluid Mechanics, Thermodynamics, Applied Maths, Field Theory. I mean, just the whole range and if you can deal with that, you can deal with a lot, I think”.

Respondent 14 also looked for broadly educated graduates “I think the person coming out should be broadly educated and then whatever industry he joins, I mean, you become a specialist”. This was also discussed by Mulhern (in NCEA and Galway RTC Seminar 1984, p.48); “Traditionally there have been two conceptions of the engineer’s education: - a generalist type of education with professional versatility; - a specialist for narrow engineering/scientific operations; the latter is resource intensive and best suited to the developed, technologically discriminating economies”.

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As technology changed and developed, the technical skills required also grew to the point where “you’ve also got ICT which is really electronics and you know, we’ve got this plethora of new disciplines now. ‘Well, I’m a nanotechnology engineer. I’m a this. I’m a that.”’ (Interview 15) and according to this respondent, currently in the United States, there is a move to “cull this back to three. We’ve civil, mechanical and electrical and each of these will fit onto one of those, you know, the same gene pool” and he commented, “I deal with red handle doors and he deals with green handle doors – yeah too specialist”.

Respondent 6 pointed to a benefit to a large multinational in having a skill pool available in the local IoT. “In EMC now we really took advantage of CIT and the technicians that were being produced there”.

Respondent 3 pointed to the policy to upgrade the level of education in the general population by producing more PhD and Masters level students but she felt that while these higher-level people might be produced they might not be employable except in other research based roles. “The stated policy of our education sector was to double the number of our PhD graduates. Where they are going to go, I don’t know?”

The danger of overspecialisation was mentioned by Respondent 14. The firm had sponsored research but while benefit was gained from the research project, the person was not likely to be employable within that company. “We have one PhD in our place... we sponsored him... and the guy is gone down such a narrow route right now and I’m not too sure we can employ him” (Interview 14).

The data also support the debate of career path divergence between management and professional engineer. This data is reviewed in the next section.

6.6.5 Professional versus Management Engineer

There was a divide between the engineer who remained as an engineer throughout his working life in industry and the one who was promoted through the management route. Respondent 12 described himself thus: “I am a hands-on engineer and I’ve had very little to do with management as such”. He distinguished the difference as “I don’t deal with
people. I deal with things”. Respondent 13 commented “There is the divide between the professional engineer and the manager and I probably went the manager route”.

According to two respondents, the good technical companies ensured that there was a promotion path for both of these types of talent. Respondent 6 commented that EMC “had a technical career path for people who wanted to stay technical, who were brilliant technical people. So, you could become the equivalent in status, let’s say director level, to being a principal engineer... You could follow both paths”. This corresponds to the comment by Respondent 12 concerning a work colleague who went to work in Analog Devices and became “a vice president of design. Analog Devices was run by engineers and they didn’t ever promote you out of your level of competence, which was a very clever thing to do. If a guy was good at designing stuff, let him design it. Don’t make him a manager of something else or anything like that. I mean [this engineer] was the greatest macro-manager you could get as well. He was the guy. He knew his engineering absolutely inside out.” (Interview 12).

The early electronic companies’ training was about the development of the engineering manager and this is described well by Respondent 14. “I had made the transition from being engineer to being supervisor with engineering responsibility. That set me up then for an Operations job, which I got. And then my boss said to me ‘You are going nowhere unless you spend some time in marketing’ and later when choosing between job options this respondent was advised “you want two years under your belt as operations manager and then you’ve done your marketing. You are dead-on then. You’ll pick up an MD job no problem” (Interview 14).

These opposing discourses may contribute to confusion about engineering identity. This confusion appears to have existed since the 1960s, as evidenced by journal papers from that time that were accessed in Engineers Ireland Journal.
6.6.6 Engineering Identity

The opposing discourses, the differences in attitude to the sector’s working environment, all lead to the question of engineering identity in the electronics sector and in the more modern ICT sector. The data collected supports this.

“I think that the problem with Engineering in general is that people don’t know what it is. I know what a Vet does, I know what a doctor does... and an engineer is what, exactly?” and “the IT/ICT sector is particularly invisible” (Interview 15). This was echoed by “So they know what a teacher is, they know what a guard is... They don’t know what a computer scientist is” (Interview 8).

In competition with other professions, which appear stable, “these new things are unstable. There’s a perception of electronics – people mix up electronic manufacturing with electronic design” (Interview 8) and “In Intel, you know, their technicians are level VII minimum” (Interview 15) but “those are really, skilled jobs. Those are quality guys. Those are really, really tough jobs but people think that that’s a production job” (Interview 8).

This chapter reviewed the data with respect to the research questions about the beginnings and the development of the current ICT sector in Ireland. Chapter Seven develops conclusions, points out the study limitations and recommends areas for further research.
Chapter 7 Conclusions

“It is also useful for the long-range planner to keep another characteristic of complex adaptive systems in mind; they continually evolve and do not have optimal end states”

(Linstone 2002).

7.1 Contributions of this research

This study is purely exploratory in that it seeks to answer questions about an industrial sector over a five decade period of time. It adds to a growing body of business research which uses a critical realist (CR) paradigm. A known framework, Technology Roadmapping (TRM) is used to explore developments in an important industrial sector that continues to have significance for this country. The roadmap takes a backward-looking perspective instead of the usual future-looking approach.

7.2 Conclusions

7.2.1 Conclusions relating to the TRM Framework

CR and TRM have the flexibility and breadth to allow a wide lens to be used in studying the case of the Irish Electronics and Software sector, now called the ICT sector. In combination, they allowed this project to progress in a manner that can be extended where necessary. It may provide a useful first reference for further studies of this industrial sector.

Two roadmaps are presented. Technology Roadmap 1, developed from the literature review, presents the data gathered in the actual CR stratum. The second roadmap, Technology Roadmap 2, was created using the interview data collected in this study and is, thus, a roadmap from the CR empirical stratum. These two roadmaps are shown below in Figures 7.1 and 7.2. The actual and empirical and real strata in CR were explained in Chapter 5.
### Technology Roadmap 1 (ICT Industry Development in Ireland)

<table>
<thead>
<tr>
<th>Pre EU Membership</th>
<th>Post EU Membership</th>
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<tbody>
<tr>
<td><strong>Pre 1960</strong></td>
<td><strong>1970s</strong></td>
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<tr>
<td>Protectionism</td>
<td>More capital intensive electronics firms</td>
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<td>R&amp;D and Software</td>
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<td>Indigenous Industry Focus</td>
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<td>Entrepreneurship → Innovation</td>
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<tr>
<td><strong>1960s</strong></td>
<td><strong>1980s</strong></td>
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<td>Free Trade, FDI and Tax</td>
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<td></td>
<td>Establishing Regional Technical Colleges</td>
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<td></td>
<td>Establishing Research base</td>
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<td>Research and Linkages to Industry</td>
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<td>Higher requirement for PhDs and Masters Students</td>
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<tr>
<td><strong>1970s</strong></td>
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<td>R&amp;D and Software</td>
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<td>Indigenous Industry Focus</td>
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<td>Entrepreneurship → Innovation</td>
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<td><strong>Post EU Membership</strong></td>
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<td><strong>2010</strong></td>
<td><strong>Current</strong></td>
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**Government Policy**
- University/Technical Colleges/Apprenticeship
- Changes to Secondary School
- Establishing Regional Technical Colleges
- Establishing a Research base
- Research and Linkages to Industry
- Higher requirement for PhDs and Masters Students

**Technical Education**
- Semi-State bodies, Radio & TV production
- Branch Plant manufacturing
- Manufacturing with higher functions such as R&D Hardware and Software
- Globalisation and Value Chain - Hardware, Software and Services
- Market led and knowledge based

**Industry**
- Semi-State bodies, Radio & TV production
- Branch Plant manufacturing-Mostly Hardware
- Manufacturing with higher functions such as R&D Hardware and Software
- Globalisation and Value Chain - Hardware, Software and Services
- Market led and knowledge based

**Technology**
- Development of Transistor, Integrated Circuit, first UNIVAC
- Mainframe → Minicomputer → first Microprocessor
- Mini-computer and start of PC
- Internet and Networking
- Convergence of Telecomm./Electronics/Data

**Global Events and Developments**

*Figure 7.1 Technology Roadmap from the literature review (the actual stratum)*
### Data Generated Time Series

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
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<tbody>
<tr>
<td>1959</td>
<td>Early manufacturing in electronics subsidiaries of GE-EI and EEC. Reactive management style, good growth. Management came from overseas parent company.</td>
</tr>
<tr>
<td>1980-1989</td>
<td>In 1974, GE subsidiary in responsibility for full product (design, development, R&amp;D) for one product. Apple doing basic design, changing market conditions and competition.</td>
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<tr>
<td>1990-1999</td>
<td>Boeing manufacturing for full product range. Outsourcing to some indigenous companies but confirmation of lack of scale in indigenous suppliers.</td>
</tr>
<tr>
<td>2010-?</td>
<td>Incubator centres associated with 3rd level universities and slfs.</td>
</tr>
</tbody>
</table>

### Technical Education

- Shannon-Free Zone, tax and low wages.
- IDA - excellent, good to solve problems, good to identify companies, helpful, geared to FDI. |
- Shannon-Free Zone, tax and low wages. |

### Government Industrial Policy

- Shannon-Free Zone, tax and low wages. |
- IDA - job counts |
- IDA interaction with local colleges on tours. |
- IDA interaction with local colleges on tours. |

### Technology

- Mainframe Computers |
- Mini-computers (DEC PDPs) |
- Hard disk modulator arrived. |
- IDA interaction with local colleges on tours. |
- Difficult getting a PC in a low cost production environment. |
- Adding a PC processor to the product design. Android and iPhone platform as a distribution mechanism. Software as a Service (SAS). |

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**Figure 7.2 Technology Roadmap from the interview data (the empirical stratum)**

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7.2.2 Conclusions relating to the Industrial Sector

From a low industrial base, a successful ICT sector has developed in Ireland between 1960 and 2010. Success in attracting Foreign Direct Investment added to a small existing base in the electronics sector. In the 1960s, electronics featured in the semi-state bodies (RTE, P&T) and in foreign-owned manufacturers of television and wireless radio. One can argue that Ireland has followed Porter’s national development path (Porter 1990). The industrial sector began as a low cost manufacturing electronics location which corresponds to factor based development; it moved to more advanced technological FDI investments (DEC, Microsoft, Apple, EMC) and then moved to encourage venture capital investment and entrepreneurship as a successful indigenous software base developed. More recently, industrial policy has sought to drive innovation to further national economic development.

In reviewing the two roadmaps produced, there appears to be similarity between the actual domain roadmap and the empirical domain roadmap produced. The influence of technology development trends can be seen with a brief analysis at the predominant computer type and the types of foreign-owned companies operating in the country. This trend indicates that the story started with hardware manufacturing. Software development followed on and currently, services, or a combination of hardware/software/services, appears to dominate. Similarly, the indigenous industry also tended to follow this technology trend with a few hardware companies in the 1960s and 1970s and a subsequent indigenous software industry.

A difficulty with manufacturing was identified in the empirical data. This is manifested in the moving of electronic manufacturing from Ireland and in the respondents’ identification of niche areas as more suitable for manufacture in this country. One respondent believes that manufacturing is a neglected area, but one where Ireland can, and should, continue to be successful. Another respondent indicated that success in a large multinational was based on their manufacturing competence and that this had led to a current “multifunctional campus”. This leads to a question of whether or not a company’s progression up the value chain requires the underlying knowledge generated in the manufacturing process.
The pace of change appears to be one of the main areas of difference between the industrial sector and the education sector and government policy sector. In industry, when something is not working, adaptation appears to be more immediate. This dynamic sector features start-ups, shut-downs, mergers & acquisitions and take-overs/buyouts on an ongoing basis, causing changes in the industry structures. The nature of the foreign-owned industry has also changed and adapted, as evidenced by the moves on the value chain. Sterne’s (2004) description of the changes in the indigenous software industry indicates that here, also, adaptation to changing circumstance was on-going.

7.2.3 Conclusions relating to the Education Sector

The pace of change in the development of technology is a particular challenge for technical education. The breadth of knowledge required to keep technical education relevant while staying true to a good fundamental training, has also grown with time. Alignment with industry specific requirements has been another continuous challenge, as has the expanding breadth required for modern industry in the personal development of the graduated student entering the workforce for the first time (teamwork, communication skills etc.).

The process of change in education proceeds at a different pace from industry. There was little disruptive thinking in the educational area over the fifty years. The educational amendments were more in line with additions, and attempts to fit with the existing educational structures, rather than a fundamental re-alignment of the structure or an identification of a complete new model to meet the country’s technical education needs.

The time series for technical education and for government policy shows the pace of change is varied in these areas. Many adaptations occur to deal with duplication of or optimisation of functionality. An example of this is the long time taken to develop a single framework for qualifications in the country. Another example is developments in management of apprenticeship training which switched from An Cheard-Chomhairle, to AnCO, to FÁS and now to Solas.

The need for change was identified, typically, using reports from outside agencies. These were often in the form of OECD reports in the area of education. A confidence in the assessment abilities within the country has developed. The more recent EGFSN reports
seek to match skills supply and demand. "Deadweight" is an economic term which can be applied to any situation where the supply and demand are not matched. This has been and continues to be an ongoing challenge for the country.

As previously mentioned, industry changes can happen quickly. Industry changes, in-turn, drive changes in the third-level technical education sector which leads to CAO entry points for courses varying widely and the number of applicants for some courses changing dramatically. This means that a flexible and adaptable system is needed.

7.2.4 Conclusions relating to Government Policy

Government industrial policy started with the requirement to kick-start industry in the country (the Second Programme for Economic Expansion) and initially sought to maximise the number of jobs as a way of reducing unemployment. According to the literature, it was accession to the E.E.C. (now the EU) that encouraged the practice of longer-term planning. A more strategic approach developed to industrial policy as the base in industry developed and as the industrial sector became more complex. This is illustrated by the 2004 report, "Ahead of the Curve".

In the area of government policy, the pace of change is very variable. The Telesis Report (1982) recommended government to focus more on the indigenous sector. It was 1998, before the Enterprise Ireland development agency was set up with this goal as its primary focus. Similarly, the two educational committees, formed in the 1960s, are a good example of this. The Commission on Higher Education was set up in 1960 but issued only an interim report in 1967. By contrast, the Steering Committee was set up in 1966 to advise on matters of technical education and it reported a year later in 1967. Also in 1992, the Culliton Report called for the setting up of a task force to implement its recommendations and response to this report led to changes where Forbairt took over the responsibility for indigenous Irish industry in 1994.

From a simple requirement to drive development of industry by a policy of foreign direct investment, government policy evolved and developed to drive industry in a more holistic process. Government policy now seeks to drive industry using other macroeconomic change drivers, such as, education.
7.3 Limitations

This single researcher project covers a broad industrial sector and a long time frame. CR is not an easy ontology to apply in such a project. It was chosen to allow the study of an open complex social structure. The choice to maintain breadth leads to difficulty in maintaining the focus completely on the unit of analysis. Nor is a TRM framework easy to apply backwards over a fifty year time period in such a broad area. The study does contain gaps due to the single researcher nature of the research study and the time limit to gather relevant material. No industry-wide examples of TRM were available to guide the study.

There is no guarantee that a different researcher using the same methods would come to the same findings and conclusions. The choice of the unit of analysis and the time frame for the study were pre-determined by the research sponsors, The Irish American Partnership. The researcher has endeavoured to stay ‘true’ to the top line brief given and this has driven the subsequent choices for the study. Interviews for this study included people who had worked in American multinationals and in indigenous Irish ICT companies. The model would also need to be validated with a sample of companies which include other nationalities of ownership.

The Electronics and Software industrial sector, as it evolved into the ICT sector, is analysed as a case study using a technology roadmap framework spanning five decades from 1960-2010. This industrial sector has broadened with developments in technology over this timeframe which imposes limits on the depth of analysis that can be achieved in the study. Contrary to the usual research choices which look to narrow and deepen the knowledge about the unit of analysis, the choice was made to use a broad sectoral definition to allow exploration of the industry sector development over the five decades.

The choice to maintain breadth imposes limitations on the generalisability of the findings. This study has taken 1960 as a starting point and looked at the development of the ICT sector in Ireland. The influences of Irish government policy and technical education on the sector were also part of the research brief. Most technology roadmaps focus on projecting forwards into the future. Case studies that use a backward-looking TRM as a framework would be of benefit in further evaluating this as a suitable industry research method. As
such, the findings of this study are not generalisable, but it is possible that this method of looking at industry development can be used to explore development of other industrial sectors. It may also be of benefit to newly industrialising countries looking to develop an ICT industry. The approach is flexible and adaptable and other relevant data points can be inserted without negating the previous work. It would probably benefit greatly from a research team which would reduce any possible single-researcher bias and would mean that a greater volume of data could be gathered and analysed.

This study chose a critical realist stance which imposes some limitations, also. Critical Realism looks to identify underlying real structures. However, this study ends with the proposing of CR mechanisms. It has not made the further steps of looking to identify the nature of the real structures underneath the mechanism or the careful checking of the required mechanisms proposed to see if other likely explanations are possible. Also, CR has been criticised as not being ‘actionable’ and this limits the usefulness of this study for policy formation. Notwithstanding this, the case is of interest. The ICT sector is a sector of growing importance and the data gathered thus has a particular relevance.

Another limitation of this study is that the time frame ends in 2010. The industrial sector, technical education and government policy have experienced many changes since then and are continuing to undergo changes. This needs to be kept in mind when reviewing the conclusions.

7.4 RECOMMENDATIONS

This study has highlighted differences in opinions about the exit strategies of some of the successful indigenous ICT companies. All were agreed that successful entrepreneurs deserve reward for their success but the question was posed as to whether some of these companies could be kept as Irish-owned companies and further developed under Irish management. Currently, there is no mechanism where this can even be considered. While it would certainly not be suitable in most cases, there are perhaps some companies where there would be merit in seeing if more larger-scale internationally trading Irish technology companies can be created. It may also improve the managerial cohort in larger scale companies in the indigenous ICT sector. Government should consider whether a layer of
support could/should be put in place to examine if entrepreneurship policy can incorporate a means to maintain businesses (with long-term scalability prospects) in Irish ownership.

Throughout the fifty years of ICT sector development considered in this study, a capable managerial cohort was developed. This cohort managed the next generation of industry, leading to a cumulative and continuous development. One of the side-effects of running a ‘lean manufacturing’ process, which is necessary to compete in the global manufacturing environment, is that the next generation of management tends not to be a priority. The ‘self-destruct’ employee also has implications in terms of employee loyalty and in terms of development of the next managerial cohort to lead the future companies to maintain a strong industrial environment. Government policy should lead the way and provide exemplars of how to build a skills portfolio for individuals and should find a means for evaluation and identification of what transferrable skills are and how they can be developed. Alternatively, a means to build these transferrable skills in co-operation with industry should be found. How can people be better prepared to meet these types of challenges in their working lives?

The reduced esteem in which education appears to be held is of particular concern to the education system. The Culliton Report (1992) reported this lack of esteem among third level students but this study shows that it may be more prevalent. It may well lead to a position of diminishing returns. People will be less willing to work hard where the outcome is not highly regarded. A further study of the prevalence of this decline in respect towards educational achievements in general is warranted, with particular focus on a means to reverse the trend, if it is found to be a widespread phenomenon.

The quality of technical graduates produced throughout the system needs to be of a high standard. The variation in Leaving Certificate points, problems with Maths and, an ability to “skim” through the system without developing a high level of understanding of the required area, do not augur well for the future ‘knowledge economy’ nor for the development of the industrial sector. With so much information available on line, this ability to ‘skim’ through needs to be better understood. Graduates need a fundamental
understanding of technical underpinnings to make a valued contribution in their chosen places of work. If a "300 point engineer isn’t an engineer" viewed by industry standards, of what use is that qualification to the young person who undertook the course, to the industry in which he/she is seeking a job and to the country as a whole? Educational policies must consider the issue of quality as well as quantity.

The move to the ‘knowledge economy’ has increased the requirement for a greater number of jobs for applicants with PhD and Masters qualifications. Not everyone is suitable to undertake such high levels of academic study and the area of apprenticeship and the role of the technician also need to be advanced to match the ‘knowledge economy’. An apprenticeship model, that can meet the modern industrial requirement and allow access to the industry for the ‘hands-on’ students who may not be as academic, is also necessary. This would allow a continuation of the ability to ‘work your way up’, as opposed to ‘walk in’, and would maintain a breadth of skills in the country. Neglect of the area of apprenticeship, certificate and diploma levels, which do not appear to be in such demand in a knowledge economy, will eventually lead to shortages in these skills, also. Government policy and education reports need to take both a macro and a micro view of education and develop relevant and respected technical education at all levels.

This study has revealed many changes in technical education over the course of the five decades reviewed. Throughout, matching of skills to what is required by the ICT sector at any given time was, and is, a particular challenge. The move to the knowledge economy has led to a decrease in the more manual jobs and an increase in the highly skilled jobs, with an increased requirement for education. As the ICT industry is fast paced, many employers are no longer willing to do on-the-job training and want them ‘oven-ready’ directly as they come out of college. This has led to a requirement in broadening technical education to produce such work-ready graduates. A key area of benefit would be identification of the best technical education model(s) to match engineering education and skills development to the needs of a dynamic and continuously changing industrial sector. The development of the EGFSN has certainly helped in this area but job churn and the
associated job insecurity are difficult selling points for an industry to attract new ‘talent’. In this area, establishment of lines of demarcation would perhaps be helpful. This demarcation was once an area of difficulty where barriers needed to be broken down to allow linkages and networking between educational institutions and industry. A framework to establish the duties of care of the various stakeholders in training and development would be beneficial. A clearer definition in areas of responsibility of education and training is needed. What are the responsibilities of the student, the third-level educational institution and the industrial sector?

7.5 AREAS FOR FURTHER RESEARCH

This study has been an exploratory research project. Many areas for further research are suggested.

In the 2013 NESC report “Ireland’s five part crisis, five Years on: Deepening Reform and Institutional Innovation”, NESC director Rory O’Donnell indicated that the main lesson from the recent recession and recovery is that government policy is only the beginning point and “What is critical for monitoring success and failure are institutional arrangements capable of review, learning and policy adaptation”. This is a recurrent theme in the fifty years reviewed. In 1964, the Second Programme for Economic Expansion Part II states: “The Council recommended that changes in the economic factors likely to influence the rate of economic expansion should be kept continuously under review so that targets and policies could be modified in the light of changing circumstances: it is at present examining how this review might best be carried out”.

In the 1992 Culliton Report: “An effective means through which the activities of the wide range of government departments and State Agencies which affect industrial development can be brought together in a more consistent way to support employment and wealth creation in the industrial sector is lacking” and the report called for a Task force. This appears to be an on-going problem and a recurrent cause of complaint, leading to the question how can a continuously changing, complex, open and adaptive environment be monitored to suit immediate, medium and long-term goals? The quotation “It is also useful for the long-range planner to keep another characteristic of complex adaptive systems in mind; they continually evolve and do not have optimal end states” (Linstone 2002) has to be kept in mind.
Further research in the area of establishing an engineering or ICT identity is also indicated. Much work has been done to make science and technology more accessible throughout the education process (such as Science Technology Engineering and Mathematics or STEM programmes) but still a shortage of people willing to undertake studies in these areas is reported. Further research into how an identity can be established in such a broad and diverse area would be useful in informing policy makers as to what means are suitable to attract young people to study in relevant technical areas and to work in the ICT industry.

One external validation reader pointed out that this study had not fully captured the divide in the electronics sector between OEMs and sub-contract manufacturers (such as Flextronics and SCI) from the 1980s and into the 1990s. The differences in their approaches to linkages, value chain systems and R&D could provide a rich area for a further in-depth study.

It would also be of benefit to establish how and where the divergences in an engineering career take place. When and how do people choose to remain in engineering or move into management or to other employment areas? Should this have implications for their initial training?

Another area for further research would be to investigate whether the broader training required by the modern workplace has other implications. What are the trade-offs in training more broadly and in developing team-players? In other words, by matching the flexibility in education required for the modern knowledge economy, what has to be left by the wayside?

A change has been identified in the working environment. This move is from the ‘job for life’ to an employee who will ‘self-destruct’ after the project finishes. This has major implications not only for attraction and recruitment but for career path development also. It means that a skills portfolio needs to be developed to continue to be employable. A further study to understand these changes would be of benefit to those already in the area and also to those who may be attracted to the area. A means of career planning in such transient environments is particularly indicated with a rise in the prevalence of contract working arrangements.
References


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Appendices

Appendix A: Advertisement for Sponsored Masters

Cork Institute of Technology
is proud to announce in association with
The Irish American Partnership

Masters Scholarship Opportunity

Cork Institute of Technology invites applications for the 18 month Masters degree by research project.

This study will enable candidates to complete an individual research project which has been developed from a collaboration between the Irish American Partnership and Cork Institute of Technology.

Details of Research Study

The early electronics industry in Ireland provided the foundation for what is now a thriving ICT and software industry sector. This study will examine and assess the origins of this important industry for Ireland and describe its key influencers and drivers, and will trace its development to the present day. The contributions of Government, Industry and Education policies will also be assessed.

This research project is open to graduates of all disciplines and might particularly appeal to graduates in business, marketing and certain engineering or IT backgrounds.

How Do I Apply?

Further Details are available at www.cit.ie/mbscholarship.

Closing Date: 12 June 2013

The Irish American Partnership was founded in Ireland by business, political and education leaders and seed funded by the Irish Parliament in 1987. The Partnership is dedicated to organizing Irish America on behalf of our Irish heritage. Today as a 501(c)(3) non profit corporation supporting education programs in Ireland, the Partnership has 4,000 active supporters throughout the United States.
Appendix B: NACE historical developments

(Source: NACE Rev.2 Introductory Guidelines)

<table>
<thead>
<tr>
<th>Year</th>
<th>NACE history</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961-1963</td>
<td>NICE developed</td>
<td>“Nomenclature des Industries établies dans les Communautés Européennes” or Classification of Industries Established in the European Communities. Original 1961 version had broad divisions. Revised 1963 version included more detailed subdivisions</td>
</tr>
<tr>
<td>1965</td>
<td>NCE developed</td>
<td>“Nomenclature du commerce dans la CEE” or Classification of Trade and Commerce in the European Communities developed to cover all commercial activities.</td>
</tr>
<tr>
<td>1967</td>
<td></td>
<td>A classification for services was developed as well as one for agriculture</td>
</tr>
<tr>
<td>1970</td>
<td>NACE Rev. 1970</td>
<td>“Nomenclature générale des activités économiques dans les Communautés Européennes” or General Classification of Economic Activities within the European Community was developed to cover the complete range of economic activity but it had problems with national as well as international framework compatibilities</td>
</tr>
<tr>
<td>1990</td>
<td>NACE Rev. 1</td>
<td>NACE Rev. 1 was established by Council Regulation on 9th October 1990. Using the ISIC Rev. 3 Structure, details were added to NACE to include European activities that were inadequately represented in ISIC.</td>
</tr>
<tr>
<td>2002</td>
<td>NACE Rev. 1.1</td>
<td>Minor updates to Rev. 1 to include   • Activities that did not exist when NACE Rev. 1 was developed   • Activities which were of increasing importance since NACE Rev. 1 due to technological or organisational changes   • Correction of errors</td>
</tr>
<tr>
<td>2006</td>
<td>NACE Rev. 2</td>
<td>Regulation to adopt NACE Rev. 2 was adopted in December 2006.</td>
</tr>
<tr>
<td>2008</td>
<td>NACE Rev. 2</td>
<td>NACE Rev. 2 to be used for statistics referring to economic activities performed from 1 January 2008 onwards.</td>
</tr>
<tr>
<td></td>
<td>ISIC Rev. 4</td>
<td>Released on 11 August 2008</td>
</tr>
<tr>
<td>Title</td>
<td>Years</td>
<td>Name</td>
</tr>
<tr>
<td>-----------------------------------------</td>
<td>----------------</td>
<td>------------------------</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1959 – 1965</td>
<td>Patrick Hillery</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1965 -1966</td>
<td>George Colley</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1966 – 1968</td>
<td>Donagh O'Malley</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1968</td>
<td>Jack Lynch (acting)</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1968 – 1969</td>
<td>Brian Lenihan</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1969 – 1973</td>
<td>Padraig Falker</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1973 – 1976</td>
<td>Richard Burke</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1976 – 1977</td>
<td>Peter Barry</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1981 – 1982</td>
<td>John Boland</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1982</td>
<td>Martin O'Donoghue</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1982</td>
<td>Charles Haughey (acting)</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1982</td>
<td>Gerard Brady</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1982 – 1986</td>
<td>Gemma Hussey</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1986 – 1987</td>
<td>Patrick Cooney</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1987 – 1991</td>
<td>Mary O'Rourke</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1991 – 1992</td>
<td>Noel Davenport</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1992 – 1993</td>
<td>Seamus Brennan</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1993 – 1994</td>
<td>Niamh Bhreathnach</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1994</td>
<td>Michael Smith</td>
</tr>
<tr>
<td>Minister for Education</td>
<td>1994 – 1997</td>
<td>Niamh Bhreathnach</td>
</tr>
<tr>
<td>Minister for Education and Science</td>
<td>1997 – 2000</td>
<td>Michael Martin</td>
</tr>
<tr>
<td>Minister for Education and Science</td>
<td>2000-2002</td>
<td>Michael Woods</td>
</tr>
<tr>
<td>Minister for Education and Science</td>
<td>2002 – 2004</td>
<td>Noel Dempsey</td>
</tr>
<tr>
<td>Minister for Education and Science</td>
<td>2004 – 2008</td>
<td>Mary Hannafin</td>
</tr>
<tr>
<td>Minister for Education and Science</td>
<td>2008 – 2010</td>
<td>Batt O’Keeffe</td>
</tr>
<tr>
<td>Minister for Education and Skills</td>
<td>2010 – 2011</td>
<td>Mary Couglan</td>
</tr>
</tbody>
</table>

List of Ministers for Education in the Republic of Ireland from 1960 to 2010
Appendix D: Semi-Structured Interview Plan for Research Project

“A study of the Electronics and Software Industry in Ireland 1960-2010”

Introduction
Hello my name is Sarah Davis and I have been sponsored by the scholarship programme of the Irish American Partnership to study The Irish Electronics and Software (ICT) Industry over 50 year period from 1960 to 2010. The object of the research is to trace the key drivers and influencers of the ICT sector over this timescale and to identify the important contributions to this sector of areas such as government policies, educational developments and industrial development through innovation, entrepreneurship, local linkages, regional development and other relevant contributions.

With these topics in mind would you

<table>
<thead>
<tr>
<th>Main Questions</th>
<th>Additional Questions</th>
<th>Clarifying Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Describe your own career path and also your company/organisational development in relation to the ICT industry</td>
<td>1) Start-up conditions for the company/organisation and operating conditions ( size, age, origin, structure, type of products/product life cycle, markets/ functions)</td>
<td>Can you expand a little on this? Can you tell me anything else? Can you give me some examples?</td>
</tr>
<tr>
<td></td>
<td>2) Interactions with Government agencies and how and where have State been of help/been a hindrance</td>
<td></td>
</tr>
<tr>
<td></td>
<td>3) Was education satisfactory for work, past present and future</td>
<td></td>
</tr>
<tr>
<td>In your experience what have been the main changes in the area over time?</td>
<td>If company – means of doing business, markets, functions, products, supports, education, policy If organisation/institution – courses/interaction methods/ division of responsibilities What drove the changes?</td>
<td>Can you expand a little on this? Can you tell me anything else? Can you give me some examples?</td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
<td></td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>------------------------------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Are these changes unique to ICT sector?</td>
<td>Infrastructure, Linkage, economy, staffing, tax/regulation, Technology visionary, identification of trends, correlation of industrial development and technological development. Strategic turning points on development curve. Can you expand a little on this? Can you tell me anything else? Can you give me some examples? Check Drivers and influencers were covered.</td>
<td></td>
</tr>
<tr>
<td>What were and are the main problems and main strengths in the ICT sector in Ireland?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>What do you think the future holds for ICT sector in Ireland?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Do you have anything to add that was not covered and that relates to the ICT sector in Ireland past or present?
Appendix E: Letter of Explanation

A Study of the Irish Electronics and Software Sector from 1960-2010

The Irish American Partnership has sponsored research into the History and Development of the Irish Electronics and Software Industry in Ireland over 50 years from 1960 to 2010. The object of the research is to trace the key drivers and influencers of the ICT sector over this timescale and to identify the important contributions to this sector of areas such as government policies, educational developments and industrial development though, innovation, developments in technology, local linkages, regional development and other relevant contributors.

- The project aim is a study of the Irish ICT sector development since the start of free trade conditions in Ireland looking to identify drivers and influencers for development. To establish drivers and influencers for the sector semi-structured interviews will be conducted with relevant key knowledge holders
- Interviews will last for approx. one hour and questions will relate to electronics and software companies in Ireland, relevant training and education and to government policies.

Interviewee Conditions

- The interview granted and the information it contains will be used solely for the purposes defined by the project
- At any time, I can refuse to answer certain questions, discuss certain topics or even put an end to the interview without prejudice to myself
- To facilitate the interviewer’s job, the interview will be recorded. However, the recording will be used only for the research purpose described (and will be subsequently destroyed)
- All interview data will be handled so as to protect confidentiality. Therefore, no names will be mentioned and the information will be coded.

For any information about the project, contact (Doctor Breda Kenny, Head, Hincks Centre for Entrepreneurship Excellence, School of Business, Cork Institute of Technology, Bishopstown, Cork, Ireland. Tel: 353 21 4335427)

Respondent’s Signature: Date:

Interviewer’s Signature: Date:
### Appendix F: List of Drivers from Empirical Data

List of Drivers from the Empirical Data arranged in Alphabetical Order

<table>
<thead>
<tr>
<th>Driver</th>
<th>Driver Type (+/-)</th>
<th>Interview No.</th>
<th>Literature Review Driver</th>
<th>Examples from empirical data collected</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ability to network</td>
<td>(+)</td>
<td>6, 4, 9</td>
<td></td>
<td>“the ability of Irish people to network, to create linkages. That’s there” 6</td>
</tr>
<tr>
<td>Accumulation of experience Management experience</td>
<td>(+)</td>
<td>13, 14, 12,</td>
<td>(Porter, 1991 - Evolutionary processes), (Begley <em>et al.</em>, 2005), (Collins and Grimes, 2008)</td>
<td></td>
</tr>
<tr>
<td>Acquisition opportunities</td>
<td>(+)</td>
<td>10, 11, 8, 1</td>
<td></td>
<td>“if there is acquisition opportunities for companies coming in then that might attract them more” (1)</td>
</tr>
<tr>
<td>Availability of Engineers</td>
<td>(+/-)</td>
<td>13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BIC (Business and Innovation Centres)</td>
<td></td>
<td>4</td>
<td></td>
<td>“They may have planted a seed there for the IT sector” 4</td>
</tr>
<tr>
<td>Communication</td>
<td></td>
<td>14, 6</td>
<td></td>
<td>Communicate with employees at difficult times/ no silos</td>
</tr>
<tr>
<td>Company Culture</td>
<td></td>
<td>7, 6</td>
<td></td>
<td>“The EMC culture was always going the extra mile” 6</td>
</tr>
<tr>
<td>Competitiveness (+2000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Complication/multiple languages of Europe</td>
<td></td>
<td>11</td>
<td>(Collins and Grimes, 2008)</td>
<td>“It’s the complication of Europe”</td>
</tr>
<tr>
<td>Continuous Change/flexibility</td>
<td></td>
<td>13, 7, 1</td>
<td></td>
<td>“the rate of change has been phenomenal” (13) “you are emphasising from the start that we are not going to survive here unless we have this flexibility” 7</td>
</tr>
<tr>
<td>Continuous Product Development and R&amp;D</td>
<td></td>
<td>14, 1, 5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cost vs Margin</td>
<td></td>
<td>5, 7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>Interview No.</td>
<td>Literature Review Driver</td>
<td>Examples from empirical data collected</td>
<td></td>
</tr>
<tr>
<td>------------------------------------</td>
<td>---------------</td>
<td>--------------------------</td>
<td>----------------------------------------</td>
<td></td>
</tr>
<tr>
<td>Critical Mass</td>
<td>(-) 8</td>
<td>(Begley et al., 2005)</td>
<td>Perceived as having critical mass in software but not in Hardware “the community in the IC design space is quite small and there aren’t that many places to float around. And in the software it is a bit bigger and it’s improving” 8</td>
<td></td>
</tr>
<tr>
<td>Crosspollination</td>
<td>(+) 15</td>
<td></td>
<td>“We are very fortunate in Ireland… We are a small place, small country. So there is good cross-pollination between companies that are here”</td>
<td></td>
</tr>
<tr>
<td>Currency/Eurozone</td>
<td>(+) 2, 8</td>
<td></td>
<td>“Eurozone makes us a little bit easier than the UK” 2</td>
<td></td>
</tr>
<tr>
<td>Customer focus / Market trends</td>
<td>1, 14,15</td>
<td></td>
<td>Cost of shipping etc</td>
<td></td>
</tr>
<tr>
<td>Developments in Logistics</td>
<td>12,13,3, 7</td>
<td></td>
<td>“Dublin has a reputation as a young city”</td>
<td></td>
</tr>
<tr>
<td>Dublin as a capital city</td>
<td>8, 1</td>
<td></td>
<td>“The ability to translate that business need and that technical need in a practical fashion” (Interview 9)</td>
<td></td>
</tr>
<tr>
<td>Education/Training Rising levels of education</td>
<td>11, 13, 6, 9 (O’Riain, 2004), (Begley et al., 2005)</td>
<td>“that’s a huge advantage” 8 , “People are less afraid of that” (10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Employee loyalty to company</td>
<td>6,4, 11</td>
<td></td>
<td>“So we can respond very quickly” – market focus “because we were rushing the thing to market” 7</td>
<td></td>
</tr>
<tr>
<td>Fast Response/Speed to market</td>
<td>14, 7</td>
<td></td>
<td>“the importance of having international experience is very, very important” 6</td>
<td></td>
</tr>
<tr>
<td>Foreign /Overseas Experience/Training</td>
<td>10,13, 6, 7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>Driver Type (+/-)</td>
<td>Interview No.</td>
<td>Literature Review Driver</td>
<td>Examples from empirical data collected</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>-------------------</td>
<td>---------------</td>
<td>-----------------------------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Foreign Direct investment (FDI)</td>
<td>(+/-)</td>
<td>14,13,2,1,1</td>
<td>(Görg and Ruane, 1998), (O’Riain, 2004), (Collins and Grimes, 2008), (Begley et al., 2005), (Ryan and Giblin, 2012), (White, 2004), (Grant, 2013)</td>
<td>“they are semestering and that is a level of globalisation there” 11, “Our academic years are far too short here [compared to other nations], I think, we will pay for that in a global economy” 15, “Thinking bigger, thinking globally” 11</td>
</tr>
<tr>
<td>Globalisation</td>
<td>(+,-)</td>
<td>11,7,1,15</td>
<td>(Fahy, 2001), (O’Riain, 2004), (Collins and Grimes, 2008), (Barry and van Egeraat, 2008), (Gorman and Cooney 2007)</td>
<td></td>
</tr>
<tr>
<td>Good location to attract overseas talent to work</td>
<td>(+)</td>
<td>2,8</td>
<td>(Collins and Grimes, 2008)</td>
<td>“So people are willing to come here and work here” 8</td>
</tr>
<tr>
<td>Good location to build market</td>
<td>(+)</td>
<td>2</td>
<td></td>
<td>“Most US companies aren’t interested in tech-developers straight off. They want sales talent. They want to build a market and they’ll build tech on top of it.” Interview 2</td>
</tr>
<tr>
<td>Government Supports including the government agencies, and State policy and Incentives</td>
<td>(+)</td>
<td>6,13,15,8,1</td>
<td>(O’Riain, 2004), (Collins and Grimes, 2008), (Begley et al., 2005), (Barry and van Egeraat, 2008), (Smith, Nicola, J. 2006), (Gorman and Cooney 2007)</td>
<td>“The IDA incentives were really, really important” 6</td>
</tr>
<tr>
<td>Heritage and familiarity with American culture</td>
<td>(+)</td>
<td>2, 6, 5</td>
<td>(Begley et al., 2005), (Grant, 2013)</td>
<td>“the Irish-American link” (6) – Dick Egan EMC and his wife “So you can’t get over the granny in Donegal bit, really worked to our advantage” Interview 2</td>
</tr>
<tr>
<td>Hiring the right kind of people</td>
<td>(+)</td>
<td>1,14, 6,9</td>
<td></td>
<td>“People are the most important asset” 6 “We have managed to pick up the right kind of people along the way”</td>
</tr>
<tr>
<td>Driver</td>
<td>Driver Type (+/-)</td>
<td>Interview No.</td>
<td>Literature Review Driver</td>
<td>Examples from empirical data collected</td>
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<tr>
<td>--------</td>
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<td>----------------------------------------</td>
</tr>
<tr>
<td>Driver</td>
<td>Type (+/-)</td>
<td>No.</td>
<td>(-)</td>
<td>Interview 9</td>
</tr>
<tr>
<td>Infrastructure</td>
<td>(+/-)</td>
<td>3, 8, 6</td>
<td>“The shortest flight from Boston to Europe” -(Interview 8) and Good internet links, high capacity links –</td>
<td></td>
</tr>
<tr>
<td>Innovation</td>
<td>7,6</td>
<td>“Innovative products”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Investment/VC/Stock market (outside VC increased in 1998)</td>
<td>(+,-)</td>
<td>8,1,2, 7</td>
<td>(O’Riain, 2004)</td>
<td>“And the critical mass, that also includes investment and VC”</td>
</tr>
<tr>
<td>Jobs</td>
<td>15</td>
<td>(Barry and vanEgeraat, 2008)</td>
<td>3D printing for future housing estates – “How many people do you need to build that?”</td>
<td></td>
</tr>
<tr>
<td>Language skills</td>
<td>(-)</td>
<td>2, 7,6</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td>(+)</td>
<td>6,9,14</td>
<td>“look at the number of people that came from that company to form their own and absolute leaders of the industry today”</td>
<td></td>
</tr>
<tr>
<td>Location “small island” “Periphery”</td>
<td>(-/+))</td>
<td>(Collins and Grimes, 2008),(Begley et al., 2005)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Management Training</td>
<td>(+)</td>
<td>6</td>
<td>“General Electric had a fantastic management training programme”</td>
<td></td>
</tr>
<tr>
<td>Manufacturing/ Hardware/Software/Service</td>
<td>1, 13, 7</td>
<td>(Grant, 2013)</td>
<td>“If I were looking at Ireland now… it is going down the software route. So if I am a hardware company is this where I want to be?” (11) “It’s software that gives the edge on the competition now”</td>
<td></td>
</tr>
<tr>
<td>Membership of EU</td>
<td>(+)</td>
<td>10,2, 3, 8</td>
<td>(NESC, 1982), (O’Riain, 2004)</td>
<td>“Accessing the European market”</td>
</tr>
<tr>
<td>National Traits</td>
<td>10, 13, 14, 6, 6</td>
<td>“Easy to get along with” -10 Can-do attitude” It was about whatever it takes. We could never become the barrier to growth” – 6 “willingness to travel”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Traits</td>
<td>13</td>
<td>“good for Bonding with Customers”</td>
<td></td>
<td></td>
</tr>
<tr>
<td>National Traits</td>
<td>13</td>
<td>Less anchored so we can shift with the technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Driver</td>
<td>Driver Type (+/-)</td>
<td>Interview No.</td>
<td>Literature Review Driver</td>
<td>Examples from empirical data collected</td>
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<tr>
<td>------------------------------</td>
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<td>--------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>National Traits</td>
<td></td>
<td>7</td>
<td></td>
<td>Ready to help in a crisis and “fire fight” but not so good for root cause analysis – better at doing than thinking out problem solutions</td>
</tr>
<tr>
<td>Networking (across third-level and industry)</td>
<td></td>
<td>4</td>
<td>(O’Riain, 2004)</td>
<td></td>
</tr>
<tr>
<td>Niche areas</td>
<td></td>
<td>14, 5,3,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Open developmental companies/ seed companies/Spin-out companies</td>
<td></td>
<td>10, 13, 14, 9 14, 6</td>
<td>(Barry and vanEgeraat, 2008) (McCambridge, 2001)</td>
<td>“At least 50 CEOs in Ireland who had worked for me, at one stage”</td>
</tr>
<tr>
<td>Patriotism</td>
<td>(+) Early driver</td>
<td>14, 10,12,7</td>
<td>(McSharry and White, 2000)</td>
<td>“I want this place to be around the place in another 50 years, to be still an Irish-owned company” 14 and “I think we need to install a bit more patriotism in people for a start” 14 – selling out of successful Irish businesses</td>
</tr>
<tr>
<td>Personal Drive and key people</td>
<td>(+)</td>
<td>13, 6, 14</td>
<td></td>
<td>To generate results or drive for entrepreneurship, drive to be managing a factory by the age of 35. Concern for co-workers + determination(14) “Personal pride in your work” (11)</td>
</tr>
<tr>
<td>Personal Relationships</td>
<td></td>
<td>11, 13, 14</td>
<td></td>
<td>“Things happen through people and through personal relationships” – gave example of Larry and Dick Egan 6</td>
</tr>
<tr>
<td>Positive business environment</td>
<td></td>
<td></td>
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<tr>
<td>Product life cycle decreasing &amp;</td>
<td></td>
<td>3, 7, 13</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Production/Operational Developments</td>
<td></td>
<td>14, 6</td>
<td></td>
<td>Kaizen “played a key role in that as well” and “They were ambitious and successful in really following the latest Japanese techniques in world-class manufacturing” 6 Lean Manufacturing –(negative driver of lack of leadership development) 14</td>
</tr>
<tr>
<td>Quality</td>
<td></td>
<td>1, 6, 7</td>
<td></td>
<td>Cost reductions overrode the reliability and second sourcing needs of earlier times. 7 “quality and reliability”</td>
</tr>
<tr>
<td>Driver</td>
<td>Driver Type (+/-)</td>
<td>Interview No.</td>
<td>Literature Review Driver</td>
<td>Examples from empirical data collected</td>
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<tr>
<td>R&amp;D</td>
<td>(+)</td>
<td>15, 7</td>
<td>(O’Riain, 2004)</td>
<td>“And R&amp;D, I use this phrase, is in the blood” 14, research in certain areas only 15</td>
</tr>
<tr>
<td>R&amp;D spending increase</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Rate of technological change</td>
<td></td>
<td>15, 13</td>
<td>(Collins and Grimes, 2008)</td>
<td></td>
</tr>
<tr>
<td>Reduction in hardware exports between 2001-2003 and rise of Computer service exports. Trend for hardware -&gt; software -&gt; service Development of software over hardware – Cluster</td>
<td></td>
<td></td>
<td>(Collins and Grimes, 2008)</td>
<td>(O’Riain, 2004), (Begley et al., 2005), (Barry and vanEgeraat, 2008)</td>
</tr>
<tr>
<td>Regulation and standards</td>
<td>(+/-)</td>
<td>14, 15</td>
<td>Regulation ,</td>
<td></td>
</tr>
<tr>
<td>Reliability/Testing</td>
<td></td>
<td>11, 7,2</td>
<td>“One thing that was different to the computing side is that, in telecommunications, reliability is just way higher. You lift off the telephone, you get dial tone – end of story.” (Interview 15) “the testing was extreme” 7</td>
<td></td>
</tr>
<tr>
<td>Reputation</td>
<td>(+)</td>
<td>6, 2</td>
<td>With the software world Ireland has a good reputation of being easy to deal with. In the hardware world there was the reputation of being a little bit unionised and sometimes having a little bit of a problem” (10) “Global reputation as being a country that can actually do stuff” and “it is fabulous on the resume that Apple has been for 30 years and they are still here. They have gone nowhere and they are getting bigger every year” (Interview 11) “We are well perceived internationally” 8</td>
<td></td>
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<td>Literature Review Driver</td>
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<tr>
<td>Resilience and Independence</td>
<td></td>
<td>14</td>
<td></td>
<td>Independent “So we have always done our own thing since then and I think it has been part of our strength” 14 Resilience 14</td>
</tr>
<tr>
<td>Risk</td>
<td></td>
<td>13, 14,</td>
<td></td>
<td>Meet Steve Jobs vs semi-state (13) “again there probably aren’t enough people who have come through the multinational, like I have, that have taken a chance and gone off and done something uncomfortable like me. It is easy to take the next easy shilling and go in and work” 14</td>
</tr>
<tr>
<td>Scale</td>
<td>(-/+)</td>
<td>2, 6, 7, 13</td>
<td>(Fahy, 2001),</td>
<td>Negative driver (as regards home market size) “Their problem was that they couldn’t get it into their heads that you weren’t just going to hire from the Irish pool” Interview 2 “we are less anchored. A huge advantage in Ireland because we don’t have the huge traditional businesses. We can go with wherever the technology goes” (13)</td>
</tr>
<tr>
<td>Scale of Irish owned suppliers</td>
<td>(-)</td>
<td>7, 3</td>
<td>(Görg and Ruane, 1998)</td>
<td>“Second sourcing was critical in that sort of scenario but we were overruled”</td>
</tr>
<tr>
<td>Second sourcing</td>
<td></td>
<td>11, 7</td>
<td></td>
<td>“the service has been helped in a big way by Kaizen”</td>
</tr>
<tr>
<td>Service</td>
<td></td>
<td>14, 9</td>
<td></td>
<td></td>
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<tr>
<td>Single European Market</td>
<td></td>
<td>(Begley et al., 2005), (Ryan and Giblin, 2012)</td>
<td>“They build market from Ireland” 2</td>
<td></td>
</tr>
<tr>
<td>Speed of communication</td>
<td>(+)</td>
<td>2, 11, 7</td>
<td></td>
<td>“The speed of communications has been a huge enabler for industry” 15</td>
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<tr>
<td>Speed to market</td>
<td></td>
<td></td>
<td></td>
<td>“Speed to market is what it is all about. It is about getting your product to the market first” &amp; in relation to Wang and DEC</td>
</tr>
<tr>
<td>Stability</td>
<td></td>
<td>2, 3, 4, 9, 15</td>
<td>(Collins and Grimes, 2008)</td>
<td></td>
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<tr>
<td>Strategic Alliances</td>
<td></td>
<td>6, 4</td>
<td>(Collins and Grimes, 2008)</td>
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<tr>
<td>Tax</td>
<td>(+)</td>
<td>10, 3, 6, 7, 8</td>
<td>(O’Riain, 2004), (Begley et al., 2005), (Ryan and Giblin, 2012), (Grant, 2013), (NESC, 1982)</td>
<td>“Double Irish” 7 “Taxation is one of the things that drives investment” 3 “The whole corporate tax rate is so important too for survival and thriving of operations in Ireland” 6</td>
</tr>
<tr>
<td>Teamwork increased importance</td>
<td></td>
<td>6, 13, 2</td>
<td>(O’Riain, 2004)</td>
<td></td>
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<tr>
<td>TimeZones</td>
<td>(+)</td>
<td>2, 6</td>
<td></td>
<td>“Link with the east in the morning and the US in the afternoon” 6 “Servicing the US from Ireland. So there is no cross-over between India and the US whereas you have a nice cross-over here and a nice cross-over back to India” 2</td>
</tr>
<tr>
<td>Timing</td>
<td></td>
<td>14, 9, 7</td>
<td></td>
<td>“The only advantage in software is time” (Interview 9)</td>
</tr>
<tr>
<td>Union</td>
<td>(-)</td>
<td>14, 7, 13, 6</td>
<td></td>
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<tr>
<td>Unique product offering</td>
<td></td>
<td>14</td>
<td></td>
<td>Key decision not to continue with subcontract work around 1990. (14)</td>
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<tr>
<td>Value Add</td>
<td></td>
<td>1</td>
<td></td>
<td></td>
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<tr>
<td>Value Chain</td>
<td>(+/-)</td>
<td>11</td>
<td>(O’Riain, 2004), (Collins and Grimes, 2008),</td>
<td>-competence in mandate, extended mandate, move to increased dependence/interaction on suppliers</td>
</tr>
<tr>
<td>Value Chain Embededness - able to compete with sister sites</td>
<td></td>
<td>6</td>
<td>(Barry and vanEgeraat, 2008), (White, 2004)</td>
<td></td>
</tr>
<tr>
<td>Value Chain Process of upgrading</td>
<td></td>
<td>6, 11</td>
<td>(Begley et al., 2005)</td>
<td></td>
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<tr>
<td>Vertical Integration</td>
<td></td>
<td>14</td>
<td>(Sturgeon and Kawakami, 2010)</td>
<td>“Everybody is cheek-by-jowl”</td>
</tr>
<tr>
<td>Vision/Ambition</td>
<td></td>
<td>14, 9</td>
<td></td>
<td>“There is no reason why we cannot become a Glen Dimplex and that’s the ambition” 14 &quot;By the time I am 35 to be… managing a factory. I made up my mind and that was on a piece of paper under my pillow” (13)</td>
</tr>
<tr>
<td>Wage Agreements</td>
<td>(+)</td>
<td></td>
<td>(Ryan and Giblin, 2012)</td>
<td></td>
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<tr>
<td>Wages /Costs</td>
<td>(+/-)</td>
<td>2, 6</td>
<td>(O'Riain, 2004), (Collins and Grimes, 2008), (NESC, 1982)</td>
<td>Changed over time from positive to negative driver. 2, “It went in the end for cost pressures” 6 – Bourns Electronics Manufacturing</td>
</tr>
<tr>
<td>Workforce Characteristics - Talent/ Skilled Workforce</td>
<td>(+/-)</td>
<td>10, 11, 2, 6, 9, 15</td>
<td>(Begley et al., 2005), (Barry and vanEgeraat, 2008)</td>
<td>Talent Availability can be a negative driver, 2, 8 – “and the talent doesn’t exist here so you either have to attract them from Europe to Dublin” or set up overseas. And “If the jobs are here the talent will come” “if you don’t have a skilled workforce for what you need, you are going to go elsewhere” and “a pipeline of skilled workers” “So availability of talent. That was a huge factor” 6 EMC locating in Cork. Talent availability - ~Expertise (8)</td>
</tr>
<tr>
<td>Young population</td>
<td></td>
<td>15</td>
<td>(Begley et al., 2005)</td>
<td>“Because of the young population, we’ve adopted it [advances in telecom and communications] quite well, compared with some other countries” 15</td>
</tr>
</tbody>
</table>
Appendix G: Ireland’s Electronics Industry in the Year 2000

Developed by Department of Electrical and Electronic Engineering of Cork Institute of Technology in conjunction with Parthus. Produced by Dr. Fergus O’Reilly