Using GIS to assess Ireland's knowledge economy and its readiness for knowledge based activity

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Using GIS to assess Ireland’s knowledge economy and its readiness for knowledge based activity

Niall McGuinness

A dissertation submitted in partial fulfilment of the requirements of
Dublin Institute of Technology for the degree of
M.Sc. in Computing (Knowledge Management)

November 2007
I certify that this dissertation which I now submit for examination for the award of MSc in Computing (Knowledge Management), is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

This dissertation was prepared according to the regulations for postgraduate study of the Dublin Institute of Technology and has not been submitted in whole or part for an award in any other Institute or University.

The work reported on in this dissertation conforms to the principles and requirements of the Institute’s guidelines for ethics in research.

Signed: Niall McGuinness

Date: 05 November 2007
1 ABSTRACT

The attractiveness of emerging low wages economies to primary industries such as manufacturing and production is forcing many western economies to transition to Knowledge Economies. In the absence of many forms of primary industry lost to low wage economies, the European Union and its members are fast realising the importance of attracting knowledge based enterprise in order to maintain Europe’s economic climate.

Ireland too has a stated aim to become a knowledge economy by the year 2010. This can be achieved by investing in higher education and attracting knowledge industry to the country. Ireland has made some progress to achieving this aim. The purpose of this project is to assess the current state of Ireland’s Knowledge Economy in light of set targets for 2010.

This project proposes to use a Geographical Information System (GIS) and the principles of Knowledge Management to assess Ireland’s progress towards its Knowledge Economy objectives. GIS and principles of knowledge management can be used to give an alternative and richer overview of Ireland’s knowledge economy and help to identify areas of Ireland that are on target to reach the knowledge economy objectives and are suitable for further knowledge based enterprise investment.

Key words: knowledge economy, knowledge management, geographical information systems, knowledge based enterprise
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# TABLE OF CONTENTS

1 ABSTRACT ......................................................................................................................... II

TABLE OF FIGURES ............................................................................................................... VII

1. INTRODUCTION ................................................................................................................. 1

1.1 Project Introduction ....................................................................................................... 1
1.2 Background ...................................................................................................................... 2
1.3 Research Problem ......................................................................................................... 3
1.4 Intellectual Challenge .................................................................................................... 4
1.5 Research Objectives ..................................................................................................... 4
1.6 Research Methodology .................................................................................................. 6
1.7 Resources ....................................................................................................................... 7
1.8 Scope and Limitations ................................................................................................. 8
1.9 Project Deliverables ..................................................................................................... 9
1.10 Organisation of the Dissertation ................................................................................ 9

2 THE KNOWLEDGE ECONOMY ............................................................................. 11

2.1 Introduction .................................................................................................................. 11
2.2 The Knowledge Economy ........................................................................................... 11
2.3 The Challenges of a Knowledge Economy ................................................................... 20
2.4 Ireland’s Knowledge Economy .................................................................................... 24
2.5 Conclusion .................................................................................................................... 33

3 KNOWLEDGE BASED INDUSTRY IN IRELAND ........................................ 35

3.1 Introduction .................................................................................................................. 35
3.2 Knowledge Based Industries ....................................................................................... 35

3.2.1 What is Knowledge Based Industry? ................................................................... 35

3.2.2 What sectors does Knowledge Based Industry encompass? ................................ 36

3.3 The Research and Development Component to the Knowledge Economy ............. 37
3.4 Conclusion .................................................................................................................... 45

4 GEOGRAPHICAL INFORMATION SYSTEMS .................................. 46
4.1 INTRODUCTION............................................................................................................ 46
4.2 GEOGRAPHICAL INFORMATION SYSTEMS .............................................................. 46
  4.2.1 Geographical Information Systems Definition.................................................. 46
  4.2.2 A Brief History of GIS............................................................................................ 47
  4.2.3 The Modern Day GIS ............................................................................................ 49
4.3 THE USES OF GIS .................................................................................................... 51
4.4 THEMATIC MAPS, SPATIAL ANALYSIS AND IRELAND’S KNOWLEDGE ECONOMY 53
  4.4.1 Thematic Map Definition....................................................................................... 53
  4.4.2 Spatial Analysis Definition...................................................................................... 54
4.5 CONCLUSION ............................................................................................................ 54

5 APPLING THE PRINCIPLES OF KNOWLEDGE MANAGEMENT TO THE KNOWLEDGE ECONOMY ............................................................................................................. 55
5.1 INTRODUCTION............................................................................................................ 55
5.2 KNOWLEDGE MANAGEMENT ................................................................................... 55
  5.2.1 The Rise of Knowledge Management ................................................................. 55
  5.2.2 Definition of Knowledge Management .............................................................. 57
  5.2.3 Benefits of Knowledge Management .................................................................... 59
  5.2.4 The Relationship between Knowledge Management and the Knowledge Economy ...................................................................................................................... 60
5.3 ASSESSING IRELAND’S KNOWLEDGE ECONOMY WITH THE PRINCIPLES OF KNOWLEDGE MANAGEMENT ............................................................................................................. 60
  5.3.1 Capture tacit knowledge about why companies choose to locate here ....... 60
  5.3.2 Assess Ireland’s Intellectual Capital................................................................. 61
  5.3.3 Disseminate Knowledge about Ireland’s Knowledge Economy ..................... 62
  5.3.4 Who should use this information? ..................................................................... 63
5.4 CONCLUSION ............................................................................................................ 64

6 PLOTTING IRELAND’S KNOWLEDGE ECONOMY WITH GIS.......................... 65
6.1 INTRODUCTION............................................................................................................ 65
6.2 WHAT CONSTITUTES A KNOWLEDGE MANAGEMENT TOOL?....................... 65
6.3 GIS AS A KNOWLEDGE MANAGEMENT TOOL ..................................................... 66
6.4 A SPATIAL ANALYSIS OF IRELAND’S KNOWLEDGE ECONOMY ...................... 67
7 A KNOWLEDGE BASED INDUSTRY FRAMEWORK AND SUPPORTING THEMATIC MAP

7.1 INTRODUCTION

7.2 FRAMEWORK

7.2.1 Drivers for Innovation

7.2.2 Survey Results

7.2.3 Knowledge Based Industry Framework

7.3 GIS IMPLEMENTATION

7.3.1 Area Background

7.3.2 Area Statistics

7.3.3 Area Results in Comparison to Survey

7.3.4 Area Results in Comparison to Irish Knowledge Economy Goals

7.4 SUITABLE AREA FOR KNOWLEDGE BASED ENTERPRISE

7.5 EVALUATION OF GIS

7.6 CONCLUSION

8 CONCLUSION

8.1 INTRODUCTION

8.2 RESEARCH DEFINITION & RESEARCH OVERVIEW

8.3 CONTRIBUTIONS TO THE BODY OF KNOWLEDGE

8.4 EXPERIMENTATION, EVALUATION AND LIMITATION

8.5 FUTURE WORK & RESEARCH

8.6 CONCLUSION

BIBLIOGRAPHY

APPENDIX A

APPENDIX B
## TABLE OF FIGURES

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIGURE 1</td>
<td>EMPLOYMENT SECTOR GROWTH 2005-2020 (ESRI)</td>
<td>42</td>
</tr>
<tr>
<td>FIGURE 2</td>
<td>GIS ARCHITECTURE (LONGLEY ET AL, 2005)</td>
<td>50</td>
</tr>
<tr>
<td>FIGURE 3</td>
<td>ECONOMIST INTELLIGENCE UNIT SURVEY RESULTS (ECONOMIST INTELLIGENCE UNIT, 2007)</td>
<td>69</td>
</tr>
<tr>
<td>FIGURE 4</td>
<td>THE PERCENTAGE OF EMPLOYEES DEVOTED TO R&amp;D OF THE COMPANIES SURVEYED (AUTHOR)</td>
<td>70</td>
</tr>
<tr>
<td>FIGURE 5</td>
<td>PERCENTAGE OF EMPLOYEES DEVOTED TO IT (AUTHOR)</td>
<td>71</td>
</tr>
<tr>
<td>FIGURE 6</td>
<td>THE MOST IMPORTANT LOCATION BASED FACTORS TO ORGANIZATIONS SURVEYED (AUTHOR)</td>
<td>72</td>
</tr>
<tr>
<td>FIGURE 7</td>
<td>MINIMUM EDUCATIONAL ACHIEVEMENT FOR EMPLOYMENT (AUTHOR)</td>
<td>73</td>
</tr>
<tr>
<td>FIGURE 8</td>
<td>THE IMPORTANCE OF THE PRESENCE OF AN EDUCATED WORKFORCE (AUTHOR)</td>
<td>73</td>
</tr>
<tr>
<td>FIGURE 9</td>
<td>PROXIMITY TO UNIVERSITIES (AUTHOR)</td>
<td>74</td>
</tr>
<tr>
<td>FIGURE 10</td>
<td>UNIVERSITY AS A FACTOR (AUTHOR)</td>
<td>74</td>
</tr>
<tr>
<td>FIGURE 11</td>
<td>THE CONTRIBUTION OF UNIVERSITY GRADUATES (AUTHOR)</td>
<td>74</td>
</tr>
<tr>
<td>FIGURE 12</td>
<td>THE QUALITY OF PUBLIC TRANSPORTATION (AUTHOR)</td>
<td>75</td>
</tr>
<tr>
<td>FIGURE 13</td>
<td>TRANSPORTATION AS A FACTOR (AUTHOR)</td>
<td>75</td>
</tr>
<tr>
<td>FIGURE 14</td>
<td>FIRMS AWARENESS OF THE KNOWLEDGE ECONOMY (AUTHOR)</td>
<td>76</td>
</tr>
<tr>
<td>FIGURE 15</td>
<td>ORGANIZATIONS CONTRIBUTION TO THE KNOWLEDGE ECONOMY (AUTHOR)</td>
<td>76</td>
</tr>
<tr>
<td>FIGURE 16</td>
<td>KNOWLEDGE BASED INDUSTRY FRAMEWORK (AUTHOR)</td>
<td>77</td>
</tr>
<tr>
<td>FIGURE 17</td>
<td>EUROPEAN CORPORATION TAX RATES (AUTHOR)</td>
<td>78</td>
</tr>
<tr>
<td>FIGURE 18</td>
<td>PERCENTAGE OF POPULATION UNDER 25 BY 2010 (AUTHOR)</td>
<td>79</td>
</tr>
</tbody>
</table>
FIGURE 19: PERCENTAGE OF THE POPULATION AGED BETWEEN 25 AND 34 WHO HAD ACHIEVED TERTIARY EDUCATION BY 2004 (CSO, 2007).............80

FIGURE 20: DEGREE BY COUNTY (CSO, 2007)...............................................................84

FIGURE 21: MAJOR UNIVERSITIES OF IRELAND (AUTHOR).................................85

FIGURE 22: IRISH LABOUR COSTS VERSUS EUROPEAN LABOUR COSTS (AUTHOR)....................................................................................................................86

FIGURE 23: THE IRISH TRANSPORT NETWORK (AUTHOR).............................87

FIGURE 24: TELECOMMUNICATIONS RATES TO EUROPEAN COUNTRIES (IDA IRELAND, 2007).........................................................................................................................88

FIGURE 25: THE NUMBER OF RESEARCHERS IN IRELAND AS OF 2002 (CSO, 2007)..............................................................................................................................89

FIGURE 26: CASTLEKNOCKS’ LOCATION (AUTHOR)........................................90

FIGURE 27: UNIVERSITIES IN CASTLEKNOCKS’ REGION (AUTHOR)........91

FIGURE 28: UNIVERSITIES PROXIMITY TO CASTLEKNOCK (AUTHOR).................................................................................................................................92

FIGURE 29: PUBLIC TRANSPORT AVAILABLE IN CASTLEKNOCK (AUTHOR)..................................................................................................................94

FIGURE 30: EVALUATION OF THE USEFULNESS AND USABILITY OF THE GIS IMAGES GENERATED FOR THIS PROJECT (AUTHOR).........................................................................................97

FIGURE 31: THE APPLICABILITY OF GIS SURVEY RESPONSES (AUTHOR)..................................................................................................................98
# TABLE OF TABLES

**TABLE 1:** EUROPE’S KNOWLEDGE BASED INDUSTRIES AS OF 2002  
(BRINKLEY AND LEE, 2006)..............................................................................................................15

**TABLE 2:** THE PROJECTED NUMBER OF RESEARCHERS REQUIRED FOR  
IRELANDS KNOWLEDGE ECONOMY FOR THE YEAR 2010 (EXPERT GROUP  
ON FUTURE SKILLS NEEDS, 2004)..................................................................................................19

**TABLE 3:** EMPLOYMENT IN KNOWLEDGE BASED INDUSTRIES 1995-2005  
(BRINKLEY AND LEE, 2006)..............................................................................................................25

**TABLE 4:** MOST NEW JOBS IN KNOWLEDGE BASED INDUSTRIES 1995-2005  
(BRINKLEY AND LEE, 2006)..............................................................................................................25

**TABLE 5:** EUROPE’S INVESTMENT IN KNOWLEDGE (BRINKLEY AND LEE,  
2006)......................................................................................................................................................27

**TABLE 6:** TOP 5 EDUCATIONAL HOTSPOTS OF IRELAND ACCORDING TO  
CSO DATA 2002 (CSO, 2007)............................................................................................................81

**TABLE 7:** TOP 5 R&D HOTSPOTS AS OF 2002 (CSO, 2007).........................................................82

**TABLE 8:** TOP 5 BANKING AND FINANCIAL SERVICES HOTSPOTS AS OF  
2002 (CSO, 2007)...............................................................................................................................82

**TABLE 9:** TOP 5 IT HOTSPOTS AS OF 2002 (CSO, 2007)..............................................................83

**TABLE 10:** TOP 5 TECHNICAL TESTING AND ANALYSIS HOTSPOTS AS OF  
2002 (CSO, 2007)..............................................................................................................................83

**TABLE 11:** AVERAGE LABOUR COSTS PER COUNTRY (IDA IRELAND,  
2007)..................................................................................................................................................93
1. INTRODUCTION

1.1 Project Introduction

The world is experiencing a new industrial revolution – ‘the Knowledge Revolution’ – fuelled by technological advances and the possibilities these offer (Inter Departmental Committee on Science, Technology and Innovation, 2004). The European Union and its members have realized that to remain a sustainable and competitive economy during this revolution, it must transform to become a knowledge-based economy, where the majority of its workforce is transformed into ‘knowledge workers’ working in industries which depend on the intellect and skills of these workers to become and remain competitive (OECD, 2001).

Ireland is one member of the European Union which has made achieving a knowledge economy a primary aim of its current and future government policy. Central to achieving this aim is attracting the right kind of multi-national enterprises to locate in Ireland and to establish the knowledge based industries, and more traditional industries which require knowledge services and products, to locate in Ireland (Inter Departmental Committee on Science, Technology and Innovation, 2004). Numerous initiatives have been established directly by Irish government, government agencies, industry sectors and educational institutes to assist with this endeavour in particular promoting and investing in foreign and indigenous R&D activity (Inter Departmental Committee on Science, Technology and Innovation, 2004).

A key part of these initiatives is to project an image of Ireland’s present and future capabilities which highlight how it can meet the needs of these enterprises. GIS and more specifically thematic maps, maps that display socio-economic or demographic data, could offer a potentially powerful tool in this effort. The premise of the project is to investigate the feasibility of utilizing thematic maps to assist in projecting an image of Ireland’s capabilities which could be used by those involved in initiatives to attract enterprises to Ireland and to such enterprises themselves to investigate the possibilities Ireland could offer.
Numerous factors are involved in enterprises decision to locate particular aspects of its business in a particular country. Similarly all initiatives involved in trying to attract such enterprises have different priorities which influence how they present Ireland. The first part of this project therefore focused on researching the current state of Ireland’s knowledge economy, to identify the types of multi-national enterprises already present in Ireland and proposed extensions of their presence. As part of this, the project investigated what factors influenced the decision to locate in specific areas of Ireland. The findings of this research contributed to the creation of a framework which would form the basis for the creation and evaluation of a thematic map of Ireland’s knowledge economy which could be used to highlight how Ireland could fulfil the requirements of prospective multi-national enterprises considering location in Ireland.

1.2 Background

In recent times Ireland has struggled to compete in the manufacturing sector with many companies opting to relocate their businesses to economies where the manufacturing process is more cost effective to operate and sustain. Consequently, Ireland needs to reposition itself as a Knowledge Economy, one in which employees that previously operated in the low skilled manufacturing area become “knowledge workers” and more suited to work in more highly-skilled positions, for example the research and development area. Ireland will have to embrace this social and scientific revolution and Ireland’s workforce will have to manifest itself into a competitive and enterprising proletariat in the new Knowledge Economy (Inter Departmental Committee on Science, Technology and Innovation, 2004).

At the core of this knowledge revolution will be new knowledge and service based initiatives. Research and Development in particular is considered to be an integral component of the Irish Knowledge Economy (Inter Departmental Committee on Science, Technology and Innovation, 2004). The Irish Interdepartmental Committee on Science, Technology and Innovation considers Research and Development activity vital to the success of Ireland’s Knowledge Economy.
“R&D is at the heart of Irish economic and social development. Investment in R&D is the foundation for increased productivity growth, a source of opportunity in new growth areas and a basis for creating knowledge driven competitive advantage across all sectors of the economy. “

(Inter Departmental Committee on Science, Technology and Innovation, 2004)

By attracting knowledge based enterprise and up-skilling its workforce, Ireland can become a leading knowledge economy of the future.

1.3 Research problem

The primary aim of the project was to investigate the feasibility of utilizing thematic maps to assist in projecting an image of the current and future capabilities of Ireland’s knowledge economy which could be used as a tool by those involved in initiatives to attract multi-national enterprises to locate Ireland.

The applications of GIS, while potentially infinite, traditionally include industries such as utilities management, telecommunications management, transportation management, emergency management, and health care applications (Longley et al., 1999). The research involved in this project was to investigate the usefulness of one aspect of GIS technology to the problem where the factors influencing the thematic map were drawn from an economic viewpoint, rather than the more traditional utilities and logistical factors which are traditionally associated with GIS.

The focus of the research was to highlight GIS usefulness as a knowledge management tool and moreover, how this knowledge management tool can be used to help understand Ireland’s Knowledge Economy.
1.4 Intellectual challenge

The intellectual challenges for this dissertation spanned all sections. These were:

- Investigate the current state of Ireland’s knowledge economy
- Research the priorities of the major initiatives in Ireland which are involved promoting Ireland’s knowledge economy world-wide, to gain an understanding in particular of the role multi-national enterprises have played and will play in helping establish such an economy and to identify the types of enterprise Ireland is currently trying to attract
- Research the factors that determine such an enterprises decision to locate a knowledge based enterprise in a particular area
- Devise a framework for presenting an image of Ireland based on these factors
- Investigate the appropriateness of implementing a GIS based assessment of the Irish Knowledge Economy through the creation of a thematic map
- Evaluate and critique the findings

1.5 Research objectives

The following objectives have been achieved throughout the dissertation and contributed to the overall outcome to highlight the appropriateness and usefulness of implementing a GIS based assessment of the Irish Knowledge Economy:

To achieve this end, the project may was divided up into 6 objectives. These were,

1. Perform a literature review of papers and sources pertaining to the Knowledge Economy
   - A literature review to determine the meaning of the knowledge economy, the European Union’s vision for a knowledge economy and Ireland’s aims for a knowledge economy was conducted.
2. Perform a literature review of the principles of Knowledge Management and how they apply to the aim of the project

   o A review of the principles of knowledge management and their applicability to the objective of the project was conducted

3. Perform a literature review of the usefulness of Geographical Information Systems

   o A literature review of the history, definition and traditional uses of geographical information systems was performed

4. Develop a framework that captures the factors that affect a knowledge based enterprise organizations’ decision to locate in a particular area

   o The factors that knowledge based enterprise organizations deem important to establish in a particular area were collated via an organizational survey and developed into a knowledge based enterprise framework

5. Apply the framework to a thematic map of an area to assess the areas readiness for knowledge based enterprise

   o A thematic map of an area of Ireland was then assessed against knowledge based enterprise framework to determine the areas readiness or suitability for knowledge based enterprise

6. Assess Ireland’s Knowledge Economy based on the results provided by GIS

   o The current state of Ireland’s knowledge economy was assessed against its vision for 2010
1.6 Research methodology

Both primary and secondary research was performed throughout the duration of this project. The secondary research comprised of a literature review of material pertaining to four topics:

- The Knowledge Economy: its definition, its benefits, the European Union’s vision for a knowledge economy and Ireland’s vision for a knowledge economy.
- Knowledge Based Industry: its definition, its benefits, its scope in terms of industries incorporated and the importance of the need to attract knowledge based industry
- Knowledge Management: its definition, its benefits form an organizational context, the principles of knowledge management and how these principles can be applied to the problem of assessing Ireland’s knowledge economy
- Geographical Information Systems: their definition, their uses and justification on how they can be used to assess Ireland’s knowledge economy

The varying sources used to complete the literature review topics included:
- White papers
- Journals
- Books
- Conference proceedings
- Organizational websites

The primary research conducted for this project involved an organizational survey of a number knowledge based enterprises currently operating in Ireland to determine the factors they considered important when choosing to locate here. The survey results, combined with the findings of the literature review on the knowledge economy and knowledge based enterprise were collated into a knowledge based industry framework of the factors essential to attract knowledge intensive industry to Ireland.
Once the framework had been devised, a GIS representation (thematic map) of an area of Ireland was developed and compared to the framework to assess the Irish knowledge economy.

Finally, a second organizational survey regarding the quality and appropriateness of the GIS based analysis of the Irish Knowledge Economy was conducted in order to get industry feedback on the applicability of GIS.

1.7 Resources

The following resources were essential components to the completion of this project:

- GIS Software/Package

Access to GIS software (MapPoint 2006) was a core component of this project, without which the thematic map could not have been developed

- Library Facilities

Access to both the Dublin Institute of Technology Library facilities and the NUI Maynooth Library facilities were of enormous benefit to the completion of this project and allowed me to access valuable sources for the literature review sections

- Computer

Access to a computer and word processing software was vital in order to complete this dissertation and to provide a facility to store my work

- Internet and Email access

The availability of the internet was crucial to this project and allowed me to access a wealth of online material to aid the literature review section. Access to my email allowed to not only communicate with my supervisor and industry contacts for the
purposes of the organizational survey, but also provided an alternative location to store my work

- Access to supervisor

Access to my supervisor through meetings and email was vital throughout this project for advice and guidance

- Industry contacts

Access to industry contacts from knowledge based industry and the IDA were essential for the completion of the organizational survey

- Survey Software

Access to survey software was essential to complete the organizational survey. The survey tool available at [http://www.surveymonkey.com](http://www.surveymonkey.com) was used to create and distribute the survey for this project.

### 1.8 Scope and limitations

This project’s sole focus was on the knowledge economy and in particular knowledge based industries that practice research and development. R&D enterprises form only a single component of knowledge based enterprise and other sectors of knowledge based industry such as the financial services sector, the environmental management sector and the Media and Entertainment sector was not incorporated into this work.

In terms of the socio-economic data used to produce the thematic map for the project, Irish census data from the year 2002 was used. At the time of writing, socio-economic data collated by the Irish Central Statistics Office (CSO) for the 2006 census of Ireland was not available to the public. In this respect, all conclusions reached about the Irish Knowledge Economy are based on CSO 2002 census data.
1.9 Project Deliverables

This project had 7 deliverables. These were

1. A literature review of the knowledge economy
2. A literature review of knowledge based enterprise
3. A literature review of knowledge management
4. A literature review of geographical information systems
5. A framework of factors knowledge based enterprise deem important when considering to locate in a particular area
6. A thematic map of an area of Ireland to highlight the socio-economic conditions of the area
7. A review of Ireland’s Knowledge Economy based on a comparison of the knowledge based enterprise framework and the information contained in the thematic map

1.10 Organisation of the dissertation

This dissertation is divided into seven chapters. Chapter two will introduce the reader to the concept of the Knowledge Economy, its definition, the reason why the Knowledge Economy is important, the benefits of a Knowledge Economy, the aims of the Lisbon Agenda – the European Union’s manifesto for its transition into a Knowledge Economy and finally Ireland vision for its own Knowledge Economy.

Chapter three will define what is meant by the term ‘knowledge based enterprise’, the types of industry knowledge based enterprise span and why attracting knowledge based is important to the knowledge economy.

Chapter four will introduce Geographical Information Systems, its definition and its uses in contemporary industry.
Chapter five will introduce the concept of Knowledge Management and illustrate how the principles of Knowledge Management may be applied to an analysis of the Irish Knowledge Economy.

Chapter six will define what the term a ‘Knowledge Management Tool’ and illustrate why Geographical Information Systems can be categorized as a Knowledge Management Tool.

Chapter seven will develop a knowledge based enterprise framework of factors that knowledge industry deem important when choosing to locate in a particular area. This chapter will include the results of the organizational survey conducted as part of this research and use the results to develop the framework. The framework will then be compared to a thematic map of an area of Ireland to determine the areas readiness for knowledge based enterprise. The thematic map will be developed using a geographical information system and will be based on Irish census 2002 data.

Finally chapter eight contains results, conclusions and future areas of work identified as a result of the research conducted for this project.
2 THE KNOWLEDGE ECONOMY

2.1 Introduction

Establishing the current state of Ireland’s knowledge economy is central to the research of this project. Fundamental to this therefore, is establishing the motivation behind Ireland’s aspiration to become a knowledge economy, the challenges faced and factors which will influence the achievement of this aspiration. A key aim is the formulation of a definition of the term knowledge economy which is suitable for Ireland’s current state and future aspirations. This chapter presents the results of the literature review conducted to achieve this.

Since Ireland’s aims and objectives are very much linked to the wider global community in which it exists, the chapter opens by presenting the wider global movement towards the creation of a knowledge economy and society, focusing in particular on the aims and objectives of the European Union and progress in this regard. The various components of a knowledge economy are examined and the challenges and factors influencing the transformation to a knowledge economy are presented and discussed. In particular, the challenges of transitioning from a traditional agricultural and capital based economy to a knowledge economy will be examined since this is the particular focus for Ireland. The chapter will conclude by presenting a cohesive definition for Ireland’s knowledge economy and presenting a summary of the current state of Ireland’s economy with this definition in mind, identifying the particular challenges Ireland faces and the future evolution envisaged for its fledgling knowledge economy.

2.2 The Knowledge Economy

2.2.1 The Changing Face of Industry

The dawn of the 21st century spawns a new social and technological revolution, the knowledge revolution. As society progresses both in a technological and social context, its reliance on capital and agricultural activities as forms of wealth generation...
and economic equilibrium is superseded by the inexorable momentum of information technology and its influence on how businesses operate.

'Knowledge is now becoming the one factor of production, sideling both capital and labour.' Drucker (1998)

The world is experiencing a new industrial revolution – ‘the Knowledge Revolution’ – fuelled by the pace of technological advances and change. Neo-classical economies that traditionally only recognized two fundamental factors of production, labour and capital are now beginning to transition from physically-based wealth generation to ‘knowledge-based’ wealth creation. While more traditional, physically-based employment sectors such as agriculture and manufacturing continue to be of relevance to economies, they have experienced somewhat of a decline in their share of employment relative to the services sector in recent years. The share of employment in the service sector has experienced considerable growth (National Skills Strategy, 2007, p6).

Many external factors are contributing to the irrevocable progression of western societies towards knowledge economies. The emergence of low cost economies such as China, India and other south-east Asian nations are exerting enormous pressure on western economies. They operate increasingly within the technology domain and are systematically exerting pressure on the competitive capability of the global triad – the EU, US and Japan (McBrierty and Kinsella, 1998, p6). A major factor contributing to the changing face of industry has been the rapid pace of technological advances and innovation. The emergence of low-cost, ubiquitous computing has transformed the way businesses all over the world operate, and has contributed immensely to the shift away from traditional agricultural and capital based economies.

Advances in the science and technology sectors and the ability to process and transmit not only information but intellectual capital instantaneously has seen an increase in the importance of the knowledge based industry sector and the role that it plays within the economy (World Bank, 2002, p4). The transition from capitalistic economies to knowledge economies, spurred by the increased role of knowledge intensive service activities (KISA) is well underway.
2.2.2 Knowledge Economy Definition

The knowledge economy, in simple terms, refers to economies whose primary source of wealth generation focuses on technological, scientific or knowledge based industries as opposed to the more traditional capitalistic or agricultural industries. The OECD recognises the knowledge economy as

‘...economies which are directly based on the production, distribution and use of knowledge and information. This is reflected in the trend in OECD economies towards growth in high-technology investments, high-technology industries, more highly-skilled labour and associated productivity gains.’ OECD (1996), p7

The term ‘Knowledge Economy’ acknowledges the role that knowledge-based industries and technology play in sustained economic growth and an economic transition to a more technologically advanced and evolved economy in comparison to the more traditional agricultural and capital based economies of the past. The term “knowledge-based economy” results from a fuller recognition of the role that knowledge and technology play in economic growth. Knowledge, as embodied in human beings (as “human capital”) and in technology, has always been pivotal in economic development however it is only in the last few years that its relative importance been recognised, just as that importance is growing. (OECD, 1996, p9)

That importance stems from increasing competition from emerging economies in the manufacturing sectors in particular. Economies that are losing out on manufacturing jobs are increasingly relying on knowledge-based enterprise to spur economic growth.

Leadbeater (Leadbeater, 1999) argues that the knowledge economy does not have to be confined simply to knowledge-based services and industry in the science and technology sectors. Alternatively, Leadbeater proposes that the knowledge economy can permeate all aspects of industry, including the more traditional agricultural and capitalistic industries that the knowledge economy itself is attempting to replace. Leadbeater envisages a knowledge economy that encompasses and incorporates all sectors of industrial activity, not just the scientific and technological realms as many
theorists and economists anticipate. He argues that the knowledge driven economy is not just a reference to high tech industries but a description of a new sources of competitive advantage which can apply to all sectors of industry, from agriculture and retailing to software and biotechnology (Leadbeater, 1999).

It is clear that irrespective of industrial sector, the knowledge economy is a looming reality and in order for companies and organizations to keep pace in an ever increasing global market place, they need to recognize and acknowledge such an economic transition and the requirements and skills needed in order to exist in it.

2.2.3 The EU Knowledge Economy Objectives

The 2000 Lisbon Agenda is the European Union’s manifesto illustrating its vision for Europe’s transition into a Knowledge Economy. The aim of the 2000 Lisbon Agenda is to transform Europe into a fully functional Knowledge Economy by the year 2010. An essential component of this vision is to increase gross expenditure on research and development within the region to 3 per cent, an aim that will enable Europe to catch up with competitor economies such as Japan and the US who currently spend roughly 3 per cent on research and development.

At present, the European Union lags some way behind its Knowledge Economy contemporaries in terms of research and innovation performance. Gross expenditure on R&D as a percentage of GDP is 1.9% in the EU compared with 2.7% in the United States and 3.1% in Japan. In order to catch up with these Knowledge Economy powerhouses, the EU proposed a research and development target of 3% of GDP by the year 2010, with two thirds of the increase to come from the business (Inter Departmental Committee on Science, Technology and Innovation, 2004, p2).

Europe’s ambitious vision of a Knowledge Economy is an attempt to increase competitiveness and annual economic growth within the region despite the lure low-wage economies such as China and India present for European industries. It is an attempt to not only quell the dispersal of low-end industry to low cost economies and high-end researchers to more advanced knowledge economies, but to evolve and transform the type of business conducted with the region. The more the European
Union can develop its knowledge and market opening initiatives in tandem, the stronger and more competitive each member state would become. The Lisbon Agenda is a comprehensive and self-reinforcing series of reforms. (Kok 2004)

Despite the series of steps put forward by the Lisbon Agenda, some economists argue that measuring the extent of the success of the agenda, or moreover, the extent of member states compliance with the steps illustrated by the Lisbon Agenda, is an impossible task. There is an urgent need to assess the knowledge economy in the absence of a concrete definition. Brinkley argues that without measurable definitions, the knowledge economy will remain a vague concept. The impact of the knowledge economy on industrial organization and society would remain more a matter of intuition as opposed to a demonstrable proof based on solid evidence. Brinkley states that without a tangible or quantifiable definition of the term ‘knowledge economy’, basic questions such as, how big is the knowledge economy, or, how many people work in the knowledge economy and what rate is it growing at will become impossible to answer. (Brinkley 2006, p12)

It is vital that the terms set out in the Lisbon agenda are quantified and measured to assess not only how Europe is performing seven years on in light of the goals set out in 2000 but also, and equally important, to determine the areas in need of improvement and the aims which Europe as a whole has failed to achieve.

Table 1 below illustrates Europe’s knowledge industries as of 2005
EU 15 % of Total Employment

<table>
<thead>
<tr>
<th>Category</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tech Based Manufacturing</td>
<td>6.9%</td>
</tr>
<tr>
<td>- High Tech Manufacturing</td>
<td>1.1%</td>
</tr>
<tr>
<td>- Medium Tech Manufacturing</td>
<td>5.8%</td>
</tr>
<tr>
<td>Marketing Services</td>
<td>15.3%</td>
</tr>
<tr>
<td>- High Tech Services</td>
<td>3.5%</td>
</tr>
<tr>
<td>- Financial Services</td>
<td>3.2%</td>
</tr>
<tr>
<td>- Business / Communications</td>
<td>8.6%</td>
</tr>
<tr>
<td>Health, Education, Cultural</td>
<td>19.4%</td>
</tr>
<tr>
<td>All Tech and Knowledge Based</td>
<td>41.5%</td>
</tr>
</tbody>
</table>

Table 1: Europe’s Knowledge Based Industries as of 2005
Source: Brinkley and Lee, 2006, p7

Over the past decade a substantial portion of new jobs within the EU15 or European Union, has come from the expansion of the knowledge based industries. Between the years 1995 and 2005, employment within the knowledge based industries has grown by 24 per cent in contrast with a growth of just under 6 per cent for the rest of the EU15 economy (Brinkley and Lee 2006, p7).

It is clear that Europe is making some strides towards the knowledge economy envisaged by the Lisbon Agenda. Brinkley and Lee argue that there has been a significant increase in the amount employed by knowledge-based industries in Europe however they go on to state that although Europe has seen substantial growth in this area, productivity levels of these knowledge-based industries have failed to match productivity levels in the U.S, a region which has experienced almost identical knowledge-based industrial growth as Europe.

Brinkley and Lee argue that despite the relative growth of employment within knowledge-based industries within the EU, there has been minimal pay-off in terms of increasing potential growth and productivity of Europe. Contrary to predictions, the
expansion of employment in knowledge-based industries has in fact produced a slowdown in productivity growth in Europe in comparison to a similar expansion of knowledge based employment in the US which has yielded a substantial acceleration in productivity growth (Brinkley and Lee, 2006, p11). Brinkley and Lee also argue the merits of the three per cent R&D investment figure set out by the Lisbon agenda in light of figures spent on R&D in other OECD economies. The United States was investing roughly 2.8 per cent of GDP at the time of the Lisbon Agenda which has since fallen to just under 2.7 per cent. Only three OECD economies invest three per cent or more of their GDP on R&D, Finland, Sweden and Japan and a case can be argued that Japan has been over-investing in R&D (Brinkley and Lee, 2006, p19).

Brinkley and Lee continue to argue that such a figure is unattainable in Europe’s current state and that a three per cent target as currently formulated is unachievable given the fact that R&D investment across the EU has increased by less than 0.1 per cent of GDP in ten years. Based on such stagnant growth margins it would take a remarkable increase in the rate of investment to reach the three per cent target by the year 2015, let alone the year 2010 as set put by the Lisbon agenda. To further highlight the arduousness of the task set out by the agenda, even if each EU member state were to fully implement their respective national development plans in terms of R&D investment in 2005, R&D spend would only reach 2.6% of GDP by 2010 (Brinkley and Lee, 2006, p19-20).

The Aho report (Aho, 2006) states the Europe is falling behind in terms of the level innovation and R&D activity in the EU region in comparison to other OECD economies. The report indicates that Europe’s failure to keep pace with its contemporaries is due to a reliance on dated and ‘unmodernised’ industrial sectors that have failed to harness to power of ICT. As a result, Aho claims that Europe is losing out as large firms globalise their research and development due its relatively low share in ICT-related sectors and a structural trade deficit in high-tech manufacturing (Aho, 2006, p2)

It is argued that the targets that were set out by the Lisbon agenda are not being met and are thus widening the innovation gulf between Europe and powerful knowledge-based economies such as the U.S and Japan. Aho illustrates this point by highlighting
the fact that Europe devotes a much lower share of its wealth to R&D than the US and Japan, (1.93% of GDP in the EU in 2003 compared to 2.59% in the US and 3.1% in Japan). Furthermore Aho states that China is on track to match the research intensity of the EU by 2010 (Aho, 2006, p13).

It is clear that the goals set out by the Lisbon Agenda can be considered somewhat overzealous and too ambitious to be met within the designated timeframe of 2010 or even 2015 as argued by Brinkley and Lee. However such lofty goals in R&D spend are vital considering the amount currently spent by Japan and the US and the emergence of China as a new world Knowledge Economy with the capability to match more established Knowledge Economies. Europe cannot afford fall behind in this regard and must strive to achieve its Knowledge Economy goals however unrealistic them may seem. The message is clear, increased research and development spend creates an environment conducive to knowledge based industry growth, by attracting and retaining the beast researchers required to sustain and evolve the Knowledge Economy and by increasing competitiveness between member states and global adversaries.

2.2.4 Ireland’s Knowledge Economy Objectives

The ICSTI has set the aim for Ireland to become a fully-fledged knowledge economy by 2010.

‘Ireland by 2010 will be internationally renowned for the excellence of its research and be at the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture.’

Inter Departmental Committee on Science, Technology and Innovation (2004), p19

This knowledge economy is to be realised by implementing and developing a national pro-innovation culture supportive of risk-taking and entrepreneurship, a less bureaucratic process and substantial budget for R&D within the enterprise sector, a national plan to increase the performance and productivity of R&D in the public sector and to make Ireland a highly attractive environment for researchers and research careers. (Inter Departmental Committee on Science, Technology and Innovation 2004, p3)
Progress is being made on these issues however improvement in all areas are needed to establish Ireland as a competitive force among the Knowledge Economies of the world. Ireland’s vision for a knowledge economy can be realized through the following steps, as defined by the Inter Departmental Committee on Science, Technology and Innovation.

“Ireland by 2010 will be internationally renowned for the excellence of its research and be at the forefront in generating and using new knowledge for economic and social progress, within an innovation driven culture”.
(Inter Departmental Committee on Science, Technology and Innovation 2004, p18)

The following targets are proposed to realize this vision:

- Business expenditure on R&D should increase from €917 million in 2001 or 0.9% GNP to €2.5 billion in 2010 or 1.7% GNP
- The number of indigenous companies with minimum scale R&D (in excess of €100,000) activity should double, from 525 in 2001 to 1,050 in 2010
- The number of indigenous enterprises performing significant R&D (in excess of €2 million) should increase from 26 in 2001 to 100 by 2010
- The number of foreign affiliates companies with minimum scale R&D activity (in excess of €100,000) should double, from 239 in 2001 to at least 520
- The number of foreign affiliates performing significant levels of R&D (in excess of €2 million) should increase from 47 in 2001 to 150 by 2010
- R&D performance in the higher education and government sectors should increase from €422 million in 2001 or 0.4% GNP to €1.1 billion in 2010 or 0.8% GNP
- Gross expenditure on R&D should increase to 2.5% of GNP by 2010
- The number of researchers should reach 9.3 per 1,000 of total employment by 2010, from 5.1 per 1,000 in 2001
(Inter Departmental Committee on Science, Technology and Innovation 2004, p18)

Ireland’s proposals to develop and enhance its knowledge economy are heavily reliant on attracting knowledge-based initiatives and industry to the country. A large component of Ireland’s Knowledge Economy is research and development, both in the context of industrial R&D by increasing indigenous R&D investment and attracting
foreign R&D investment and by enhancing R&D performance from within the higher education and government sectors.

It is worth noting that Ireland’s desired gross expenditure on R&D by the year 2010 should be increased to 2.5%, 0.5% lower than the target set out by the Lisbon agenda, as illustrated in section 2.2.3. It is projected that Ireland will need 9.3 employees per 1000 in research to supplement the 2.5% research and development investment figure. Table 2 below illustrates the projected number of researcher needed by the year 2010.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Business Expenditure on R&amp;D</td>
<td>5,800</td>
<td>6,600</td>
<td>8,200</td>
<td>10,000</td>
<td>11,100</td>
</tr>
<tr>
<td>Public Sector R&amp;D Performance</td>
<td>560</td>
<td>560</td>
<td>560</td>
<td>700</td>
<td>810</td>
</tr>
<tr>
<td>Higher Education R&amp;D Performance</td>
<td>3,800</td>
<td>4,400</td>
<td>5,300</td>
<td>6,000</td>
<td>6,400</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>10,160</strong></td>
<td><strong>11,560</strong></td>
<td><strong>14,060</strong></td>
<td><strong>16,700</strong></td>
<td><strong>18,310</strong></td>
</tr>
<tr>
<td>Researchers per 1000 Employment</td>
<td>6.1</td>
<td>6.8</td>
<td>8.0</td>
<td>8.9</td>
<td>9.3</td>
</tr>
</tbody>
</table>

Table 2: The projected number of researchers required for Ireland’s Knowledge Economy for the year 2010.

Source: Expert Group on Future Skills Needs, 2004

2.3 The Challenges of a Knowledge Economy

2.3.1 Why the Knowledge Economy is important globally

If global economies are to fully embrace the knowledge economy paradigm and embrace innovation and change then the accrued knowledge from knowledge based
activity and industry will become a truly valuable resource. Brinkley argues that intellectual property or knowledge will become a vital facet of economic prosperity (Brinkley 2006, p5).

Striglitz reinforces this theory by stressing that investment in education and the harvesting of knowledge can ultimately lead to economic development. Striglitz argues that we can now see economic development as less like the construction business and more like education in the broad sense that covers knowledge, institutions and culture. (Striglitz, 1999, p2)

Both Brinkley and Striglitz predict that knowledge will become an increasingly valuable commodity in the knowledge economy, that ‘know-how’ and intellectual capital will be prized assets in the development of new products and services. However, despite the opinion of many economists that knowledge and know-how will become important facets of economic development however, it is important that the tangible benefits of such activities and the precise value of knowledge to the economy are made clear. The OECD estimates that more than 50 per cent of Gross Domestic Product (GDP) in the major OECD economies is now knowledge-based (OECD, 1996, p9).

This equates to quite a substantial portion of economic activity. According to the World Bank, the ability of economies to acquire and use knowledge is increasingly becoming a major factor in determining the competitiveness that economy and could possibly mark the difference between prosperity and poverty both within and between countries (World Bank, 2002, p1). Countries that are reluctant to transition into knowledge-based societies are in severe danger of lagging behind both in the context of economic prosperity and competitiveness.

2.3.2 Why the Knowledge Economy is important to the EU

There is overwhelming evidence of the vital importance of boosting R&D as a means for the European economy to become more competitive. To fail to act on such evidence would be a fundamental strategic error — yet too many European economies
remain worryingly complacent and need to instil a much greater sense of urgency (Kok, 2004, p21).

If Europe does not act quickly to reform its policies on attracting knowledge-based industry and in particular, research and development activities, the EU is in perilous danger of further lagging behind contemporary knowledge economies such as the US and Japan and being superseded by emerging knowledge economies such as India, China and South Korea.

At the core of the recommendations proposed by the Aho report, is the need for Europe to provide an innovation-friendly market for its businesses, the absence of which is proving to be the main barrier to investment in research and innovation. (Aho, 2006) Between the years 2000 and 2004 spending on research and development within most EU member states remained virtually unchanged, while investment in research and development investment actually fell in Sweden, Finland, Belgium, the UK, the Netherlands and Greece. Europe’s relative position against the US remained unchanged as US spending on R&D has also reduced since the year 2000, however Japan’s investment in R&D increased by 0.15% in the period 2000-2004.

Europe must quickly realise that the US economy is no longer the primary competitive force, and economies such as India, Japan and China are now becoming major forces of world economics. In a survey conducted by the economist intelligence unit (Economist Intelligence Unit, 2007) companies cited India (26% of respondents), the US (22%) and China (14%) as the top three locations to offshore their Research and Development activities. This should send a clear message to the EU that much work needs to be done to make Europe an attractive location for Knowledge Based Enterprise.

2.3.3 Why the Knowledge Economy is important to Ireland?

The ability of Irish companies to research, commercialise, produce and sell higher value-added products and services to foreign markets will be crucial to the future success of Ireland’s Knowledge Economy (ICSTI, 2004, p5).
It is imperative that Ireland exhausts all avenues to ensure that it maintains pace with the economic superpowers. No country can compete without a clear vision and deep understanding of the role that knowledge based industry can play for long term economic and social well-being. The Irish economy needs to advocate a drive to increase awareness of the benefits that sustained knowledge based enterprise can provide for the economy. However, the enterprise sector itself must recognise the importance of increasing research and development levels. A cohesive, tangible and transparent partnership must be established across the higher education sector, Government Departments and agencies if the vision and objectives for Ireland’s Knowledge Economy are to be achieved. (Inter Departmental Committee on Science, Technology and Innovation 2004, p23)

2.3.4 Factors affecting the Knowledge Economy

The co-emergence of scientific and technological advances and globalization has undoubtedly changed the industrial landscape as we know it. The workplace has been transformed by a wealth of new technologies and scientific innovations ranging from information and communications technologies, energy production advances and efficiencies and biotechnologies. As a result we therefore see the knowledge economy driven primarily by technological advance and rising domestic prosperity which increases the demand for knowledge based activity and services (Brinkley, 2006, p10).

As the traditional manufacturing-type industries relocate to more cost effective economies, contemporary industry is consequentially becoming ever more reliant on knowledge and advanced skills as a means to generate profit. Knowledge, information and associated skills have displaced labour as the primary source of productivity and competitiveness - that is to say, brains have replaced brawn. (McBrierty and Kinsella, 1998, p8).

Globalisation is considered to be the cornerstone in the shift from traditional economies to the current information based economies. Globalisation is seen as a key driver and determinant of change across the OECD and it would be foolish to deny the importance of the dramatic increase in international trade and investment flows over the last decade. (Brinkley, 2006, p9) The development of the Knowledge Economy has
been aided greatly by the advent of globalisation. Global organizations have built integrated, international production chains, with innovation (for example, R&D facilities) in the United States and Europe, creating new products that are built in assembly plants in China and shipped back to the West for added value in “knowledge” areas such as design and marketing and providing associated services in Europe and the US (Brinkley, 2006, p9).

Globalization has had a two-pronged affect on western society and their economies. On the one hand, globalisation has provided western economies with cheaper products and produce developed in emerging economies such as China and India. However, on the other hand, the cost of operating and producing such products and produce at such cheap prices has had an almost magnet effect on western economies, with many companies opting to take advantage of economic conditions in such economies, such as low wages and reduced operating cost to boost their profit margins. As a result, manufacturing costs and operations in low wage economies is dictating the nature of jobs and services provided in western economies. This has an adverse effect on the Knowledge Economy. Globalisation is facilitating the rapid spread of emerging skills and technologies, requiring an adaptive, flexible workforce which can meet the changing needs of industry (National Skills Strategy Research Report, 2007, p30).

2.4 Ireland’s Knowledge Economy

2.4.1 Ireland’s Changing Economy

The IDA however, (IDA 2006), states that Ireland can convincingly claim to be a knowledge-based economy, a statement which is reinforced by satisfying the World Bank Group’s four key pillars of a knowledge economy,

- An economic and institutional framework that ensures a stable macroeconomic environment, competition, flexible labour markets and adequate social protection.

- A quality education system that ensures that citizens are equipped to acquire, use and share knowledge
• A dynamic information infrastructure that can facilitate the effective communication, dissemination and processing of information

• Innovative systems that bring together researchers and businesses in commercial applications of science and technology

(IDA, 2006, p3)

Ireland has become in the last two decades one of the most dynamic knowledge-based economies in Europe. Its GDP per capita has risen in 15 years from less than 60% of the EU average to slightly better than the EU average in 2002. Ireland’s growth rate has averaged 6.5% over the past ten years, during which it has created four times as many net jobs as the United Kingdom. Ireland has now become a high-technology powerhouse within the European Union, and has become the largest exporter of software in the region. (World Bank, 2002, p8)

There is no doubt the Irish economy, spurred on by the Celtic Tiger in the 1990’s, has taken enormous strides in terms of economic growth, the ability to attract foreign investment and the amelioration of the Irish workforce. The Irish economy has seen a substantial transformation from a largely agricultural based economy to becoming one of the knowledge based industry powerhouses of Europe. Table 3 below shows employment in Knowledge Based Industries in EU15 in 2005:

<table>
<thead>
<tr>
<th>Country</th>
<th>Manufacturing</th>
<th>Services</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>6.5%</td>
<td>47.8%</td>
<td>54.3%</td>
</tr>
<tr>
<td>Denmark</td>
<td>6.3%</td>
<td>42.8%</td>
<td>49.1%</td>
</tr>
<tr>
<td>UK</td>
<td>5.6%</td>
<td>42.4%</td>
<td>48.0%</td>
</tr>
<tr>
<td>Finland</td>
<td>6.8%</td>
<td>40.5%</td>
<td>47.3%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.3%</td>
<td>41.9%</td>
<td>45.2%</td>
</tr>
<tr>
<td>Belgium</td>
<td>6.5%</td>
<td>38.3%</td>
<td>44.8%</td>
</tr>
<tr>
<td>Germany</td>
<td>10.4%</td>
<td>33.4%</td>
<td>43.8%</td>
</tr>
<tr>
<td>France</td>
<td>6.3%</td>
<td>36.3%</td>
<td>42.6%</td>
</tr>
<tr>
<td>Ireland</td>
<td>6.0%</td>
<td>33.9%</td>
<td>39.9%</td>
</tr>
<tr>
<td>Austria</td>
<td>6.5%</td>
<td>31.0%</td>
<td>37.5%</td>
</tr>
<tr>
<td>Italy</td>
<td>7.4%</td>
<td>29.8%</td>
<td>37.2%</td>
</tr>
</tbody>
</table>
Spain 4.7%  27.0%  31.7%
Greece 2.1%  24.5%  26.6%
Portugal 3.3%  22.7%  26.0%
EU15 6.7%  34.7%  41.4%

Table 3: Employment in Knowledge Based Industries within the EU15 as of 2005
Source: Brinkley and Lee, 2006, p6

Claims that Ireland is now a Knowledge Economy appear to be founded when the level of new jobs created in knowledge based industries is assessed against the rest of the E.U economies. Table 4 below illustrates this.

<table>
<thead>
<tr>
<th>Change in Employment</th>
<th>Knowledge Based Industries</th>
<th>All Other Industries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spain</td>
<td>+74.6%</td>
<td>+42.4%</td>
</tr>
<tr>
<td>Ireland</td>
<td>+70.7%</td>
<td>+42.9%</td>
</tr>
<tr>
<td>Greece</td>
<td>+36.8%</td>
<td>+8.3%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>+29.9%</td>
<td>+12.3%</td>
</tr>
<tr>
<td>Italy</td>
<td>+28.4%</td>
<td>+4.1%</td>
</tr>
<tr>
<td>Belgium</td>
<td>+23.3%</td>
<td>+3.7%</td>
</tr>
<tr>
<td>Finland</td>
<td>+29.6%</td>
<td>+13.5%</td>
</tr>
<tr>
<td>Austria</td>
<td>+18.3%</td>
<td>-5.4%</td>
</tr>
<tr>
<td>Germany</td>
<td>+17.1%</td>
<td>-8.6%</td>
</tr>
<tr>
<td>UK</td>
<td>+16.7%</td>
<td>+1.0%</td>
</tr>
<tr>
<td>France</td>
<td>+16.3%</td>
<td>+7.3%</td>
</tr>
<tr>
<td>Portugal</td>
<td>+11.1%</td>
<td>+1.4%</td>
</tr>
<tr>
<td>Denmark</td>
<td>+11.6%</td>
<td>-0.2%</td>
</tr>
<tr>
<td>Sweden</td>
<td>+12.8%</td>
<td>+2.0%</td>
</tr>
<tr>
<td>EU15</td>
<td>+23.9%</td>
<td>+5.7%</td>
</tr>
</tbody>
</table>

Table 4: Most new jobs in knowledge based industries 1995-2005
Source: Brinkley and Lee, 2006, p8

An objective view however is needed and Ireland’s economic progress must be put into perspective. In the context of where the economy was 20 years ago in terms of
high unemployment rates and a reliance on primary industry, the economic advances have been quite astounding. However these economic achievements have only managed to propel Ireland into the middle of the European league in terms of knowledge-based services operating in this country. The focus must now be to build on the relative success of the economy, to drive forward and attract a superior breed of industry to the country. The foundations are in place it is now a matter of perseverance and competence.

Table 5 below displays the percentage of GDP the OECD countries apportion to investment in knowledge-based activities. Ireland ranks 16th in terms of the level of GDP invested in knowledge industries at 2.4% of GDP, a decrease of 0.2% on its 1994 figure of 2.6%. There is evidence to suggest Europe is falling someway behind its peers, with the top 8 OECD countries comprising of 5 nations outside of the E.U, with only Sweden, Finland and Denmark representing Europe.

<table>
<thead>
<tr>
<th>% of GDP</th>
<th>1994</th>
<th>2002</th>
<th>Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sweden</td>
<td>5.1%</td>
<td>6.8%</td>
<td>+1.7%</td>
</tr>
<tr>
<td>US</td>
<td>5.4%</td>
<td>6.6%</td>
<td>+1.2%</td>
</tr>
<tr>
<td>Finland</td>
<td>4.7%</td>
<td>6.1%</td>
<td>+1.4%</td>
</tr>
<tr>
<td>Korea</td>
<td>4.9%</td>
<td>5.9%</td>
<td>+1.0%</td>
</tr>
<tr>
<td>Denmark</td>
<td>3.7%</td>
<td>5.5%</td>
<td>+1.8%</td>
</tr>
<tr>
<td>Japan</td>
<td>3.9%</td>
<td>5.0%</td>
<td>+1.1%</td>
</tr>
<tr>
<td>Canada</td>
<td>4.5%</td>
<td>4.7%</td>
<td>+0.2%</td>
</tr>
<tr>
<td>Australia</td>
<td>3.9%</td>
<td>4.1%</td>
<td>+0.2%</td>
</tr>
<tr>
<td>Germany</td>
<td>3.4%</td>
<td>3.7%</td>
<td>+0.3%</td>
</tr>
<tr>
<td>Belgium</td>
<td>3.6%</td>
<td>3.8%</td>
<td>+0.2%</td>
</tr>
<tr>
<td>Netherlands</td>
<td>3.4%</td>
<td>3.8%</td>
<td>+0.4%</td>
</tr>
<tr>
<td>France</td>
<td>3.4%</td>
<td>3.7%</td>
<td>+0.3%</td>
</tr>
<tr>
<td>UK</td>
<td>3.5%</td>
<td>3.7%</td>
<td>+0.2%</td>
</tr>
<tr>
<td>Austria</td>
<td>2.3%</td>
<td>3.4%</td>
<td>+1.1%</td>
</tr>
<tr>
<td>Spain</td>
<td>2.1%</td>
<td>2.8%</td>
<td>+0.7%</td>
</tr>
<tr>
<td>Ireland</td>
<td>2.6%</td>
<td>2.4%</td>
<td>-0.2%</td>
</tr>
</tbody>
</table>
Between 1994 and 2004 R&D spending as a share of GDP across the EU increased by less than 0.1 per cent of GDP while the US and Japanese economies increased R&D spending by between 0.3 and 0.4 per cent of GDP over the same period. R&D spending went up in many EU States but R&D spending fell as a share of GDP in France, the UK, the Netherlands, and Ireland (Brinkley and Lee, 2006, p13).

In terms of investment in research and development, Ireland’s performance compares poorly with that of its European contemporaries and even worse in comparison to the Knowledge Economy powerhouses of the US, Japan and Korea. However IDA statistics contort Ireland’s investment in ‘knowledge’ by incorporating Ireland’s investment in higher education into their statistics. Ireland’s total investment in knowledge (including investment in public and private spending on higher education) increased by an average annual rate of over 10% over the past decade compared with averages of around 3% by the EU and the OECD (IDA, 2006, p7).

It is essential that Ireland capitalizes on its investment in higher-education by continually increasing its investment in research and development. It is vital that the researchers produced by Ireland’s investment in education are given the appropriate platform from which to contribute to Ireland’s Knowledge Economy.

2.4.2 The future of Ireland’s Economy

The Irish Government’s stated objective is to develop Ireland as a knowledge economy, as a way of sustaining increases in employment, wealth creation and social well-being in an increasingly competitive global economy (Inter Departmental Committee on Science, Technology and Innovation, 2004, p19).
Attracting multi-national research and development operations to Ireland, on the presence of a skilled labour force is crucial to maintaining Ireland’s competitive advantage and must be the cornerstone of future economic policy (Inter Departmental Committee on Science, Technology and Innovation, 2004, p3). ‘New economy’ theory postulates that advanced economies are witnessing a significant growth in ‘knowledge jobs’, and that standardised manual labour is being increasingly displaced by knowledge intensive employment. (National Skills Strategy Research Report, 2007, p45) With an increase in high-skilled, knowledge-based services and industries throughout the E.U, it is natural that the skillset required by an employee to fill a position in a knowledge-based company requires, for the most part, a substantially higher level of skills and education. Knowledge, and the ability to create, access and use it effectively, has long been a tool of economic success and a central component of economic and social development more broadly (World Bank, 2002, p4).

As Ireland’s economy transitions into a knowledge economy the need for highly-skilled, highly trained workers will increase. Non-production or “knowledge” workers – workers who do not engage in the output of physical products – are the employees in most demand in a wide range of activities, from computer technicians, through physical therapists to marketing specialists. The use of new technologies - the engine of longer-term gains in productivity and employment, generally improves the ‘skills base’ of the labour force in both manufacturing and services (OECD, 1996, p10-13).

The nature of work in knowledge-intensive sectors will also require knowledge workers to constantly refresh, renew and update their skills and qualifications in order to keep abreast of the dynamic nature of change the knowledge-based industry demands. Knowledge workers will be required to embark on a path of life long learning in order to remain an integral component of their organization within the Knowledge Economy. The knowledge-based economy will be characterised by the need for continuous learning of both codified information and the competencies to use such information (OECD, 1996, p10-13).

In terms of educated, high-skilled employees such as researchers, Ireland will need a substantial influx of foreign academics and researchers in order to supply the demands
of the Knowledge Economy. It is projected Ireland will require, an additional 8,000 researchers over the period to 2010 in order to achieve the targets set out for R&D performance (Inter Departmental Committee on Science, Technology and Innovation, 2004, p21)

However at present Ireland’s education system does not produce the amount of researchers that is required to meet these requirements. Ireland will have to attract numerous types of knowledge-based industries and activity to match the skills and qualifications currently possessed by the Irish workforce. The supply of certain types of skills is likely to have a substantial influence on the types of enterprises which locate here (National Skills Strategy Research Report, 2007, p31). Knowledge Workers do not necessarily have to be confined to the realm of researchers but can span a wealth of industrial disciplines.

Knowledge workers are essential to the Knowledge Economy. It is imperative that new additions to the workforce and current members of the workforce are made aware of their duties to sustain Ireland’s Knowledge Economy, such as lifelong learning and a national change in attitude that incorporates a willingness to embark on a path of lifelong learning.

2.4.3 Future skills requirements for the Irish Knowledge Economy

Pressures to increase the role of information and knowledge in national economies have provoked a wide-ranging debate about what kinds of competencies and skills young people and adults now need to be an active part of the Knowledge Economy (OECD, 2001).

It is clear that the skills of traditional agricultural and capital based economies are being superseded by the skills required to compete in the Knowledge Economy. Ireland’s education system will need to tailor itself to meet the needs of the knowledge economy by providing courses and qualifications that can be used to gain employment within knowledge based services and industries. Critically, Labour force participation is linked to educational qualification. As educational attainment increases, so does the

The skills required by the Knowledge Economy will vary in nature but will not be static. The dynamic, constantly evolving and competitive nature of the Knowledge Economy will determine the type of skills needed. As the economy increases its dependence on knowledge based services and high technology manufacturing, and the more traditional sectors such as low level manufacturing and agriculture decline in importance, there will be a corresponding change in the particular skills and the balance of skills needed in the economy (National Skills Strategy Research Report, 2007, p5)

Due to the almost volatile nature of the Knowledge Economy in terms of the educational attainment and skills, knowledge workers will be required to not only constantly refresh and upgrade their skills and know-how but to change their working habits and attitudes to conform to the rapid pace of technological change in the workplace.

All occupations are becoming more knowledge-intensive which is evident in the corresponding rise in the requirement for qualifications and technical skills. Employees in the Knowledge Economy will be required to possess and/or acquire a wide range of generic and transferable skills and attitudes. In most jobs, work is becoming less routine, with a requirement for flexibility, continuous learning, and individual initiative and judgment (National Skills Strategy Research Report, 2007, p34).

Since innovation tends to be increasingly complex, a broad set of skills is an integral part of success. For example, the development of a new type of printing paper amalgamates a diverse set of skills and knowledge intensive services ranging from expertise in fibre research, biotechnology, chemistry, electronics, engineering, business management, marketing, logistics, software development and printing technology. Such cases highlight the multidimensional nature of research and innovation, and the diverse set of skills needed to bring new products or services to the marketplace. (OECD, 2006, p10)
The skills demanded by the new knowledge economy will be vast and multifaceted however the underlying ideal will that such skills will need to be able to adapt to the dynamic and innovative nature of the knowledge economy.

2.4.4 The need to embrace innovation

Whatever sectors of industry the knowledge economy manages to penetrate, one thing is for certain - it will be the result of strenuous innovation and change from within that sector. The pace of scientific and technological advancement is dictating the needs of society and alternatively, the needs of an increasingly global society, is dictating the pace of scientific and technological advancement.

It is imperative that all segments of industry embrace innovation in order to keep up with the demands of contemporary society. It is argued that research and development is the key to innovation and as such, the key a prosperous and sustainable knowledge economy. Equally important are more intangible investments in research and development (R&D), the training of the labour force, computer software and technical expertise (OECD, 1996, p10).

In order to promote long-term investment in R&D, the Irish Council for Science, Technology and Innovation recommends that future expenditure and investment in R&D should focus on achieving two main goals, sustainability of research funding and a competitive mix of R&D support for enterprise:

Sustainability of research funding: A new, longer-term multi annual outlook and budgeting approach should be adopted for public R&D investment that guarantees funding and provides stability to the research system and;

A competitive mix of R&D support for enterprise: The promotion of a dynamic knowledge-intensive enterprise base, with world-class, innovation-driven, small and medium enterprises will require the continued development of a competitive mix of fiscal incentives and grant supports for promoting enterprise R&D, particularly for the SME’s (ICSTI, 2004, p2).
Europe needs to recognize the importance of innovation and in particular the role that research and development plays. Kok argues that Europe is some way behind its contemporaries in terms of its attractiveness as a research and development region. Europe needs to drastically improve its attractiveness to researchers, as too many young scientists continue to leave Europe on graduating, notably for the US (Kok, 2004, p20). Ireland too needs to put measures in place to embrace innovation through research and development activity.

A substantial component of embracing innovation is in having appropriate financial and fiscal mechanisms in place in order to accommodate the level of research and development required to sustain the knowledge economy. Kok stresses that funding and in particular funding to universities is crucial to attracting quality researchers to Europe.

In order to increase attractiveness, there are also financial questions requiring attention. The European Union Member States need to urgently address the problem of funding for universities and third level institutes. If Europe wants to attract more of the world’s best researchers, the question of improving their research environment and remuneration needs to be addressed now (Kok, 2004, p20).

In order for European economies to maintain their economic status, the foundations for the new Knowledge Economy must be laid in earnest. Kok argues that Europe does not have an adequate environment to attract the best academics and researchers needed to supply Europe’s economy with pioneering new ideas and knowledge. If a Knowledge Economy is to be realised, the need to embrace innovation must be recognized through appropriate mechanisms geared to not only attract the best and the brightest academics and research, but to produce them as well.

2.5 Conclusion

This chapter has defined what is meant by the term ‘The Knowledge Economy.’ It has detailed the importance of the knowledge economy and the need for economies to transition from traditional agricultural and capital based economies to Knowledge
Economies in order to sustain economic growth and maintain the economies way of life.

This chapter then detailed the European Union’s vision for a Knowledge Economy in the form of the Lisbon Agenda and highlighted the need for Europe to continue to strive to meet the 3 per cent of GDP invested in R&D by 2010 however unattainable it might seem.

This chapter then discussed Ireland’s Knowledge Economy goals and assessed its current investment in knowledge in comparison to other EU15 nations. This chapter then discussed the future of the Irish Knowledge Economy, the need for Ireland to invest heavily in R&D and to substantially increase its current investment. The need to attract highly qualified researchers and the requirements of the knowledge workers of the future were detailed.
3 KNOWLEDGE BASED INDUSTRY IN IRELAND

3.1 Introduction

Ireland has strategically targeted multi-national enterprises as part of its plan to achieve a knowledge economy. It has particularly focused on attracting enterprises which are considered to be involved in Knowledge Based Industries and Services such as management consulting, IT and technology services, legal services, R&D services, accounting and financial services, marketing services, environmental management services and human resource management.

This chapter will examine the types of industry and service of particular interest to Ireland, focusing in particular on the research and development sector which has been identified as a key area of interest in Ireland’s development plans. The current state of such industry in Ireland will be examined and their performance relative to other types of industry will be presented.

The chapter will conclude by examining the impact Ireland’s aspirations in this regard will have on Ireland’s current and future workforce and the challenges faced by industry, education and government to achieve the required outcome.

3.2 Knowledge based industries

3.2.1 What is Knowledge Based Industry?

“Knowledge-based industries are those which are relatively intensive in their inputs of technology and human capital. These include aerospace, chemicals/biotechnology, ICT equipment and services, consumer electronics and the environment industry.”

Knowledge based industries typically operate within the high-end, knowledge intensive sectors of industry, where intellectual capital provides the primary source of revenue for such organizations. What distinguishes Knowledge Intensive Industry from other Industries such as manufacturing or agriculture is that Knowledge Intensive firms rely heavily on an input of highly skilled, highly qualified professionals. Knowledge Based Industries should be considered in terms of the output of knowledge intensive service activities performed, perceivable increased competences and the development of innovative capabilities and innovative activity. Competences in this instance refer to a firm’s ability to perform certain tasks in a competitive environment. The concept of a competency can be viewed as a ‘shippable’ aspect of science or technology-related service such as configured equipment, prototypes, documents or software or entities that contain embedded knowledge (Broch and Isaksen, 2004, p8).

From an Irish perspective, it is imperative that an economy designed to attract and nurture such knowledge-intensive industry is established. The skills required for Knowledge Based Industry are predicted to be in great demand within the coming years and will see a shift from the traditional sectors of industry towards areas where high-skills and a competent educational background will be required.

3.2.2 What sectors does Knowledge Based Industry encompass?

The presence of Knowledge Intensive Service Activities (KISA) and industries will be a crucial component of the future of the Irish Knowledge Economy.

Typical examples of Knowledge Intensive Service Activities (KISA) include research and development (R&D), management consulting, information and communications services, human resource management and employment services, legal services (including those related to intellectual property rights) accounting, financing, and marketing-related service activities (OECD, 2006, p7).
3.3 The Research and Development Component to the Knowledge Economy

3.3.1 Research and Developments Role in the Knowledge Economy

Studies demonstrate that up to 40% of labour productivity growth is generated by research and development spending and that there are powerful and beneficial spillover effects into other areas of the economy, depending on the way in which the money is spent. (Kok, 2004, p19).

It is widely regarded that promoting research and development is the best route to stimulating an economy and that nurturing research and development is a vital component of economic policy. (Whatmore 2002)

Both the Lisbon Agenda put forward by the European Union, and the Irish Action Plan for Promoting R&D devised by the Irish Government, contribute the presence of Research and Development activity in a region as the foundation for the success of that regions Knowledge Economy. Research and Development is at the heart of Irish economic and social development. Investment in Research and Development is paramount for increased productivity growth, a source of opportunity in new areas and the foundation for creating knowledge-driven competitive advantage across all sectors of the economy. (Inter Departmental Committee on Science, Technology and Innovation, 2004)

Increased investment in Research and Development must remain a top priority for the expansion of Irelands Knowledge Economy. Brinkley and Lee argue that increasing investment in Research and Development must remain a key objective for all economies. (Brinkley and Lee 2006), p3). Increased and improved Research and Development activities are vital to sustain the Knowledge Economy for a number of reasons. The way in which western economies can generate wealth and attract industry has been altered radically by the emergence of low-cost economies, reduced trade barriers, improved and increased telecommunication and transportation networks. The
production of goods is increasingly organized along global supply chains and spread across countries and regions according to their comparative advantage.

By attracting Research and Development, economies can participate in new markets and industries or reposition their participation in markets that were taken away from them by the emerging economies. Research and Development can spur economic development by providing employment opportunities, providing cost savings and benefits via new or improved products and services developed by R&D activity.

The premise of the Aho Report was to alert Europe to the tangible benefits of increased investment in R&D in order to sustain the European way of life in the face of emerging economic rivals. The Aho report placed research and innovation at the centre of the endeavour to recapture the entrepreneurial vigour and value-creation that are needed to sustain and improve the European way of life (Aho, 2006, p1). Aho argues that a new approach is needed in order for Europe to support its current quality of life. Aho identifies three areas, the creation of new markets, increased R&D spend and a European structural improvement, in order for Europe to sustain and improve its Knowledge Economy.

Achieving an Innovative Europe requires a new paradigm of mobility, flexibility and adaptability to allow research and development and innovation to create the value that can then support the current quality of life experienced in the EU. Simultaneous and synchronous efforts are needed at all levels in three areas, which we use to structure this report:

- creation of a market for innovative products and services;
- providing sufficient resources for R&D and innovation; And
- improving the structural mobility and adaptability of Europe.

(Aho, 2006, p1).

Brinkley and Lee admit that while the current target of 3 per cent of EU GDP for R&D is unrealistic and largely unattainable, it should not be compromised in a bid to elevate Europe’s R&D infrastructure. R&D must be increased, but targets must be realistic and have a clear justification. The current target of 3 per cent of EU GDP for R&D spending should not be reconsidered or revised (Brinkley and Lee, 2006, p23).
While much hype and fanfare has been made of the importance of Research and Development to the Knowledge Economy, however, some economists worry that the R&D paradigm has been widely acknowledged but not understood. Kok argues that the Lisbon Agenda has been so little understood that minimal improvements have been made. (Kok 2004, p19)

3.3.2 Ireland’s Current R&D Performance

In light of the orders from Europe to increase R&D investment to 3 per cent throughout Europe, Ireland needs to substantially improve its investment in R&D if it is to meet the requirements devised by the Lisbon Agenda. Ireland’s expenditure of 0.9% GNP falls some way behind the EU average and that of Knowledge Economy powerhouses such as the US and Japan.

Business expenditure on R&D reached €917 million in 2001, or 0.9% GNP, compared to the EU average of 1.25% and the US value of 2% (Inter Departmental Committee on Science, Technology and Innovation, 2004, p9).

In terms of investment in higher education and the public research sector, Ireland again lags behind its contemporaries in terms of investment. Research and Development spend in the higher education and public research sector was €422 million in the year 2001, equating to 0.4% of GNP in comparison to the EU average of 0.66%. Of Government funding for R&D, 56 per cent of funding is allocated to third level institutes and universities, 32 per cent is allocated to public research organizations and 12 per cent to support R&D firms. The Irish Government funds roughly 4.5 per cent of the total business R&D performance, well below the EU average of 8 per cent (Inter Departmental Committee on Science, Technology and Innovation 2004, p9).

Of the companies currently involved in Research and Development activity in Ireland, the top 100 performers of these business account for 60 per cent of total business expenditure on R&D. Of the companies involved in R&D in Ireland, two thirds of them are foreign investors, with only one third of indigenous enterprises, roughly 1000 businesses, having some expenditure on R&D, and of these indigenous firms, 85 per
One third of foreign affiliates in Ireland, roughly 300 enterprises are currently active in Research and Development. Of these firms, 50 per cent spend less than half a million euro on R&D per annum, with only nineteen foreign investors spending over €5 million per annum with these investments accounting for two-thirds of the total spend by foreign affiliates (Inter Departmental Committee on Science, Technology and Innovation 2004, p9). In terms of the areas of industry these companies are involved in, there is a strong focus on research in biotechnology and information and communications technologies, supporting researchers in Ireland and attracting researchers from abroad (Inter Departmental Committee on Science, Technology and Innovation, 2004, p9).

Despite having a relatively stable base of core Research and Development practicing enterprises operating in this country, Ireland must prioritise not only attracting further R&D activity in these areas, but also must strive to attract research and development enterprises operating in alternative sectors such as the financial and engineering and environmental sectors.

3.3.3 The future of Research and Development in Ireland

A poignant question is, considering Ireland’s recognition of the importance of attracting knowledge based industry and in particular research and development activity, and its proposed initiatives to attract such investment, what does the future of research and development in Ireland hold?

Ireland will require approximately 8,000 additional researchers over the period to 2010. According to the Inter Departmental Committee on Science, Technology and Innovation’s projections, it is estimated that more than half of these researchers can be produced in Ireland with a further 3,600 additional high quality researchers will need to be made available through a combination of further increases in domestic supply and attraction of personnel from abroad.
In addition to the 8,000 researchers needed by 2010, Ireland will have to provide appropriate and competitive funding programs for its researchers. Such programs should have the objective of projecting a greater emphasis on developing research careers for young students by providing an attractive environment and career prospects and employment opportunities for researchers in Ireland and those coming from abroad to work as researchers in Ireland. (Inter Departmental Committee on Science, Technology and Innovation, p28)

It is also recommended that specific programs to encourage greater female participation in fields such as engineering and to increase the amount of women in the research area are introduced both in an industrial and academic context. (Inter Departmental Committee on Science, Technology and Innovation, 2004, p28)

Another feature of the future Irish Research and Development sector will be to encourage and enable the mobility between public and private industries to increase the level of collaboration between private industries and public third level institutes and universities.

Targets for Research and Development in Ireland in the European Research Area are as follows:

- Business expenditure on R&D should increase from €917 million in 2001 or 0.9% GNP to €2.5 billion in 2010 or 1.7% GNP;
- The number of indigenous companies with minimum scale R&D (in excess of €100,000) activity should double, from 525 in 2001 to 1,050 in 2010;
- The number of indigenous enterprises performing significant R&D (in excess of €2 million) should increase from 26 in 2001 to 100 by 2010;
- The number of foreign affiliates companies with minimum scale R&D activity (in excess of €100,000) should double, from 239 in 2001 to at least 520;
- The number of foreign affiliates performing significant levels of R&D (in excess of €2 million) should increase from 47 in 2001 to 150 by 2010;
- R&D performance in the higher education and government sectors should increase from €422 million in 2001 or 0.4% GNP to €1.1 billion in 2010 or 0.8% GNP;
- Gross expenditure on R&D should increase to 2.5% of GNP by 2010;
- The number of researchers should reach 9.3 per 1,000 of total employment by 2010, from 5.1 per 1,000 in 2001.

(Inter Departmental Committee on Science, Technology and Innovation 2004, p18)

It is clear that improved and sustained investment in research and development is the cornerstone to the success of Ireland’s knowledge economy. Increased investment in order to align with the R&D spend of other contemporary knowledge economies should be a minimum requirement. Special emphasis should be placed on cultivating the indigenous research and development sector and initiatives to increase the number of Irish researchers being produced both from an academic and industrial environment promoted.

3.3.4 Workforce Requirements for Research and Development

The Expert Group (National Skills Strategy Research Report, 2007, p48) published its findings in relation to the human capital requirements to support research and development in Ireland. The Expert Group highlights the key steps needed to build the human capital required to underpin world class research. These steps include,

- The enhancement of post graduate skills through a graduate schools mechanism;
- The development of sustainable career paths for researchers;
- The enhancement of mobility of researchers; and
- The doubling of PhD graduate output by 2013.’

(National Skills Strategy Research Report, 2007, p48)

With the output of PhD graduates expected to increase by the year 2013, it is vital that there is an appropriate market available to absorb such highly skilled employees. Government projections predict that there will a high demand for graduates of the science and technology fields and in particular, a chronic lack of software engineering graduates is expected.
Government industrial predictions conform to the fundamentals of a Knowledge Economy, an increase in high-end industries such as science and technology and a decline in the more traditional, low-skilled jobs such as manufacturing.

The projected decline in manual, low skilled occupations and the rise in importance of professional and associated professional occupations will almost certainly impact on the types of skills which will be required by enterprise (National Skills Strategy Research Report, 2007, p48).

This decline in low skilled occupations could have significant ramifications for many of the population. The ESRI diagram below (Figure 1) illustrates Ireland’s current employment are per sector as of 2005 versus the projected rates of employment in those sectors by the year 2020.

![Figure 1: Employment sector growth 2005-2020
Source ESRI](image)

There are significant declines in sectors such as Plant & Machinery, Agricultural Occupations, Clerical and Craft Related disciplines with declines of 1.3%, 2.5%, 0.7%
and 0.7% respectively. Alternatively there is significant growth projected in the Professional and Personal & Service areas with growth of 2.4% and 1.3% respectively. With such a decrease in many of the low-skilled job sectors many Irish workers will be forced to ‘up-skill’ or increase and improve their current qualification in order to become employable in the new Knowledge Economy.

A worrying trend that needs to be addressed is the steady decline of students studying science, technology and engineering at undergraduate level. The Irish government has increased investment in these areas which in turn will lead to the creation of additional postgraduate opportunities in the short to medium term. However, should current trends continue a significant shortage of research professionals can be expected in the future (Expert Group on Future Skills Needs 2006, p47).

It is predicted that the level of graduate output from the third level education system will not match the future demands of the Irish Knowledge Economy. This trend is underpinned by the steady decline in the level of student uptake in technical disciplines such as computing courses, particularly since the downturn of the IT sector in 2001. Since then, the level of student uptake in computing courses in both 2004 and 2005 was less than half the level in 2000 (Expert Group on Future Skills Needs, 2006, p51).

Failing that the number of graduates can meet the demands of the new Knowledge Economy, a large portion of researchers and professionals will need to come from population up-skilling. The National Skills Strategy points out that in the coming years the predicted collected educational attainment of the workforce to match the demands of the Knowledge Economy will require that

- 48 percent of the labour force should have qualifications at NFQ Levels 6 to 10;
- 45 percent should have qualifications at NFQ levels 4 and 5; and
- The remaining 7 percent will have qualifications at NFQ levels 1 to 3 but should aspire to achieve skills at higher levels.’


In order to meet the requirements that Knowledge Based Industry and R&D activity will pose for the Irish workforce it is vital that up-skilling and further education become engrained in the Irish knowledge workers psyche.
3.4 Conclusion

This chapter defined what is meant by the phrase ‘knowledge based enterprise’ and detailed the sectors of industry encompassed by knowledge based enterprise.

This chapter then illustrated the research and development component to the knowledge economy and the importance of attracting and investing in research and development both from an industrial and an academic context.

This chapter then highlighted Ireland’s current research and development performance and detailed its research and development goals for the future. This chapter stressed the need for Ireland to significantly increase the number of indigenous and foreign companies performing R&D if it is to become a successful knowledge economy. Finally this chapter detailed the predicted areas for growth for knowledge based industries and underlined the need for the Irish workforce to upskill and improve their educational qualifications to become knowledge workers of the knowledge economy.
4 GEOGRAPHICAL INFORMATION SYSTEMS

4.1 Introduction

Geographical Information Systems (GIS) have permeated all aspects of contemporary industry such as utilities management, transportation management, emergency management, urban planning, health and health care applications and have emerged as a leading tool used in an ever expanding myriad of applications particularly supporting decisions where location is a factor.

This chapter will open by establishing exactly what GIS are, the history of GIS and the many uses of GIS in modern society will then be discussed. The chapter will conclude by describing thematic maps and spatial analysis, explaining the usefulness of such maps and analysis for the purpose of this project.

4.2 Geographical Information Systems

4.2.1 Geographical Information Systems Definition

Geographical Information Systems or GIS are essentially computer or software based systems used to display and manipulate geographical information.

GIS may also be defined as mapping systems that uses computers to collect, store, manipulate, analyze, and display data (Agency for Toxic Substances and Disease Registry 2007), computer based mapping that allows for seeing, exploring, and analyze data by location (Princeton 2007) and a computer system designed to tie data and information to locations and display that information on a map (Kansas 2007). For the purposes of this project GIS will be defined as,
4.2.2 A Brief History of GIS

The hand drawn map has been the traditional and time-honoured means of recording observations and information about the Earth for subsequent visual retrieval or simple measurement (Peuquet and Marble, 1990, p5).

The exact origins of map-making, cartography and indeed GIS itself are shrouded in mystery and controversy. It is extremely difficult to pinpoint a single, simple explanation for the exact origins of geographical representation due to the synergistic, convoluted and confluent influences of the art which is drawn from a myriad of ancient roots and practices. The earliest known map, a regional map imprinted in a clay tablet, dates from around 2500 B.C (Star and Estes, 1990, p17).

Techniques for geographic representation and inquiry have existed for centuries, long before the notion of geographic analysis was formed. A technique known as mapping overlay, a component of modern day GIS is reputed to have been utilized as far back as the eleventh century. Evidence for antiquity of the logical overlay technique has been documented in a series of etched stones at Angkor Wat, a major temple of the eleventh-century Khmer Empire in north-west Cambodia (Foresman 1998, p4). The origins of more sophisticated GIS can be traced back to early developments in cartography in the mid-eighteenth century. The advent of higher quality base maps emanating at this time resulted in a more accurate depiction of spatial attributes. (Parent and Church, 1988, p63-71)

In the early nineteenth century advances in the social and physical sciences and in particular the fields of statistical analysis, number theory and advanced mathematics added important intellectual tools and techniques for the analysis of spatial information. The ‘Atlas to Accompany the Second Report of the Irish Railway
Commissioners’ published in 1838 is considered to be the first geographical study to incorporate technical, social and scientific advances related to spatial analysis. The report consisted of a concrete series of maps with a uniform base depicting population, traffic flow, geology and topography and was an example that a single map may not contain all of the data required to satisfy a particular query. (Star and Estes, 1990, p18)

The foundations of automated geographic processing were laid in the late 1800’s when an American Statistician, Herman Hollerith adapted punch-card techniques, previously used in France to program looms, to process data obtained during the United States Census of 1890. This evolutionary bound towards electro-mechanical data-processing satisfied the increasing need to rapidly, accurately and cost-effectively collect, analyze and distribute spatially disposed information. (Steich, 1986)

It was not until advances in computing, cartography and photogrammetry in the early 1060’s that automated GIS became an established field. The first geographical information system was developed in Canada in the 1960’s. At that particular time, the emphasis of GIS was on overcoming the technical problems that arose in handling traditionally graphic data by numerical methods, of putting maps into computers that by today’s standards were slow, small and cumbersome (Peuquet and Marble, 1990, p5).

The term GIS, however was not coined until 1964 (Schuurman, 2004, p22). The Canada Geographic Information System or CGIS was designed specifically for the Agricultural Rehabilitation and Development Agency Program within the Canadian Government. Its main purpose was to analyse Canadian Land Inventory data which was being collected to find marginal lands. (Star and Estes, 1990, p21)

A second burst of innovation occurred in the late 1960’s and the US Bureau of the Census developed the DIME program (Dual Independent Map Encoding) which created digital records of all US streets to support automaton referencing and aggregation of census records. (Longley et al. 1990, p17) In the 1970’s agriculture and forestry provided a fertile environment for the development of many GIS algorithms, many of which provide the foundations for today’s commercial software (Foresman, 1998, p8).
The first automated cartography developments occurred in the 1960’s, by the late 1970’s most cartographic agencies were automated to some extent, but it was not until 1995 that Great Britain became the first county to achieve complete digital map coverage in a database.

The complexity and nature of Geographic Information Systems was becoming such that an International Geographic Union (IGU) report on GIS entitled ‘Computer Handling of Geographic Data’, published by Unesco in 1976 noted that ‘there are now just as many problems and possibly more on the management side of implementing a geographical information system as there are on the technical side’ (Peuquet and Marble, 1990, p23). The situation in the early eighties was one of an increasing and widening demand for geographic information systems to meet local, national, multinational and global requirements (Peuquet and Marble, 1990, p23).

As the capabilities of computer technology and software development became ever-more complex during the late eighties and 1990’s, the capabilities and range of functionality afforded to GIS became increasingly useful.

4.2.3 The Modern Day GIS

‘There is almost as much debate over the components of a GIS as there is about its definition.’ Heywood, I., Cornelius, S. and Carver, S. (2006), p19

At a basic level a Geographical Information System may be viewed as a software package, comprising of the various components or tools needed to enter, analyse, manipulate and display geographic data. Conversely, a GIS may be viewed as a complex, enterprise-wide information system used to structure many of an organization’s assets, processes and workflows through a series of integrated hardware and software systems, standardized processes for data collection and dissemination and utilized and maintained by a large, focused GIS team or department.

GIS run on the whole spectrum of computer systems ranging from portable personal computers (PC’s) to multi-user super computers, personal data assistants (PDA’s),
handheld GIS/GPS devices (Heywood et al. 2006, p19). In all scenarios there are a set of elements crucial to the effective operation of a GIS system: hardware, software and people. Hardware elements include, the presence of a processor with sufficient power to run the software, sufficient memory for the storage of large volumes of data, a good quality, high resolution colour graphics screen and data input and output devices (Burrough and McDonnell 1998 and Heywood et al. 2006, p19). GIS software must include appropriate provisions to handle spatial data.


The spatial referencing of spatial data is also of fundamental importance within the GIS software. There are two principle methods to consider, representing spatial data as layers, known as the layer-based approach (Heywood et al. 2006, p22), or representing spatial data as objects, known as the object-oriented approach (Longley et al. 2005). At the core of any GIS, the software should incorporate a storage mechanism for the input and management of large quantities of both graphic data and non-spatial attribute data. Graphic data describes the spatial characteristics of the real world feature that is to be modelled while non-spatial attribute data describe what the features represent (Heywood et al. 2006, p23-24).

Longley et al. describe a three tier GIS software architecture. This architecture is illustrated in Figure x
The user’s interaction with the system is via the graphical user interface (GUI) in the presentation layer. The GUI comprises of an integrated collection of menus, commands, toolbars and other controls to manipulate the display of data.

The business logic layer is responsible for performing computer-intensive operations such as data overlay and processing and raster analysis.

The data server tier must import and export data and service requests from the database. (Longley et al. 2005, p16)

4.3 The Uses of GIS

GIS is used to enhance a myriad of our day-to-day working and living arrangements (Longley et al., 2005, p40).
The range and diversity of GIS applications in business, social and environmental science permeate every aspect of our everyday lives. Such is the applicability of GIS that Starbucks is reputed to use GIS to site its very successful coffee shops (Schuurman, 2004, p1). GIS applications include topographic base mapping, socio-economic and environmental modelling, global and interplanetary modelling and education and span the fields of military, government, education, utilities, banking, financial services, transportation, real-estate and market analysis organizations. Applications generally set out to fulfil the five ‘M’s’ of GIS: mapping, measurement, monitoring, modelling and management (Longley et al. 2005, p41).

As GIS has become less expensive, so it has come to be adopted in all government decision making and at all levels ranging from the nation to the neighbourhood (Longley et al., 2005, p42).

Applications of GIS include utilities management, telecommunications management, transportation management, emergency management, land administration, urban planning, military applications, health and health care applications and landscape conservation so much so that some analyst believe that the technical advances in GIS have proceeded before our ability to realize and understand its potential effects (Schuurman, 2004, p1).

Fry in Longley et al.(1999) describes how GIS is now the standard technology applied throughout the telecoms industry. Fry explains how GIS is at the forefront of advancements in the telecommunications industry. As telecommunications companies transform their networks from dated, copper wire cabled networks to fibre optic cables or satellite links, GIS have been used to determine the most suitable method of transmission, plan network layouts and target customers.

Gatrell and Loytonen describe and analyse the uses of GIS in public health. They detail the specific areas of public health that benefit from a GIS based approach such as the uptake of services for preventive medicine such as childhood immunisation and the screening of breast and cervical cancers in women. (Gatrell and Loytonen, 1998)
GIS may also be used in the Environmental Management and Conservation fields for habitat, wetland, and water quality mapping and planning, in the banking sector for targeting their markets by visualizing service needs, and in the educational sector to as a tool to help researchers model the real world, classify and observe phenomena, and predict changes over time (ESRI, 2007).

The uses of GIS span numerous disciplines and professions, the capabilities of which are only limited by the imagination.

4.4 Thematic Maps, Spatial Analysis and Ireland’s Knowledge Economy

4.4.1 Thematic Map Definition

Without doubt, GIS has fundamentally changed cartography and the way we create, use and think about maps (Longley et al., 2005, p269).

The primary goals of map design are to share information, highlight patterns and processes, and illustrate results. A secondary objective is to create a pleasing and interesting picture but not at the expense of map accuracy or quality and meeting the map’s primary goals.

Thematic maps are maps which communicate a single theme or subject. A population density map and political boundary map are both examples of thematic maps (Digimap 2007). A thematic map is a map that symbolizes features according to a certain attribute. Examples include maps displaying businesses as dots of different sizes or colors according to number of employees or, a map displaying census tracts in different colors according to median household income (Mapping Analytics 2007).

For the purposes of this project a thematic map may be defined as,

‘Maps that are used to display geographical concepts such as density, distribution, relative magnitudes, gradients, spatial relationships and movements.’ PCMag (2007)
4.4.2 Spatial Analysis Definition

Spatial Analysis is essentially the process of modelling, examining or analysing geographic information or topological, geographic or geometric properties. Spatial analysis can be termed as the determination of the spatial relationships between geographic objects, such as the distance between them or the extent to which they overlap (Mapping Analytics 2007).

For the purposes of this project however we will refer to spatial analysis as meaning,

‘The process of applying analytical techniques to geographically-referenced data sets to extract or generate new geographical information’ DigiMap, (2007)

4.5 Conclusion

This chapter has defined the term Geographical Information System or GIS and has illustrated a brief history of GIS and the components of a modern day Geographical Information System.

This chapter then detailed the various industrial and academic uses of GIS citing examples from the public health, telecoms and environmental management industries.

This chapter then defined the terms thematic map and spatial analysis and explained how both could be utilized on this particular project.
5 APPLYING THE PRINCIPLES OF KNOWLEDGE MANAGEMENT TO THE KNOWLEDGE ECONOMY

5.1 Introduction

The project presented in this dissertation is concerned with developing a knowledge management tool which can be used to assist with marketing Ireland to enterprises considering locating there.

This chapter will discuss how such a tool constitutes a knowledge management tool, describing the concepts of knowledge management and the principles and techniques of knowledge management to provide context, and examining the attributes of knowledge management tools. GIS will be examined from this perspective to show where and how they fall into the spectrum of knowledge management tools.

The chapter concludes by illustrating how the principles of knowledge management can be applied to collect, assess and disseminate relevant information and knowledge about Ireland’s knowledge economy to relevant policy makers.

5.2 Knowledge Management

5.2.1 The Rise of Knowledge Management

In today’s rapidly changing business environment, companies are required to remain at the forefront of entrepreneurial innovation in order to remain a competitive force in an emerging global marketplace. Traditionally companies have been run by standard ‘recipes for success’, such as age-old business practices and company mottos (Awad and Ghaziri, 2004, p15)

By adhering to old company adages and policies, out-dated company methods or standards and aged company practices, an organization is in severe danger of losing out in an increasingly competitive marketplace. In the contemporary business
environment, the heartbeat of an organization depends firmly on its ability to assess the needs of the consumer and to be able to adapt quickly to it through constantly evolving business practices, company policy and company infrastructure. An organization that has not recognized the need to be constantly “on their toes” or perennially ready to adapt to rapid changes in the marketplace is in critical danger of losing touch with the customer, losing hard-gained market share and potentially losing jobs. The concept of ‘Knowledge Management’ has thus emerged out of the need for companies to sustain innovation, retain and harness employee knowledge to fuel innovation and to be innovative in a more efficient manner.

‘As a reaction to the questionable benefits from downsizing, business process reengineering, and other cost-cutting measures in the 1980’s and 1990’s, knowledge management surfaced as the best next step to addressing the competition in a hard-to-predict environment.’ Awad and Ghaziri (2004), p16

The advent of the internet changed the way people communicate forever, providing an instantaneous medium by which people can express opinion, share ideas and impart knowledge. Businesses were quick to realize the power of the internet and over the course of the 1990’s and early 21st century the internet was a basic fixture in every workplace throughout the world. Aided by this technology, employees could now create, store and distribute knowledge in a way previously unimaginable and thus contribute to a more empowered and productive enterprise. Consequently the seeds of knowledge management were sown.

Knowledge Management has steadily been gaining credibility and recognition across industries. There is a number of contributing factors that have propelled knowledge management to the forefront of the business world.

The pace of change has accelerated dramatically during the past decade as companies constantly look at innovative ways of etching a space for themselves in the marketplace. Globalization and geographic dispersion has changed the organization’s scope and an increasing number of firms are attempting to leverage knowledge about particular regions to increase their market share.
Organizational initiatives such as downsizing and reengineering that result in staff attrition and knowledge drain only created new problems for organizations and highlighted the need to retain company knowledge. (Awad and Ghaziri 2004, p16)

In order to enhance and enrich company knowledge, many organizations are now realizing that the role of continuous education and employee training and development are crucial in refreshing and updating the organizations collective knowledge. Learning is the integral process for progress. It is an investment rather than an expense to the firm. In an organizational context, the knowledge that one creates and applies is more important than the knowledge one accumulates (Leibold et al., 2002, p15).

Organizations have realized that knowledge retention and continuous learning are increasingly vital elements to maintaining and enhancing a company’s intellectual capital.

5.2.2 Definition of Knowledge Management

Knowledge Management is rooted in many disciplines including business, economics, psychology, and information management. Knowledge Management is a conscious strategy of getting the right knowledge to the right people at the right time; it is also a strategy for helping people to share and put information into action in ways that strive to improve organizational performance (O’Dell et al., 1998).

Knowledge Management is concerned with assessing the level, depth and breadth of the knowledge in an organization’s possession. It is a methodology for establishing ‘who knows what’ within an organization and where particular knowledge can be located. Knowledge Management promotes the creation, storing and sharing of company knowledge throughout the whole organization.

‘Knowledge Management is the classification, dissemination, and categorization of information and people throughout an organization.’ Taft (2000), p14
A key aspect of a Knowledge Management initiative is in locating employee expertise and capturing it in a thorough and appropriate fashion. Knowledge Management resolves the issue of employee ‘knowledge drain’ by capturing the tacit or undocumented knowledge possessed by employees thus ensuring that such knowledge is not lost to the company upon employee retirement or job transfer. Svieby states the Knowledge Management is the art of distilling value from a company’s intangible assets such as the tacit knowledge of employees. Knowledge Management is the ability to create value from an organization’s intangible assets (Sveiby, 2000)

Knowledge Management also promotes a change in organizational culture. For Knowledge Management to be successful in an organizational context, a culture whereby the free dissemination and creation of employee knowledge must be nurtured and encouraged. Awad and Ghaziri (2004) argue that for Knowledge Management to succeed a shift in both organizational and individual philosophy is required. It is imperative that the philosophies underpinning Knowledge Management become ingrained within the organizational culture. If the culture is not one that encourages cooperation and trust among employees, employees will not cooperate. Many experts suggest that the first objective is to make knowledge sharing profitable for the employee and the firm as well (Awad and Ghaziri, 2004, p17)

Employees must be taught about the value of knowledge to the organization, the value of sharing knowledge with the organization and the value of teamwork and cooperation in sharing such knowledge throughout the organization.

In this respect Knowledge Management may be viewed every bit as a sociological endeavour as it is a technological one. The cornerstone of Knowledge Management is that employees or factions that embark in a Knowledge Management initiative actively participate within the program and empower themselves with the knowledge made available to them to contribute in a positive manner to the goals and objectives of the organization.

A core component of any Knowledge Management initiative is to ensure that the employees participate, encourage and communicate effectively with other employees who utilize the knowledge management system, whatever form it may be.
5.2.3 Benefits of Knowledge Management

The primary benefit of Knowledge Management is that tacit and undocumented knowledge of the organization is captured, thus avoiding knowledge drain.

Knowledge Management also provides organizations with a tool to assess the intellectual capital of an organization and to pinpoint particular areas of expertise within the firm. A ‘Knowledge Map’ may be implemented to provide a comprehensive analysis of a firm’s intangible assets and tool whereby specialist areas or silos of knowledge may be located and exploited.

Knowledge Management also enforces cultural change within an organization. This cultural change promotes the ideals of Knowledge Management, the open creation, dissemination and storing of company knowledge among employees thus improving a company’s business processes and enriching its decision making capabilities.

Awad and Ghaziri (2004) identify eight major and tangible benefits of knowledge management when applied in an organizational context. Knowledge Management:

1. Creates exponential benefits from the knowledge as people learn from it
2. Has a positive impact on business processes
3. Enables the organization to position itself for responding quickly to customers, creating new markets, developing new products, and dominating emerging technologies
4. Builds mutual trust between knowledge workers and management and facilitates cooperation in handling time-sensitive tasks
5. Builds better sensitivity to ‘brain-drain’
6. Ensures successful partnering and core competencies with suppliers, vendors, customers, and other constituents
7. Shortens the learning curve, facilitates the sharing of knowledge, and quickly enables less-trained brokers to achieve higher performance levels
8. Enhances employee problem-solving capacity by providing access to compiled subject
The open, sharing and creative environment that a knowledge management initiative can create affords better transparency of a company’s intellectual capital which allows companies to develop better products and services, improve customer relationships, create new markets and enhance share in existing markets.

5.2.4 The Relationship between Knowledge Management and the Knowledge Economy

‘Understand motives and you understand why many things happen.’
Longley et al., (2005), p411

The reasoning behind this project is to understand why companies set up here, what attracts them to the Irish economy and what attracts them about the Irish workforce. If we know the answers to these questions we can exploit them to attract further knowledge based industry investment in the future and continue to do the things that make the Irish economy an attractive place to invest.

5.3 Assessing Ireland’s Knowledge Economy with the Principles of Knowledge Management

5.3.1 Capture tacit knowledge about why companies choose to locate here

The primary goal of Knowledge Management, to capture the tacit and undocumented knowledge of an organization and make it readily available to those who want it is quite a fitting concept for the purposes of this project.

It is in capturing and documenting the reasoning behind why industries involved in Research and Development and knowledge based services chose to locate in Ireland can we gain a valuable insight into the state of Ireland’s Knowledge Economy. The
goal of this project is to capture the tacit knowledge of Irish knowledge-based service and research and development companies and to document and share these insights with the relevant parties. If an organization can succeed in capturing and disseminating knowledge contained within its walls then the benefits for that company are limitless. If this project can succeed in capturing the underlying reasons why companies choose to locate their industry here in this country, then the benefits to the Irish Knowledge Economy could be substantial.

The organizational survey conducted in section 6.2.2 encourages companies to share their knowledge about why they chose to establish their business here in Ireland. By sharing knowledge, an organization creates exponential benefits from the knowledge as people learn from it (Awad and Ghaziri, 2004, p10). In a similar vein, sharing knowledge about the reasons why knowledge enterprise is attracted to a particular area can create exponential benefits for the Irish Knowledge Economy.

Information regarding why high-end companies choose to set up here can be leveraged and exploited to the advantage of the Irish economy. If Ireland can uncover what really makes us an attractive location then government and local authorities, empowered by such knowledge, can put in motion initiatives in order to cater to the needs of high-end companies and secure substantial investment for Ireland’s Knowledge Economy.

5.3.2 Assess Ireland’s Intellectual Capital

Knowledge Management can also provide a means to assess the intellectual capital of an organization. This can equally be applied to the Irish Knowledge Economy. Knowledge Management’s primary goal is to,

‘capture the tacit knowledge required by a business process and encourage knowledge workers to share and communicate knowledge with peers.’ Awad and Ghaziri (2004), p10

By sharing or making available statistics about the Irish workforce and how it measures up to the requirements of a knowledge economy, both Governmental
agencies and potential investors to Ireland can access and harness the tangible benefits that Knowledge Management can provide.

Incorporating census data about the Irish workforce into a thematic map can achieve an intellectual capital analysis of the Irish population.

5.3.3 Disseminate Knowledge about Ireland’s Knowledge Economy

The Knowledge Management guru, Ikujiro Nonaka discusses the idea of the ‘knowledge-creating company’ in The Harvard Business Review on Knowledge Management (1998). Nonaka states that successful companies are those that consistently create new knowledge, disseminate it widely throughout the organization, and quickly embody it in new technologies and products (Nonaka, 1998, p22), i.e. successful organizations are those which can act quickly upon gaining new knowledge and tailor it to their advantage.

In terms of this project and Ireland’s Knowledge Economy, a successful knowledge economy is one that can consistently review its performance, identify its strengths and weaknesses and convey these strengths and weaknesses to the appropriate policy makers to ensure a strong knowledge economy through sustained initiatives for growth and prosperity.

The medium of which to communicate such information can take many forms such as government reports, spreadsheets and web pages. This project however proposes the use of Geographical Information Systems as the medium to disseminate information about Ireland’s Knowledge Economy. To further highlight the power of GIS this project will utilize a GIS to pinpoint the location or potential location Knowledge Based Industrial Centre in particular area, taking into account the economic, educational and infrastructural condition of the region in accordance with the ideal criteria by which a large organization would require to establish a Knowledge Based Industrial Centre in the area.
5.3.4 Who should use this information?

‘...it is essential that the relevant stakeholders are involved in the development and implementation of strategies for achieving this vision.’
Inter Departmental Committee on Science, Technology and Innovation (2004), p3

The development of the Irish Knowledge Economy requires a profound effort from all segments of society, from governmental organizations to citizens. It is the duty of the government to provide an adequate platform for knowledge economy industries to establish and operate from this country through sustained investment and promotion of the Irish Knowledge Economy. It is the duty of the Irish citizenry to inform and empower themselves about the Irish Knowledge Economy and to make a concerted effort to acquire the skills need to participate fully in the Irish Knowledge Economy.

The information acquired in this document can be utilized by the various stakeholders relevant to the Irish Knowledge Economy.

Organizations can use census data and statistics generated by the report to get a greater understanding of the proletariat in their area and also identify where they skills they need are located.

Government Agencies can use the thematic map to analyse the Irish and regional workforces to understand where and why R&D organizations are located and where and why R&D organizations might locate in the future.

Local Authorities and County Councils can use this information and the framework to identify gaps in the transportation or telecommunications network in their area to cater towards the organizations that are operating in their area.

Universities can use this information to identify what kind of organizations operate in their area and the type of skills they require. Using such information they could provide courses that correspond to the needs of industry in their particular area.
Citizens can identify the companies located in their area and tailor their skills and qualifications to meet the needs of such organizations in order to improve their employment prospects and to become a fully integrated ‘knowledge worker’ in Ireland’s Knowledge Economy.

5.4 Conclusion

This chapter discussed how the principles of knowledge management are of relevance to this project.

This chapter first introduced a definition of the term of knowledge management from an organizational context and briefly detailed how and why the concept of knowledge management became recognized as an organizational tool. The benefits of knowledge management were also detailed.

Next knowledge management was discussed in relation to the knowledge economy and the principles of knowledge management that were deemed relevant and useful to the completion of this project were highlighted, capture organizational tacit knowledge, assess Ireland’s intellectual capital and disseminate knowledge.

Finally, this chapter concluded by detailing the people or groups that may find the information presented in this project valuable.
6 PLOTTING IRELAND'S KNOWLEDGE ECONOMY WITH GIS

6.1 Introduction

This chapter will detail how GIS is relative to an assessment of the Irish Knowledge economy.

This chapter will firstly describe what exactly constitutes a knowledge management tool and how GIS conforms to this definition. This chapter will then detail the relationship between GIS and the Knowledge Economy how GIS can be used to perform a spatial analysis of the Irish Knowledge Economy.

6.2 What constitutes a Knowledge Management Tool?

The capacity to create knowledge begins with the collecting, storing, organizing and displaying relevant, up-to-date and accurate information. Therefore a Knowledge Management tool can be defined as a tool that displays accurate information in a timely fashion. The more accurate and timely information is, the more valuable it becomes for analysis and the creation of insight and new knowledge (Awad and Ghaziri, 2004, p356).

To be useful in creating knowledge, information must reach the relevant parties in the most convenient, accurate and efficient way. Such information must be easily accessible by all parties to whom the information pertains to, it must be relevant and be utilized appropriately to the relevant parties’ advantage. It must also be accurate and up-to-date with the relevant parties’ goals and objectives.
6.3 GIS as a Knowledge Management Tool

Geographical Information Systems are becoming increasingly used for decision support in applications such as regional planning to agriculture and the utilities.

‘In this respect GIS may be seen as an adjunct to management science, and for some organizations the GIS related functionality may become entirely integrated with a corporate or management information system.’ Jones (1997), p6

GIS is involved inescapably in this innovative gallop and is part of the Knowledge Industries (Longley et al, 2005, p414). Geographical Information Systems are considered a classic Knowledge Management tool. The measure of a knowledge management tool is how well it can present information so that knowledge about a particular subject may be acquired by the user and utilized to their advantage.

A thematic map devised by a Geographical Information System contains many of the hallmarks associated with traditional knowledge management tools. A map can be easily interpreted irrespective of academic background or qualifications ensuring that cross-boundary collaboration and cooperation between various entities utilizing the map can occur relatively unabated.

The varying views and visualizations of phenomena provided by a map can greatly enhance a persons understanding of a particular event or concept. The level of detail shown in a map can also determine how well a map communicates information (Heywood et al., 2006, p255). How well a map can communicate the information that it contains can determine the quality of the decisions made on the basis of the data depicted in the map.

As GIS becomes increasingly engrained in knowledge based industry such as a decision support mechanism, its reputation as a knowledge management tool grows ever stronger.
6.4 A Spatial Analysis of Ireland’s Knowledge Economy

In terms of this project, the correlation between thematic maps and the Irish Knowledge Economy may not be entirely evident at first. However certain data is needed in terms of the Irish labour force, Irish educational statistics and transportation information in order to properly quantify or measure the current state of the Irish Knowledge Economy against the goals set by the Lisbon Agenda and the Irish Government.

Irish census data (CSO 2005) can provide vital statistics on the Irish population which may be used as attribute data in a thematic map.

Most paper maps present a static, stagnant view of the world, whereas conventional paper maps and charts are not adept at portraying dynamics. GIS-based representations however, are able to achieve this through animation (Longley et al., 2005, p270).

Analysing census data using a thematic map representation can give a richer and more insightful view of population information and can help to identify spatial correlations, clusters and patterns in a way that other reporting mechanisms such as databases and spreadsheets cannot.

Despite recent advances in computer graphics and visualization, the map is still the most elegant and compact method of displaying spatial data (Heywood et al., 2006, p254).

6.5 Conclusions

This chapter discussed Geographical Information Systems firstly in terms of their importance as a knowledge management tool and secondly their relationship with the knowledge economy.
Finally this chapter explained the relationship between GIS and the Knowledge Economy and how performing a spatial analysis of Ireland using GIS can give a richer and more insightful view of the Irish Knowledge Economy.
7. **A KNOWLEDGE BASED INDUSTRY FRAMEWORK AND SUPPORTING THEMATIC MAP**

### 7.1 Introduction

This chapter presents the framework of criteria developed as part of this project to allow regions of Ireland to be assessed for suitability for location by high-end knowledge based enterprises.

The chapter opens by presenting drivers for innovation and future skills requirement in Ireland supported by literature and the results of surveys conducted during the research for this project. From this a Knowledge Based Enterprise Framework was developed which is presented and examined.

Next, this chapter presents the results of an evaluation of the framework using a GIS and data from the Central Statistics Office to produce a report showing how a sample region of Ireland performs against the framework developed.

This chapter concludes by using knowledge based industry feedback to evaluate the usefulness of GIS at displaying information pertaining to the Irish Knowledge Economy.

### 7.2 Framework

#### 7.2.1 Drivers for Innovation

A prime example of the factors that affect a Knowledge-Based company’s decision to locate in a particular country or region is to cite the current trend among large Knowledge-Based organizations to offshore their knowledge based tasks such as R&D to Asian economies such as India and China.

The Asia-Pacific region is experiencing substantial growth in knowledge based activity. A survey conducted by the Economist Intelligence Unit (Economist
Intelligence Unit, 2007, p7) showed that 30% of companies surveyed intended to increase their investment in the Asia-Pacific region substantially in comparison to 14% who intended to increase their investment in the US. Factors affecting firms’ propensity to invest in Asian markets include improvement in higher education, infrastructure and business practices.

The survey conducted by the Economist Intelligence Unit revealed that ‘access to qualified staff” ranked extremely highly, with 61% of respondent’s claiming it to be ‘very important’ when considering to locate in a particular area. An interesting point as noted by Richard Scase of the University of Kent is that the reason why many companies chose to locate in Asia is that they have plugged many of the ‘skills gaps’ that Europe has failed to recognize by appealing to more women, ethnic minorities and older workers.

Another important factor for Knowledge-Based Enterprise to consider is proximity to Universities. Relationships with universities can prove a vital resource in the innovation chain by not only providing de facto recruitment pools, but also companies view relationships with students as essential to improve the quality of their graduate intake. 60% of respondents to the Economist Intelligence Unit survey currently have universities assisting with their innovation processes. (Economist Intelligence Unit, 2007, p10)

Another vital facet of a knowledge economy is to have a modern, dynamic information infrastructure that can facilitate effective communication, dissemination and processing of information. This is one of the World Banks four key pillars of a knowledge economy and is an imperative entity if a region is to be attractive to Knowledge Based Enterprise. (IDA, 2007)

Low local labour costs and low local tax regime also rank among the more desirable factors to consider for knowledge based industry.

The Economist Intelligence Units survey indicates the key factors to consider when establishing a knowledge-based industrial centre at a particular location. Figure 3
below illustrates the nine key factors that were deemed important when companies chose to establish an R&D site.

![Figure 3: Economist Intelligence Unit Survey Results](image)

**Figure 3: Economist Intelligence Unit Survey Results**

Source: Economist Intelligence Unit, 2007, p20

Access to qualified staff, local labour costs, access to universities and tax incentives were deemed the most important factors to consider according to the Economist survey results.

### 7.2.2 Survey Results

The survey conducted as part of this project assessed a number of companies in the knowledge based enterprise sector incorporating software engineering, management consulting, high-end manufacturing and medical research.

The main aim of the survey was to assess the reasons why the particular company chose to locate in Ireland. Questions to companies included, what percentage of staff in the company is devoted to research and development, what is the minimum level of educational attainment required to work in the company, does the company rely on
university graduates to fill positions and was proximity to university a factor when choosing to establish at their location. Companies were also asked to rate the in order the factors they considered important when choosing to locate in their area.

Figure 4 below illustrates the survey responses to the question of how much of their staff is devoted to research and development, an essential component of knowledge based enterprise and a sector vital to the success of the Irish Knowledge Economy.

Of the respondents to the survey, 66% had only up to ten per cent of their organization devoted to research and development with 11% of organizations surveyed having 40-50% of staff devoted to R&D.

Figure 5 below shows the amount of employees devoted to IT of the survey respondents.
Judging from the survey responses the majority of employee’s devoted to IT fall between 0-40%. IT can be considered as the most basic component of knowledge bases industry and is a useful benchmark to assess the level of knowledge based activity present in a given organization.

Most organizations surveyed had a substantial investment in information technology suggesting that basic knowledge based enterprise activity is prevalent among Irish organizations however the relative investment in research and development is still some way behind the investment in IT.

Companies were asked to rate in order of 1-8, an answer of one indicating most importance, the factors which most affected the company’s decision to locate their knowledge based enterprise at their location. Figure 6 below shows the nature of responses to this question. The lower the average response, the more important a factor it was.
From the responses obtained, the most important factors to organizations setting up in Ireland are as follows:

1. The presence of an educated workforce
2. The current rate of corporation tax
3. The company was already operating in Ireland
4. The quality of the areas telecommunications system
5. The quality of the areas transportation system
6. The strategic location of the area
7. The level of wages of employees
8. The cost of operating form the area

The next series of questions focused on the role that the presence of an educated workforce had on a company’s decision to locate in a certain region. The average qualification to be employed in one of the responding companies was a university degree, indicating that the majority of companies surveyed required highly-skilled and qualified professionals. Figure 7 illustrates this fact.
Figure 7: Minimum educational achievement required for employment

Figure 8 corroborates this finding with 71.4% of respondents citing that the presence of an educated workforce was a factor to consider when the location of the knowledge based enterprise.

Figure 8: The importance of the presence of an educated workforce

Figure 9 shows that 66.7% of respondents have facilities cited in the catchment areas of universities and third level institutes of education.
Figure 9: Proximity to universities

Figure 10 shows a somewhat mixed response to the proximity to university factor. Only 33% of respondents cited that proximity to a third level institute was a factor that influenced the location of their enterprise.

Figure 10: University as a factor

However an overwhelming 100% of respondents stated that university graduates have an important contribution to the organizations knowledge based activities. This is depicted in figure 11.

Figure 11: The contribution of university graduates
The next series of questions focused on the quality of public transportation in the company’s vicinity and its relevance to choosing an area to locate knowledge based enterprise. Figure 12 indicates the respondents overall satisfaction with the public transportation service in their area.

The majority of respondents (66.6%) rated the level of public transport in their area as either good or excellent. When asked whether the quality of transportation network was a factor in choosing their location 83.3% of firms responded that it was. Figure 13 displays these responses.

The next series of questions focused on the organization’s awareness of the concept of the Knowledge Economy and their feelings towards their level of contribution to it. In general most respondents were aware of the term the knowledge economy (83%, see figure 14) and 60% felt that the nature of their respective operations was contributing in a meaningful way to the Irish knowledge economy. Figure 15 depicts the response.
7.2.3 Knowledge Based Industry Framework

From the results of the survey for this project and the results of the Economist Intelligence Unit Survey, the presence of the following factors are deemed important for the location of Knowledge Based Enterprise,

- Access to qualified staff
- Links / graduate intake from local universities
- Local labour costs
- Local tax regime
- Infrastructure and transportation links

These factors are collated into a Knowledge Based Enterprise Framework which is illustrated below in figure 16:
<table>
<thead>
<tr>
<th>Criteria</th>
<th>Rating</th>
</tr>
</thead>
<tbody>
<tr>
<td>Access to qualified staff</td>
<td>1. very \important</td>
</tr>
<tr>
<td>Graduate intake from local universities</td>
<td>2</td>
</tr>
<tr>
<td>Local labour costs</td>
<td>3</td>
</tr>
<tr>
<td>Quality of transportation infrastructure</td>
<td>4</td>
</tr>
<tr>
<td>Quality of telecommunication infrastructure</td>
<td>5</td>
</tr>
<tr>
<td>Local corporation tax rate</td>
<td>6</td>
</tr>
</tbody>
</table>

Figure 16: Knowledge Based Industry Framework

From the framework, the two essential and most critical factors for the presence of Knowledge Based Activity in an area are access to qualified staff and access to graduates from local universities. Without a significant supply of suitable workers present in a particular area and the presence of universities producing industry ready graduates to supplement the enterprise, knowledge based activity could not operate in a given region.

Secondary factors to consider, but still deemed quite important to Knowledge Based Industry are local or regional labour costs, the quality of the transportation infrastructure and the quality of the telecommunications infrastructure. It is important that local wages are void of extensive inflation, the transportation infrastructure is adequate and offers variety and flexibility in terms of public transportation and that the telecommunications market is modernized and competitive offering organizations a wealth of choice by which to chose their telecommunications plan.

7.3 GIS Implementation

7.3.1 Area Background
From a European perspective, Ireland compares favourably to many of its EU contemporaries in terms of some of the conditions necessary to attract knowledge based enterprise (IDA Ireland, 2006).

In terms of Corporation Tax rate, one of the key factors identified by the Knowledge Based Industry Framework in section 6.2.3, Ireland can boast one of the lowest tax rates in the EU, a factor that should be conducive to attracting future Knowledge Based Industry.

Figure 17 below shows a thematic map based comparison of European corporation tax rates as of 2007 (IDA Ireland, 2007, p9). The areas of dark green indicate countries with a lower corporation tax rate than countries shaded in lighter green.
Ireland boasts a tax rate of 12.5%. Cyprus has the lowest European corporation tax rate at 10%, while Germany has the highest rate at 38.60%.

Another core element of the future of the Irish Knowledge Economy will be a young and dynamic workforce with the ability to embark on a path of life-long learning as Knowledge Workers of the Irish Knowledge Economy.

To this end, Ireland will be in the position to boast a significantly younger proletariat than many of its European neighbours. The thematic map in figure 18 below compares the percentage of the European population that will be under 25 by the year 2010. The dark brown shaded regions indicate countries with a higher percentage of the population under 25 by 2010.

Figure 18: Percentage of population under 25 by 2010
Source of data: IDA Ireland, 2007
34.1% of the Irish population will be under 25 in 2010, the highest in Europe. France & UK will have 30.4% of the population under 25, while Germany and Spain will only have 24.9% and 25.1% of the population under the age of 25 by 2010.

This fact coupled with the current trend of achievements in tertiary education could make Ireland an extremely attractive location for Knowledge Based Industry in terms of access to qualified staff, the number one factor as defined by the Knowledge Based Industry Framework in section 6.2.3. In 2004, 40% of the Irish population aged between 25 and 34 had achieved some form of tertiary education. This figure is only superseded by Belgium at 41% of the population.

Figure 19 below shows a thematic map based comparison of the tertiary educational achievements of the populations of some of the countries of Europe aged between 25 and 34.

![Thematic Map](image)

**Figure 19:** Percentage of the population aged between 25 and 34 who had achieved tertiary education by 2004.
The areas of dark red indicate countries with high tertiary educational achievement.

7.3.2 Area Statistics

The Irish CSO data (CSO 2007) reveals vital statistics regarding the current state of Ireland’s Knowledge Economy. From the CSO data the total number of Irish people in degree or higher education equates to 396,408.

From this data a selection of the top 5 education ‘hotspots’ can be devised. Table 6 below indicates the five areas with the most students in full time education. These areas will experience a significant number of graduates in the coming years with skills that can contribute to the knowledge economy. Such graduates are pivotal to the knowledge economy and knowledge based organizations will look to establish in these areas to avail of the access qualified professionals.

<table>
<thead>
<tr>
<th>Top 5 Education ‘Hotspots’ of Ireland</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
<tr>
<td>3</td>
</tr>
<tr>
<td>4</td>
</tr>
<tr>
<td>5</td>
</tr>
</tbody>
</table>

Table 6: Top 5 Educational ‘Hotspots’ of Ireland according to CSO data 2002
Source: CSO data 2002, (CSO 2007)

The CSO data indicates that there are currently 1,125,296 people employed in knowledge based industry-type work. Namely, these areas as defined by the CSO are clerical managing and government workers, communication and transport workers, sales and commercial workers, professional, technical and health workers and service workers (CSO 2007).
Delving deeper into these statistics reveal more definitive employment categorisations. In terms of people employed in Research and Development, the CSO data indicates that as of 2002 there were 2,954 people devoted to R&D in Ireland, 1,385 were male and 1,569 were female (CSO 2007).

Table 7 below depicts the top 5 R&D ‘hotspots’ in Ireland as of 2002.

<table>
<thead>
<tr>
<th>Top 5 Research and Development ‘Hotspots’ of Ireland</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Dublin City</td>
</tr>
<tr>
<td>2  Dun Laoghaire-Rathdown</td>
</tr>
<tr>
<td>3  Cork County</td>
</tr>
<tr>
<td>4  Fingal</td>
</tr>
<tr>
<td>5  South Dublin</td>
</tr>
</tbody>
</table>

Another sector of knowledge based enterprise is banking and financial services. The CSO data (CSO 2007) indicates that as of 2002, there were a total of 70,838 people employed in the financial sector comprising of 29,557 males and 41,281 males. Table 8 below highlights the top 5 banking and financial services ‘hotspots’ as of 2002.

<table>
<thead>
<tr>
<th>Top 5 Banking and Financial Services ‘Hotspots’ of Ireland</th>
</tr>
</thead>
<tbody>
<tr>
<td>1  Dublin City</td>
</tr>
<tr>
<td>2  Dun Laoghaire-Rathdown</td>
</tr>
<tr>
<td>3  South Dublin</td>
</tr>
<tr>
<td>4  Fingal</td>
</tr>
<tr>
<td>5  Cork County</td>
</tr>
</tbody>
</table>

Another sector important to the Knowledge Economy is the IT sector, computer and computer related activities sector. As of 2002 there were 33,966 people employed in
this market, 22,153 male and 11,813 female (CSO 2007). Table 9 below shows the top 5 IT ‘hotspots of Ireland as of 2002.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Area</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dublin City</td>
<td>8569</td>
</tr>
<tr>
<td>2</td>
<td>Dun Laoghaire-Rathdown</td>
<td>4305</td>
</tr>
<tr>
<td>3</td>
<td>Fingal</td>
<td>3174</td>
</tr>
<tr>
<td>4</td>
<td>South Dublin</td>
<td>2888</td>
</tr>
<tr>
<td>5</td>
<td>Cork County</td>
<td>2006</td>
</tr>
</tbody>
</table>

Table 9: Top 5 IT ‘hotspots’ as of 2002
Source: CSO 2007

Another area of potential growth in the Knowledge Economy will be highly-skilled jobs such as technical testing and analysis. As of 2002 there were 1,124 people employed in this area, 610 males and 514 females. The top 5 technical testing and analysis ‘hotspots’ are illustrated in table 10 below.

<table>
<thead>
<tr>
<th>Rank</th>
<th>Area</th>
<th>Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Dublin City</td>
<td>120</td>
</tr>
<tr>
<td>2</td>
<td>Cork County</td>
<td>118</td>
</tr>
<tr>
<td>3</td>
<td>South Dublin</td>
<td>81</td>
</tr>
<tr>
<td>4</td>
<td>Dun Laoghaire-Rathdown</td>
<td>79</td>
</tr>
<tr>
<td>5</td>
<td>Galway County</td>
<td>70</td>
</tr>
</tbody>
</table>

Table 10: Top 5 Technical Testing and Analysis ‘hotspots’ as of 2002
Source: CSO 2007

From the statistics revealed by the Census 2002 data (CSO 2007), it is evident that Dublin County and its electoral divisions contain the highest percentage of highly-skilled and qualified staff needed to contribute to Ireland’s Knowledge Economy.
7.3.3 Area Results in Comparison to Survey

The survey conducted in section 6.2.2 revealed the primary factor in a knowledge based organizations decision to locate in an area is access to qualified staff.

Figure 20 below shows a comparative analysis of the number of people possessing a third level degree or higher by county.

Figure 20: Degree by County
Source: CSO 2007
Clearly the area with the highest number of people containing is Dublin County with 180,000.

The next factor affecting a knowledge based organizations decision to locate in an area according to the survey is access to university graduates. Figure 21 below indicates where the major universities and third level institutes are located in Ireland.

![Figure 21: Major Universities of Ireland](image)

Local labour costs was deemed to be the third most important factor affecting a knowledge based organizations decision to locate in an area. Figure 22 illustrates the local labour costs for five sample positions for Ireland in comparison to the UK, Germany and the Netherlands. The red bar indicates the average rate for a junior technician, in Ireland it is €13.29 per hour. The yellow bar indicates the hourly rate for a senior technician (€19.24 per hour in Ireland), the blue bar depicts the rate for a senior accountant (€39.85 in Ireland) per hour, the green bar indicates a middle
managers’ hourly rate (€47.80 in Ireland) and finally the purple bar highlights a senior manager average hourly earnings (€53.60 in Ireland).

![Figure 22: Irish Labour Costs vs. European Labour Costs](image)

Source IDA Ireland 2007

The fourth most important factor to a knowledge based firm is the quality of the transportation network. Figure 23 below highlights the main arteries of Ireland.
The major Irish roads stem from the M50, the ring road of Dublin City to the major towns of the country including Galway, Cork, Sligo and Limerick.

Telecommunications and the quality of the local telecommunications service was deemed the next most important factor to Knowledge Based Enterprise. Figure 24 below shows the rates for calls to the highlighted countries.
Purple areas indicate rates of over 0.38 euro per minute. Rates from Ireland to UK are 0.1535 euro per minute, to France and Benelux 0.242 euro per minute and to Finland, Spain, Austria, and Denmark 0.3872 euro per minute.

The Corporation Tax rate was the final factor affecting a Knowledge Based Enterprises decision to locate in a particular region. Figure 17, section 6.3.1, page 78, illustrate Ireland’s 12.5% corporation tax in comparison to the rest of Europe.
7.3.4 Area Results in Comparison to Irish Knowledge Economy Goals

The number of researchers needed by the year 2010 to meet Ireland’s Knowledge Economy aims is 8,000. The CSO 2002 data (CSO 2007) indicates that as of the year 2002 there were 2,964 researchers in Ireland, mostly centralized in the Dublin region. This is illustrated in figure 25 below.

![Map of Ireland showing research distribution by county](image)

Figure 25: The number of researchers in Ireland as of 2002

Source: CSO 2007
Ireland needs to attract research and development activity to areas outside of the Dublin region in order to take full advantage of the qualified personnel and graduates coming from these areas.

### 7.4 Suitable Area for Knowledge Based Enterprise

The area chosen as a suitable location for a Knowledge Based Organization to locate its enterprise was Castleknock in Dublin 15. Castleknock was chosen as a potential knowledge based enterprise location due to the area meeting all of the required standards and conditions outlined by the knowledge based industry framework in section 6.2.3.

Figure 26 indicates Castleknocks’ position on the map.

![Figure 26: Castleknocks’ location](image)

Castleknock meet all of the criteria as defined by the framework. These criteria were:
1. Access to qualified staff

Dublin County and in particular Fingal County in which Castleknock is situated was consistently featured in all of the top five employment ‘hotspots’ illustrated in section 6.3.2. Castleknock and its surrounding areas can provide a knowledge based organization with a wealth of qualified and highly-skilled workers to contribute to its business including researchers, IT staff and technical testers and analysts.

2. Access to universities

Figure 27 below highlights the abundance of universities and third level institutes in Castleknocks region.

![Figure 27: Universities in Castleknocks’ Region](image)

Universities and third level institutes in the region include NUI Maynooth, Blanchardstown IT, Tallaght IT, DIT Aungier St, DIT Kevin St, Dublin City
University and Trinity College Dublin. Figure 28 indicates their exactly proximity to Castleknock.

**Figure 28: Universities proximity to Castleknock**

DCU (green line) is 11.6 km from Castleknock, NUI Maynooth (purple line) is 17.0km, Tallaght IT (red line) is 14.3km, Trinity College (yellow line) is 7.0km, DIT Kevin St (brown line) is 6.94km and finally DIT Aungier St (blue line) is 6.67km away form Castleknock. The proximity to so many third level institutes could provide the knowledge based industry with a wealth of qualified graduates.

3. Local labour costs
Table 11 shows the local labour costs for a sample of five given high-end positions for Ireland, the UK, Germany and the Netherlands.
<table>
<thead>
<tr>
<th>Employee</th>
<th>Ireland</th>
<th>UK</th>
<th>Germany</th>
<th>Netherlands</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technician (Entry Level)</td>
<td>13.29</td>
<td>12.66</td>
<td>14.35</td>
<td>13.77</td>
</tr>
<tr>
<td>Technician (Senior Level)</td>
<td>19.24</td>
<td>17.35</td>
<td>21.61</td>
<td>19.76</td>
</tr>
<tr>
<td>Senior Accountant</td>
<td>39.85</td>
<td>30.12</td>
<td>42.44</td>
<td>35.12</td>
</tr>
<tr>
<td>Middle Manager</td>
<td>47.80</td>
<td>34.57</td>
<td>50.25</td>
<td>40.55</td>
</tr>
<tr>
<td>Senior Manager</td>
<td>53.60</td>
<td>40.80</td>
<td>55.31</td>
<td>47.88</td>
</tr>
</tbody>
</table>

Table 11: Average Labour Costs per Country
Source: IDA Ireland 2007

4. Transportation links

Figure 29 shows the transportation links available in the Castleknock area. Numerous Dublin City buses (yellow line) are available which service Castleknock to Dublin City Centre. There is also a rail service (orange line) that connects to Dublin City centre and continues through Castleknock to Maynooth. The M50 motorway is also in close proximity to Castleknock and is a major artery for Dublin traffic.
5. Telecommunications network

Caslteknock boasts a state of the art telecommunications network with multiple phone, mobile phone and internet providers servicing the area.

6. Corporation Tax Rates

The corporation tax rate is standard throughout Ireland.

Having met all of the required standards and conditions defined by the knowledge industry framework, Castleknock possess all of the desired attributes to locate a knowledge based enterprise.
7.5 Evaluation of GIS

GIS’s usefulness as a knowledge management tool was then assessed by various knowledge based industries. The images developed using the GIS in sections 7.3 and 7.4 were presented to 8 organizations for analysis and feedback on GIS’s usefulness at displaying information pertaining to Ireland’s knowledge economy. Knowledge Based Industries included in this GIS Evaluation survey were Microsoft, Intel, AIB, Bank of Ireland, OcucoRelcon, Accenture Ireland and Mazars Accounting.

A sample set of four images generated by the GIS on Ireland’s Knowledge Economy were presented to the various organizations. These images were Figure 17 (page 80), Figure 19 (page 82), Figure 20 (page 86) and Figure 28 (page 94). Organizations were asked to assess the usability of GIS and whether or not the thematic maps presented were a useful way to display information about Ireland’s Knowledge Economy. Figure 30 below illustrates the industry feedback regarding the usefulness of GIS to display information about the Irish Knowledge Economy.

![Figure 30: Evaluation of the usefulness and usability of the GIS images generated for this project](image)

All respondents to the survey considered Figures 17 and 19 to be an appropriate, comprehensible and useful way to display information regarding the Irish Knowledge Economy while only one company considered Figure 20 and 28 to be an inappropriate portrayal of the Irish Knowledge Economy.
Next companies were asked to consider GIS’s usefulness as a knowledge management tool and to assess its overall appropriateness or applicability at depicting information about Ireland’s Knowledge Economy. Figure 31 displays the responses to these survey questions.

![Figure 31: The applicability of GIS survey responses](image)

First organizations were asked to consider GIS’s overall usefulness as a knowledge management tool and assess whether GIS is an appropriate way to display information about the Irish Knowledge Economy based on the images presented. 100% of respondents (8 out of 8) considered GIS to be an appropriate way to display such information. Next organizations were asked to compare GIS as a method of displaying and communicating statistical and census based information versus the more traditional methods of communicating this type of information such as spreadsheets and statistical reports. 87.5% or 7 out of 8 respondents considered GIS to be a better way to display such information. Next organizations were asked to consider the potential of a GIS based application that might be used to display census data and data about the Irish Knowledge Economy to government agencies and knowledge based organizations. 7 out of 8 respondents considered a GIS based application to be a good idea. Finally, organizations were asked whether a GIS could be used in their company to display and evaluate any data they might have. 7 out of 8 respondents said they would consider using GIS in their organization.
7.6 Conclusion

This chapter firstly detailed the drivers for innovation and discussed the results of the Economist Intelligence Unit survey (Economist Intelligence Unit, 2007) on the factors affecting a knowledge based enterprises’ decision to locate in a particular area.

Next this chapter presented the findings of organizational survey conducted as part of this research and defined the core elements required for a knowledge based enterprise to site at a particular location. The survey results were then collated into a Knowledge Based Industry Framework in order of importance.

The ix most important factors were:

- Access to qualified staff
- Access to university graduates
- Local labour costs
- Quality transportation network
- Quality telecommunications network
- Corporation tax rates

This chapter then discussed these factors in comparison to our European contemporaries and used thematic maps developed in a GIS to highlight our strengths and shortcomings in terms of knowledge based industry factors. Next some statistics from the CSO data 2002 (CSO 2007) were illustrated and some area ‘hotspots’ containing conditions conducive to knowledge based industry were highlighted.

Next, GIS was used to display current (2002) Irish Knowledge Economy data in light of the survey findings. GIS was then used to highlight the state of Ireland’s Knowledge Economy in comparison to its knowledge economy goals.

Next, this chapter used a Geographical Information System to pinpoint an area of Ireland (Castleknock) that matched all of the predetermined criteria suitable to site a
knowledge based enterprise and to provide adequate and logical reason on why such a location was suitable.

Finally, this chapter used knowledge based industry feedback to evaluate the images generated by GIS for the purposes of this project and to assess GIS’s usefulness as a knowledge management tool and its appropriateness at displaying information pertaining to the Irish Knowledge Economy.
8 CONCLUSION

8.1 Introduction

This chapter will detail the results, conclusions and recommendations reached from the research conducted into the Irish Knowledge Economy. The aim of this project was to highlight the applicability and usefulness of applying a Geographical Information System (GIS) to the analysis of the Irish Knowledge Economy and this chapter will illustrate conclusions drawn on the usefulness of this approach. This chapter will also recommend future research needed to give a more comprehensive overview of the Irish knowledge economy.

8.2 Research Definition & Research Overview

The knowledge economy refers to economies whose primary source of wealth generation focuses on technological, scientific or knowledge based industries as opposed to more traditional capitalistic and agriculturally based industries (OECD 1996). Many external factors are contributing to the irrevocable progression of western societies towards knowledge economies. The emergence of low cost economies such as China, India and other south-east Asian nations are exerting enormous pressure on western economies (McBrierty and Kinsella, 1998, p6). This employment shift is forcing many economies to reposition themselves as Knowledge Economies so that they can continue to attract economic investment, continue current employment trends and sustain economic growth in the absence of the many sections of industry lost to low wage economies. In order for companies and organizations to keep pace in an ever increasing global market place, they need to recognize and acknowledge such an economic transition and the requirements and skills needed in order to exist in it.
8.3 Contributions to the Body of Knowledge

This project has presented an overview of the current state of Ireland’s Knowledge Economy (CSO 2007).

This project has highlighted the applicability and usefulness of Geographical Information Systems as a tool to assess the current state of Ireland’s Knowledge Economy. Geographical Information Systems can be used to analyse and visualize the Irish Knowledge Economy in a much richer format than can be achieved through static economic reports or mundane spreadsheets. The simplicity and intuitiveness of maps produced by Geographical Information Systems make it an ideal agent by which to disseminate information about the state of Ireland’s’ Knowledge Economy to the relevant parties, policy makers and potential investors.

The knowledge based enterprise framework developed for this project has indicated the important factors knowledge intensive industry considers when choosing to locate in a particular area. This organizational tacit knowledge has been captured in the form of a survey and codified in the form a framework and may be disseminated to relevant parties such as government organizations and knowledge industries to highlight Ireland’s readiness for knowledge based activity.

This project has highlighted a potential location of a Knowledge Based Industrial Centre in particular area, taking into account the economic, educational and infrastructural condition of the region in accordance with the ideal criteria by which a large organization would require to establish a facility in the area.

Finally, this project has used knowledge based industry feedback to conclude that GIS is an extremely useful agent to display and communicate information pertaining to the Irish Knowledge Economy.
8.4 Experimentation, Evaluation and Limitation

The primary limitation of this research was the nature of the data used in generating the thematic maps. Only CSO 2002 data was available at the time of writing and a more accurate picture of the Irish knowledge economy would have been obtained had 2006 data been available.

However the nature of the data used did not detract from the primary aim of the research, to highlight GIS’s usefulness in assessing the Irish Knowledge Economy.

The final limitation of this project was in the volume of survey responses received. In all just under 20 responses were received out of 180 organizations polled. Given further time a more comprehensive push for survey feedback might have been achieved.

8.5 Future Work & Research

The most obvious recommendation in regards to future work on this project is the use of census 2006 data. As Irish census 2006 data was not available to the public at the time of writing, all conclusions drawn are based on 2002 census data. A more accurate picture of the Irish Knowledge Economy can be painted using the 2006 census data.

An area of future work would be to conduct this project in the year 2010 and assess

1. The percentage of the EU GDP invested research and development in comparison to the 3% GDP proposed by the Lisbon Agenda
2. Irish business expenditure on R&D in comparison to the €2.5 billion or 1.7% GDP target for 2010
3. The number of indigenous companies with minimum scale R&D in excess of €100,000 in comparison to the 1,050 target for 2010
4. The number of indigenous enterprises performing significant R&D in excess of €2 million in comparison to the 2010 target of 100
5. The number of foreign affiliates companies with minimum scale R&D activity in excess of €100,000 in comparison to the 2010 target of 520
6. The number of foreign affiliates performing significant levels of R&D in excess of €2 million in comparison to 150 by 2010

7. The R&D performance in the higher education and government sectors in comparison to the target of €1.1 billion in 2010 or 0.8% GNP

8. Gross expenditure on R&D in comparison to the target to 2.5% of GNP by 2010

9. The number of researchers in total employment compared to the target of 9.3 per 1000 by 2010

Finally, another potential area for future work would be to develop a GIS based application to display information about the Irish Knowledge Economy. This application could be web-based and could update automatically upon the receipt of new census data. This way information about the Irish Knowledge Economy would be up-to-date and could provide ease of access to the relevant policy makers and knowledge based industries to whom such information would be most advantageous.

8.6 Conclusion

This project highlighted the applicability and usefulness of applying a Geographical Information System (GIS) to the analysis of the Irish Knowledge Economy. It used a GIS to perform a spatial analysis of the Irish Knowledge Economy and evaluate it against a knowledge based industry framework developed from knowledge based industry survey responses.
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## APPENDIX A

Organizational Survey Screen shots:

<table>
<thead>
<tr>
<th>Section 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Profile</td>
</tr>
</tbody>
</table>

1. **Company Name:**

2. **Company Address:**

3. **What is the main focus of your company?**

4. **How many employees are employed at your facility?**

5. **In percentage terms, roughly how many employees in your Irish operation are devoted to manufacturing?**

6. **In percentage terms, roughly how many employees in your Irish operation are devoted to R&D?**

7. **In percentage terms, roughly how many employees in your Irish operation are devoted to I.T.?**

8. **Please rank in order from 1 to 8 (1 being the highest or most prominent reason) the factors which most affected your company’s decision to locate its R&D activity at your location.**
The company was already operating here
The presence of an educated workforce
The quality of the area's transportation system
The quality of the area's telecommunications system
The current corporation tax rate
The level of wages / salaries of employees
The strategic location of your area
The cost of operating in your area

9. **Were there any other factors affecting your decision to site your R&D activity at your location? If yes please specify:**
### Section 2

#### Education

1. **What is the minimum level of educational achievement required in order to work for your company?**

   ![Checkbox]

2. **Was higher educational attainment of the population / workforce in your area a desirable factor when considering the location of your R&D facility?**

   ![Checkbox]

3. **What specific skills / qualifications would graduates need to contribute to your R&D activity? Please specify:**

   ![TextArea]

4. **Is your facility cited near or in the catchment area of an institute of third level education?**

   ![Checkbox]

#### Proximity to University

1. **What is the name of the university / institute of education?**

   ![TextArea]

2. **Was the proximity to the university / institute a factor when choosing your location?**

   ![Checkbox]

3. **Does the output of graduates from the university / institute correlate to your companies R&D skills requirements?**

   ![Checkbox]
Non-proximity to University

1. Do any universities contribute graduates to your operation?

2. Please specify the universities who supply graduates

Section 3
Transportation and Telecommunications

1. Is a quality transportation network in your area an issue for your company’s R&D activities?

2. How would you rate the quality of the transportation network in your area?

3. Was the quality of the transportation network in your area a factor when choosing your location?

4. Is a quality telecommunications network in your area an issue for your company’s R&D activities?

5. How would you rate the quality of the telecommunications network in your area?

6. Was the quality of the telecommunications network in your area a factor when
7. Does your company have a policy whereby staff are allowed/encouraged to work from home?

Section 4

Governmental Factors and Quality of Life

1. Was the rate of corporation tax or government grants a factor when citing your R&D facility?

2. If located outside of Dublin, were the cost of expenses such as rent, water and the cost of living in comparison to Dublin a factor when citing your R&D facility?

3. If located outside Dublin, did the decentralization initiative by the Irish Government influence the location of your R&D facility?

4. Did your company view proximity to social amenities such as schools, hospitals and shopping centre’s as an important factor when choosing to locate in your area?

5. Can employees avail of public transportation to your workplace?

6. Does your company have a staff retention policy?

7. Does your company have a lifelong learning policy whereby employees are encouraged to continue their education?
Section 5

Future Skills

1. Is your company worried about the projected lack of scientific and technologically skilled graduates in the coming years?

2. If yes, please specify any mitigating activities you plan to implement to combat such skills shortages in order to sustain your operation in Ireland.

3. Does your company recognise the need for PhD qualified graduates in the future?

4. Is your company aware of the term 'the Knowledge Economy' and the need to strengthen Ireland's Knowledge Economy through investment in knowledge-based activities such as R&D?

5. If yes, does your company feel that it is contributing to Ireland's Knowledge Economy?
APPENDIX B

GIS Evaluation Survey:

Please enter your name, company name and the nature of your organisation/business/operations.

Name: 

Company Name: 

Business: 

Question 1: Look at the image below. It is a thematic map of Europe which displays the rate of corporation tax in selected countries. The data gives some insight into which countries have a low tax rate (e.g. Ireland) and those high rates (e.g. France and Germany).

Do you think that this map is a useful way of comparing and displaying European Corporation Tax rates? [ ] Yes/ [ ] No

Question 2: Take a look at the image below. It shows a thematic map based on comparison of the tertiary educational achievements of the population of some of the countries of Europe aged between 25 and 34. The darker red/purple indicate countries with higher educational achievements, for example Russia has a tertiary education level of 46% for persons aged between 25 and 34.
Question 3: Take a look at the map image below. It illustrates the volume of people with a University degree or higher per county.

Do you think that this map is an appropriate way of displaying this information? [ ] [ ]

Question 4: The map below displays the universities and third level institutions in the greater Dublin region and their proximity to a chosen location, Castlemall.

Do you think that this map is an appropriate way of displaying this information? [ ] [ ]

Question 5: The images displayed above were generated using a Geographical Information System or GIS. GIS can be used to display a wealth of socio-demographic information and can be utilized by numerous industries to showcase data and trends (e.g., transportation, demographics, etc.).

These images have displayed Irish census 2000 data such as image 3 which compares the volume of people with a university degree per county.
Do you feel GIS is a good way to display and evaluate census data?

Do you feel GIS provides better ways to visualize and reason about census data than government reports, spreadsheets or statistical reports?

Do you think a Web-based application that displays census data in map format would be a good way to communicate information about our state's economy?

Finally, do you think a Geographic Information System could be used in your company to display and analyze any data you might have?