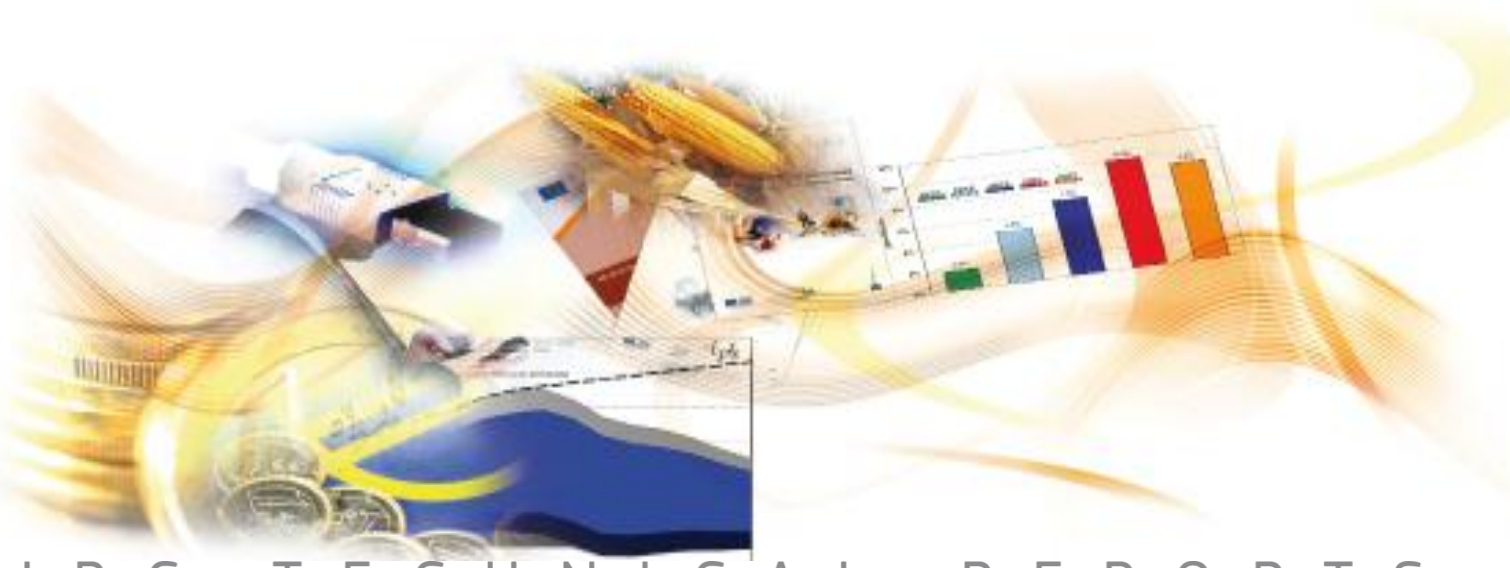
European Commission



J R C T E C H N I C A L R E P O R T S

The Knowledge Economy, Economic Transformations and ICT in the EU25+: Regional Dynamics in the Deployment Phase

Case Study: Southern and Eastern Ireland

Author: Professor Frank Barry

Editors: Andrea de Panizza, Marc Bogdanowicz

2013

Report EUR 26063 EN

Joint Research Centre

European Commission
Joint Research Centre
Institute for Prospective Technological Studies

Contact information
Address: Edificio Expo. c/ Inca Garcilaso, 3. E-41092 Seville (Spain)
E-mail: jrc-ipts-secretariat@ec.europa.eu
Tel.: +34 954488318
Fax: +34 954488300

http://ipts.jrc.ec.europa.eu
http://www.jrc.ec.europa.eu

This publication is a Technical Report by the Joint Research Centre of the European Commission

JRC83549

EUR 26063 EN

ISBN 978-92-79-32385-0 (pdf)

ISSN 1831-9424 (online)

doi:10.2788/66281

Luxembourg: Publications Office of the European Union, 2013

Printed in Spain

Introduction

This case study was prepared as part of the research project "The Knowledge Economy, Economic Transformations and ICT in the EU25+: Regional Dynamics in the Deployment Phase" (Contract No. 150605-2006F1SC-IR), commissioned by the Institute for Prospective Technological Studies of the European Commission's Joint Research Centre.

Its current publication under the EIPE banner, several years later, underlines the validity of the author's analysis of the emergence and growth of an indigenous Irish software sector, strongly rooted in Dublin. The report charts the role played by the foreign-owned high-tech ICT-using sectors in seeding this ICT-producing activity and provides details of the types of state interventions that emerged through a process of trial and error to support it.

Acknowledgments

Gavin Murphy, Donal Smith and Xiaoheng Zhang provided valuable research assistance.

Table of Contents

Executive Summary

The objective of this study is to analyse the consequences of the nexus between ICT use and globalisation for the regional economy of Southern and Eastern Ireland, which has been one of the most rapidly growing EU regions over the last two decades. The specific focus of the study in on the role played by foreign direct investment inflows in ICT-using high-tech sectors, and the policies designed to attract such inflows (including the regional innovation system), in the emergence of a dynamic indigenous ICT-producing computer-software sector.

The nexus between ICT use and globalisation has been explored in Report A of the overall project, which notes that "the tendency of ICT to reduce transaction costs and to facilitate communication and control over longer distances is a major factor behind globalisation. The application of ICT allows for new forms of spatial specialization leading via outsourcing and offshoring to a new … spatial division of labour."

The consequences of the nexus between ICT use and globalisation are particularly apparent in Ireland, which is by most measures the most FDI-intensive economy in Europe. Most of the country's high-tech and largely foreign-owned sectors –including computer hardware and components, computer software, and international financial services – are clustered in the Southern and Eastern region, which is centred around the capital city of Dublin and is by far the richer of the country's two NUTS 2 regions. The indigenous ICT-producing computer-software sector is almost exclusively located in Dublin, suggesting that clustering effects are particularly important in this sector.

We identify several ways by which the presence of a strong FDI presence in high-tech sectors, and the policy environment constructed to attract this presence, facilitated the emergence of a successful indigenous software sector.

Foreign MNCs were important in the early stages of the industry's emergence due to the sophisticated nature of their demands and the access they provided, for successful indigenous suppliers, to their external customer networks. The importance of this mechanism has diminished with time as the cluster matured. Changing patterns as the cluster evolved are indicative of path dependence: spillover effects remain even after the initial firms leave.

Foreign MNCs also served an important role as managerial and entrepreneurial incubators. Several studies have found that around two-thirds of entrepreneurs had worked for Irish-based foreign MNCs at some stage in their careers. As the cluster matured, more and more entrepreneurs gained equivalent experience in other indigenous companies, and a process of continuous new-firm spinoffs became embedded. *Relevant work experience was gained not just in foreign software companies. There is evidence that work experience in targeted vertical markets such as banking, financial services and telecommunications was also important.*

Several types of state interventions directed towards increasing the country's attractiveness to high-tech FDI also proved important in supporting the cluster's emergence.

One of these was the development of a highly advanced digital-based telecommunications infrastructure from the late 1970s in response to foreign-MNC criticisms of the state telephone system, communicated to government through the Industrial Development Agency (IDA). This helped Ireland to capture newly emerging industries in which first-class international telecommunications was a key factor. Also important however from the perspective of the present study is the stimulus it gave to entrepreneurs in this sector, which has become one of the important sub-sectors of the indigenous software industry.

The second state intervention of relevance concerns the incentive to bolster the education system that FDI imparted. This would arguably have been less apparent to policymakers had they been focussed solely on developing indigenous industry.

Report A refers to the importance of different types of knowledge – whether in the form of human capital or more differentiated as tacit or codified – within the regional innovation system. Our discussion of the evolution of the Irish cluster sheds further light on this. *Huge efforts were made over the 1970s and beyond to ensure that Ireland was sufficiently well endowed with the type of general human capital required to support the country's other advantages in attracting FDI. This helped the economy to reap the benefits of the increased global availability of FDI as ICT use and knowledge codification proceeded. Once the indigenous software sector began to take off however, the importance of tacit knowledge – as the glue that holds a cluster in place – grew.*

Path dependency causes local clusters to grow more idiosyncratic over time. This allows local clusters to survive even in an increasingly globalised world. Export-oriented local clusters such as the one explored in the present study must develop and maintain strong links with the most advanced clusters. In the case of computer software, this is Silicon Valley. As charted here, newly emerging Irish firms move rapidly to establish Silicon Valley offices and operations. Without a presence in Silicon Valley, there is little possibility of Irish software firms being featured in the US press, of developing relationships with computer vendors, or of attracting the attention of local specialist venture capitalists. By way of example, the report notes the importance of a Silicon Valley presence for a particular indigenous courseware development company. Product differentiation among such companies requires receiving early access to new subject matter and launching the new training software as soon as new Silicon Valley products are shipped.

As Ireland's Celtic Tiger era proceeded over the last two decades, the importance of developing the local innovation system received increasing recognition. Report A noted the importance of the quality of educational institutions and the availability of venture capital as influences on the RIS environment. In relation to these factors, *the Irish state agency Enterprise Ireland employed part of the country's allocation of EU regional aid to bolster the availability of venture capital, while steps have been taken to facilitate the strengthening and deepening of tacit knowledge through the establishment of Science Foundation Ireland and the funding it has provided to campus-industry partnerships in ICT and the biosciences.*

What implications might the present study have for other regions? One refers to the role of FDI. Contrary to the view espoused by Michael Porter for example, foreign direct investment does seem capable of playing an important role in indigenous industrial development under certain circumstances, as has been noted also in the case of OEMs in Singapore for example.

In terms of the importance of different types of industrial externalities, our research supports the perspective associated with Jane Jacobs, that diversity *across complementary economic activities sharing a common science base* is conducive to innovation.

The Irish state has played a substantial part in maintaining the country's attractiveness as a location for FDI, in ensuring that conditions were appropriate for the kinds of FDI sectors targeted, and in supporting the indigenous firms and sectors that emerged. It is important to note, in this light, that the state's industrial development agencies have been found to conform to a large extent to the design principles advanced by Rodrik (2004) in seeking to ensure that government failures are avoided.

A. General Background

A.1 Policy Reform, External Developments and the "Celtic Tiger" Era

Irish real national income per head rose from less than 65% of the Western European EU average in 1987 to achieve rough parity by the end of the 1990s. Unemployment tumbled from a high of 17% in the mid-to-late 1980s to less than 4% in the early years of the new millennium. Employment expanded by more than 50% over this period. This section considers the series of beneficial shocks – policy-induced and otherwise – to which the economy was subjected in the late 1980s and which created a virtuous circle of economic progress.[1]

The beneficial shocks included a change in fiscal strategy in the late 1980s. Expenditure reductions rather than continued tax increases helped resolve the long-running crisis in the country's public finances. This allowed room for future tax reductions, which, in combination with the country's newly developed 'social partnership model' of wage determination, bolstered competitiveness. The doubling of the EU Structural Funds in 1989 made it possible to implement the badly-needed infrastructural projects that had been put on hold as part of the change in fiscal strategy. Airline deregulation, in 1986, facilitated a more than doubling of tourist numbers over the following decade while the establishment of the Single Market, the increase in services offshoring and the high global corporate profitability of the era saw a huge increase in FDI flows both into and within Europe, with Ireland capturing a sharply increased share.

Consensus has yet to be reached on the relative importance of these various factors. Honohan and Walsh (2002) in their assessment pay little attention to the role of increased FDI inflows, while Barry (2002) – echoing some of the points made by Blanchard (2002) in his discussion of the Honohan and Walsh paper – argues that they were crucial.

The only work to attempt an empirical evaluation of a full range of factors – including education, industrial strategy, the Single Market, EU Regional Aid, social partnership and the resolution of the country's fiscal crisis – is forced to the conclusion that "the sources of the 'Irish miracle' of the last decade are not entirely clear" (de la Fuente and Vives, 1997). In the same spirit, OECD (1999) concludes that

> "It would seem that there has been no 'silver bullet' – no single overriding policy that could be adopted elsewhere in order to emulate the Irish experience. Rather the breaks in trend, first around 1987 when the deterioration ceased and performance improved, and then around 1994 when the boom began, are attributable to the confluence of a series of favourable changes in the environment and other exogenous factors, as well as prudent planning and a range of policy shifts that lay the foundations for the pickup in growth. Most of the items that have contributed to the improvement are well known to other policy makers, but other countries' situations may not be so propitious as to allow such a strong response, even to fully appropriate incentives and institutional arrangements."

A brief discussion of the factors that are generally agreed to have been of importance in triggering the era of rapid growth is now provided. Taking fiscal policy to begin with, successive Irish governments had struggled throughout the 1980s to overcome the debt crisis that had resulted from inappropriate pro-cyclical fiscal expansion at the end of the previous decade. The attempt to close the deficit via high taxation proved unsuccessful – because it was by necessity pro-cyclical (in a contractionary direction) – while workers responded to the tax increases by raising wage demands.

---

[1] A fuller account of the emergence of the Celtic Tiger era is available in Barry (1999).

A new approach was tried in the 1987-89 period, when government expenditure was reined in as an alternative to further tax increases. Rather than being pushed into recession, as many would have predicted, the economy expanded. Barry and Devereux (1995) reject the expansionary-fiscal-contraction hypothesis developed to explain episodes like this, concluding instead that "the factors which were working in the direction of recovery – buoyant world demand, improvements in cost competitiveness and an inflow of foreign investment in the lead-up to the Single European Market – more than outweighed the short-run contractionary effects of fiscal contraction". The competitiveness gains alluded to arose not just from the preceding sharp devaluation of the currency (in 1986) but also from the simultaneous development of the 'social partnership' approach to wage determination.

The social partnership approach brought government, unions and employers together every three years to agree a general path for wages and working conditions over the course of the agreement. Successive governments used the process to purchase wage moderation via the promise of future tax cuts, and these tax cuts accounted for about one-third of the rise in real take-home pay from the beginning of the partnership process to the end of the export-led growth phase. This phase gave way to a construction-driven bubble in the early years of the new millennium. The partnership approach has also been argued by its architects to have promoted a shared understanding of key economic mechanisms and relationships between the parties to the agreements, and the partnership period coincided with a sharp reduction in strike activity.

EU regional aid through the Structural and Cohesion Funds increased substantially in the 1990s, though careful analysis suggests that the direct effects on GDP of these programmes would have been moderate – adding about half of one percentage point per annum to the GDP growth rate of the 1990s.[2] EU support may have had further indirect beneficial effects however. One that is widely recognised concerns its impact, through the introduction of rigorous evaluation procedures, on the efficiency of the overall system of public administration. Another relates to the fortuitous timing of the increased aid flows, allowing the implementation of badly-needed infrastructure projects that had been postponed during the fiscal contraction of the late 1980s. Infrastructural constraints would have emerged far earlier to choke off the boom had the new infrastructure not been brought on stream. Besides expanding the level of FDI inflows that the economy could handle, the aid would also have impacted on the type of FDI that Ireland was able to attract. The increasingly high-tech FDI inflows of recent decades rely on ready supplies of skilled labour, to which the human-resource programmes of the Structural Funds contributed.[3]

The Celtic Tiger era overlapped with an era of high global corporate profitability (which is particularly advantageous for a low corporation tax regime such as Ireland's), with increased services offshoring, and with the establishment of the Single Market. US investments in Europe increased substantially, with Ireland captured a growing share. MacSharry and White (2000) explain the latter by describing how restrictive public procurement policies on the part of the larger EU member states had disadvantaged Ireland as a location for FDI. With the outlawing of these practices within the Single Market, Ireland's attractiveness as a destination for FDI increased.

---

[2] As the OECD (1999, footnote 32) points out however, even this apparently modest effect nevertheless represents quite a respectable internal rate of return, of 6 to 7% per annum, on the funds invested.

[3] Ferreira and Vanhoudt (2002) argue plausibly that the increased throughput – especially given the vocational/technical slant of the skills provided at third level – and the sectoral (high-tech) composition of the increased FDI inflows were self-reinforcing factors that proved decisive for the Irish boom.

We now turn to a description of the FDI-intensity of the Irish economy and an analysis of how it attained this status.

A.2 The FDI-Intensity of the Irish Economy

A.2.1 Inward FDI in Ireland

One of the defining characteristics of the modern Irish economy is its FDI-intensity. Foreign-owned firms account for almost 50% of Irish manufacturing employment, compared to an average figure of 23% for the Western European EU member states and 33% for the larger Central and Eastern European economies. Of the 17 EU countries plus the US and Norway for which OECD (2005, E7) provides data, Ireland, at just over 20%, also records the highest share of services-sector employment in foreign-owned firms. These figures are reflected in the value of the inward FDI stock per head of population, where the Irish figure is a multiple of the EU average.[4]

Table A.2.1.1: FDI-Intensity of the Irish Economy

	Share of foreign affiliates in manufacturing employment	Share of foreign affiliates in services employment	FDI inward stock (USD) per head of population (2007)
Ireland	49	22	43,384
EU15	23	10	16,364
CEE	33	16	6,634

Notes: affiliate employment shares come from OECD (2005, tables E6 and E7) Science, Technology and Industry Scoreboard. CEE refers to the country average for Hungary, Poland and the Czech Republic. FDI Inward Stock data come from the UNCTAD (2009) World Investment Report.

Within manufacturing, the significant inward-FDI concentrations are in computer hardware and electronic components, pharmaceuticals and medical devices/precision engineering. Within services there are significant offshored elements in computer software, business process outsourcing (BPO) and international financial services.

Ireland has attracted many of the leading firms in each of these sectors. Hardware firms in Ireland include IBM, Intel, Hewlett Packard, Apple and Dell. Nine of the top ten pharmaceutical companies in the world – including Glaxo, Johnson and Johnson, Pfizer, and Merck – also have operations in the country, as have 13 of the world's top 25 medical devices and diagnostics companies. The list is equally impressive within services. The software companies with plants in Ireland include Microsoft, Lotus, Oracle and Corel. Almost 450 international financial institutions, including half of the world's top 50 banks and top 20 insurance companies, operate out of Dublin's International Financial Services Centre (IFSC), while many IFSC-based treasury operations – such as Bristol-Myers Squibb, Ericsson and Volkswagen – are recognisable names in other industries. Other BPO activities offshored in Ireland include supply-chain management, sales and marketing, intellectual property licensing and regional headquarters.

[4] Luxembourg comes out ahead of Ireland in terms of FDI stock per capita, and some studies record it as having a lower effective corporation tax rate though its tax incentives are targeted primarily towards the financial sector. As UNCTAD (2004, p. 104) notes: "a good deal of services FDI – notably that in holdings and financial affiliates – involves activities with little value added, employment, sales or investment expenditure on fixed capital".

Table A.2.1.2 provides a timeline of major events in Ireland's emergence as one of the most FDI-intensive economies in the world.

Table A.2.1.2: Timeline of Ireland's Path towards FDI Intensity

1956	Finance Act introduces Export Profits Tax Relief, with 50% remission on profits from manufactured exports, increased to 100% relief two years later.
1958	Control of Manufactures Acts, designed to keep control of industry in Irish hands, relaxed. Fully repealed in 1964.
1969	Industrial Development Authority, which had been established in 1950 within the Department of Industry of Commerce to initiate proposals for industrial development from domestic and foreign sources, instituted as an independent state agency outside civil service structures. Major rationalisation of industrial promotion and grant incentives.
1973	Ireland joins European Economic Community.
1978	Government abolishes Export Profits Tax Relief to be replaced by a 10% rate of corporation profits tax for all manufacturing industry.
1981	IDA granted the power to give employment grants unrelated to building and machinery investment. Act also allows the Minister to designate the specific types of services businesses that can qualify for these grants.
1987	Financial Services Act establishes the International Financial Services Centre in Dublin, to be marketed internationally by the IDA. Profits of qualifying activities to be taxed at 10% until 2005.
1993	On foot of external report, IDA split into three separate agencies: IDA-Ireland for overseas industry; Forbairt (which was merged with other agencies to become Enterprise Ireland in 1998) for indigenous industry; and Forfás, as the policy advisory and coordination board.
1996	First-ever Irish Government White Paper on Science, Technology and Innovation released.
1998	Programme for Research in Third Level Institutions launched.
2000	Science Foundation Ireland established.

Source: Largely adapted from MacSharry and White (2000)

A.2.2 Factors Accounting for Ireland's Success in Attracting Inward FDI

The nexus between ICT use and globalisation has been explored in Report A of the overall project, which notes that "the tendency of ICT to reduce transaction costs and to facilitate communication and control over longer distances is a major factor behind globalisation. The application of ICT allows for new forms of spatial specialization leading via outsourcing and offshoring to a new ... spatial division of labour."

The link between ICT use and globalisation is particularly apparent in the area of IT-enabled services, as MacSharry and White's (2000) account of the rationale behind Ireland's decision to develop as an international financial services centre makes clear. "The analysis suggested that a combination of factors now created an opportunity for a regional location like Ireland to become a player in the international financial services industry. First, world financial markets had become highly interdependent and operated on a round-the-clock basis. Second, the technology to set up and run international data- and fund-management centres was, in turn, creating an electronic marketplace, thanks to improvements in international telecommunications. And third, global deregulation of financial services meant that an increasing range of these services were provided from beyond national

boundaries…. Ireland was well placed to meet these opportunities, and the national advantages were identified as location, language, education and technology. We were in the same time zone as London. We spoke the language of international finance, namely, English. We had a computer literate young labour force. And we had a modern digital-based telecommunications network".

The factors accounting for Ireland's success in the global competition for FDI more generally include:

- EU membership, Western European governance standards and an English-speaking environment (characteristics which the country shares with the UK of course)
- a low corporation tax rate
- the experience, influence and resources of the Industrial Development Agency, and
- an educational system that is integrated to a large extent with the country's FDI-oriented development strategy.

These favourable background characteristics were augmented by the resolution of the Irish debt crisis of the 1980s and the establishment of the Single Market in the early 1990s.

The Corporation Tax Regime

Ireland was one of the first countries in the world (along with Puerto Rico and Singapore) to adopt an FDI-oriented development strategy. Ireland's low corporation tax regime was instituted in 1956 and the effective corporation tax rate remains one of the lowest in the EU.

The Finance Act of 1984 extended the favourable corporation rate of 10% then available to manufacturing companies to data processing services and software development services.[5] In 1987 the rate was further extended to qualifying activities carried out at the newly-established International Financial Services Centre in Dublin. In the face of European Commission pressure to harmonise rates across sectors, the government agreed in 1998 on a new harmonised rate of 12½%, to be instituted from 2003, across all sectors. The Finance Act of 2004, furthermore, established a new headquarters regime aimed at attracting international corporations to establish their regional HQs in Dublin. This has also served to attract other activities such as shared services and treasury management.

The Role of the Industrial Development Agency

The term "industrial policy" in Ireland refers to the actions of the IDA – which is tasked with attracting foreign industry to the country – and of its sister agencies, the most important of which, for present purposes, is Enterprise Ireland, whose remit covers export-oriented indigenous industry. The IDA is widely cited as an example of best-practice in the investment promotion field, with a well-developed "transnational strategic network" that assists the government in understanding the needs and concerns of prospective foreign firms and the potential benefits they can offer to the country.

This transnational strategic network consists of the IDA's overseas offices and its ongoing relations with the Irish-American diaspora and with foreign MNCs which have established operations in Ireland.[6] Its overseas offices are tasked not just with identifying and meeting

---

[5] The IDA commissioned a report from consultancy firm Arthur D. Little, which was delivered in 1984, which sought to identify opportunities for job creation in internationally traded services. The report suggested computer services in general and courseware in particular (Sterne, page 161).

[6] Links with the diaspora have proved useful in helping to ensure that changes to the US tax code do not disadvantage Ireland's ability to attract US FDI and also in attracting investments such as that of the Pfizer Corporation in 1969. As MacSharry and White (2000: 189) recount, the

with prospective investors in the region, but also with gathering information about trends in sectors in which the agency is interested and about new emerging sectors that might warrant the agency's attention. This network guides the agency's efforts to inform and persuade the government about required legislative changes, necessary additions to infrastructure, and specific training programs to serve the needs of targeted sectors.

The modus operandi of the IDA is explained in detail by Padraic White, a long-term Managing Director of the agency, in MacSharry and White (2000). The first step consists of the identification of sectors and sub-sectors that are experiencing international growth and that are thought to provide a good fit for Ireland's resources and development aims. These decisions are sometimes made *ab initio* (as in the case of the IFSC) but are more frequently interactive. Having attracted several computer and components firms in the 1970s, for example, and being favourably impressed by their performance in situ, the IDA added electronics and computer software to their list of targeted sectors in the early 1980s. (Table A.2.2.1 provides an indicative timeline of FDI sectoral targeting decisions made over this period).

Table A.2.2.1: Indicative Timeline of FDI Sectoral Targeting Decisions, 1960s-80s

1967	External consultancy report, noting that incentives apply only to manufacturing, recommends that these be extended to include technical and scientific service companies.
Pre-1969	"Low capital intensity" frequently mentioned as desirable
1968-70.1	IDA influenced by papers from National Science Council which suggested electronics and fine chemicals (including pharmaceuticals) as possibilities. (1972 NSC report foresees "much scope for development of an export-orientated computer industry in Ireland, in the fields of consultancy, software and peripheral equipment manufacture").
Early 1970s	Focus on man-made fibre industries (badly affected by 1979 oil shock)
1972	IDA paper suggests that in contrast to 1960s, where manufacturing activity heavily dependent on food processing, textiles, clothing and footwear, newer industries would be in the areas of engineering goods, electronics and electrical equipment, pharma and chemical products, and plastic products.
1972-73	Following a "preliminary study" on specialist engineering consultants, IDA working group proposes that IDA should also target service companies
1973	Service Industry Programme established to create jobs in sectors such as engineering consulting and quantity surveying (programme extended substantially in 1981)
From 1979	Shift in emphasis in IDA annual reports from regional development to sectoral approach and sectoral strategies
1979	MD of IDA predicts that "electronics would be the single biggest source of new jobs in coming years". (New MD of IDA in 1981 says that "electronics and its alliance with telecommunications will transform the nature of office activity")
1981	International Services Programme established/extended to include *inter alia* data processing, software development, HQ and R&D centres; IDA given powers to administer employment grants for service sectors [IBM Software

dominant influence on Pfizer's decision in favour of Ireland was an Irish emigrant who was a substantial shareholder in the company.

	Centre established in 1983; Lotus Software establishes in Ireland in 1984; Microsoft in 1985]
1982	IDA annual report notes as of particular interest, "the number of electronics companies which established software development groups as part of their Irish operations".
1987	Policy document "Ireland as an International Financial Services Centre" launched.

Source: Largely based on O'Connor (2005)

The next stage involves identifying the strongest companies in these sub-sectors and approaching them with a view to persuading them to locate in Ireland. These are the "flagship projects" which are widely considered to be of importance in cluster development. Once a sector or sub-sector has been established, the agency then assesses whether further processes might be successfully targeted or linkages developed.

The IDA has grant-giving powers and has traditionally had very substantial resources at its disposal. "In its heyday in the early 1980s ", according to Ó Gráda (1997), "the IDA (which at the time included what would later become Enterprise Ireland) accounted for 12% of all public investment and absorbed 2% of GDP. A decade later these shares had dropped to 8% and 0.6% respectively." Even at this later stage, however, Irish state financial support to industry, in terms of euro per person employed, was some 15% above the Western EU average. As EU restrictions on state aids to industry tightened, the industrial development agencies shifted their focus from 'capacity' support for employment creation and fixed asset investment to 'capability' support in areas such as human resource development, R&D, marketing and market development, with Enterprise Ireland increasingly shifting towards equity participation.

The IDA and the other development agencies have attained over time a substantial degree of bureaucratic, administrative and political "clout" within the policymaking hierarchy, which has yielded them an influence in areas not traditionally recognised as lying within the industrial promotion remit. Effectively, they can be regarded as coordinating factor market changes to attract technology-intensive FDI.

One such area concerns telecommunications infrastructure. MacSharry and White (2000) recount the hostile responses of the moribund state Department of Posts and Telegraphs to IDA criticisms of the state telephone system in the 1970s. The IDA eventually won the battle to have the service commercialised in 1979. A digital-based network was developed which was at the time one of the most advanced in Europe, enhancing Ireland's ability to capture newly emerging industries in which first-class international telecommunications was a key factor. These ranged from software development to call centres, customer support and data-related services. The IDA has also had an influence on the Irish educational system, as recounted below.

The Education System and the FDI-oriented Development Strategy

The annual surveys of corporate executives reported upon in the IMD *World Competitiveness Yearbook* consistently rank Ireland within the top five of fifty or more countries in terms of the extent to which the educational system is thought to meets the needs of a competitive economy.

This is consistent with the evidence showing that Ireland has one of the highest proportions of the population aged 25 to 34 in the OECD with third-level educational qualifications, with a very high proportion holding science and engineering degrees (Barry, 2007b).

Amongst these, however, Ireland has an unusually large cohort endowed with non-university 3rd level educational qualifications in technical and vocational fields. These are graduates of the country's Institutes of Technology, which resemble the former UK *polytechnics*. While the latter were granted university status in 1992, the Irish Institutes of Technology remain more amenable to government policy objectives than the autonomous universities.

From 1978, however, the universities also became more responsive to government manpower policy objectives. The Manpower Consultative Committee was established in that year to provide a forum for dialogue between the IDA and the education system. The Irish system offers a finite number of places in most third-level courses, and while these numbers are decided by the universities themselves, they are subject to government influence given that the latter provides the bulk of university funding.

MacSharry and White (2000) provide an example of how IDA influence operated in this regard. Concerned by the looming disparity between electronics graduate outflows and IDA demand projections, the IDA convinced the government to fund a massive expansion in educational capacity in these areas. The output of engineering graduates, as a result, increased by 40% between 1978 and 1983, while the output from computer science increased tenfold over the same short period. The IDA in turn was able to use the rapidity of this response – exemplified by the immediate introduction of a range of one-year conversion courses to furnish science graduates with electronics qualifications – as a further selling point to foreign investors.

A.2.3 Factors Facilitating a Dynamic Entrepreneurial Response to the Opportunities afforded by FDI

This sub-section draws attention to two characteristics of the economy that may have facilitated a dynamic entrepreneurial response to the opportunities that FDI inflows afforded. These are the general business-friendly environment and degree of labour-market flexibility.

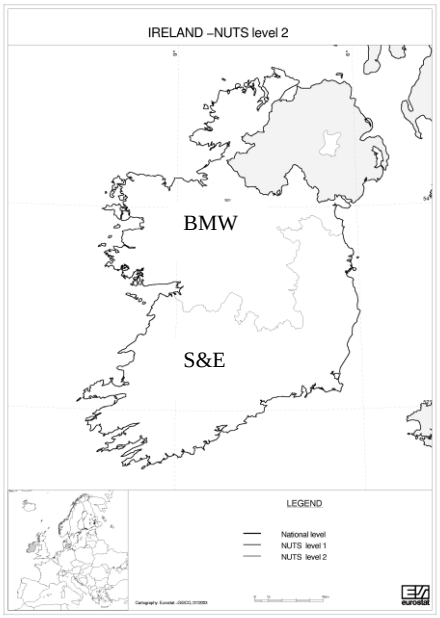
One measure of the business-friendliness of the environment is provided by the World Bank's "Ease of Doing Business" website (http://www.doingbusiness.org/EconomyRankings/). Ireland generally ranks around 10th amongst this group of 135 countries across the world, and Djankov, McLiesh and Ramalho (2006) employ these measures to establish that, on average, countries with better regulations grow faster.

While Koedijk and Kremers (1996) find that Ireland comes out best of all EU countries in terms of product-market freedom from regulation, they also find that it scores highly in terms of a freely functioning labour market. In terms of the specific focus of the present study, a freely-functioning labour market should facilitate inter-sectoral and inter-firm mobility on the part of both workers and managers.

A3. Ireland: The Regional Dimension

Ireland is divided into two NUTS II regions; the more advanced South and East (S&E) region and the lagging Border, Midlands and West (BMW) region, as show in Map 1.

Map 1: The Two NUTS II Regions in Ireland



BMW: Border, Midlands and West Region.

S&E: South and East Region.

The South and East region, which is the focus of analysis of the present paper, is substantially wealthier, has a lower unemployment and a higher labour-force participation rate, a higher share of ICT jobs, better broadband connectivity and higher internet usage than the other region of the country. Data from the European Commission's Fourth Report on Economic and Social Cohesion (2007) allow one compare the structure and growth of both regions to the EU27 average.

Table A.3.1: Structure and Growth of the Irish Regions and the EU27

	GDP per head, 2004**	Employment by sector (% of total empl.), 2005			Population growth, 1995-2004*	GDP growth, 1995-2004*
		Agriculture	Industry	Services		
EU27	**100.0**	**6.2**	**27.7**	**66.1**	**0.3**	**2.3**
IRL: BMW region	**100.1**	**9.4**	**31.1**	**59.5**	**1.4**	**7.7**
IRL: S&E region	**156.5**	**4.7**	**26.4**	**68.9**	**1.3**	**8.2**

Notes: * Average annual percentage change; ** Measured in PPS, EU27=100
Source: EU (2007)

Both regions of Ireland emerge then as high-growth regions, though account must be taken of the high share of Irish GDP that is accounted for by the profits of foreign MNCs (which is not counted as part of GNP, which is a preferable measure of national income for Ireland). Rough attempts to subtract imputed foreign MNC profits from regional GDP show that for the S&E region Gross Value Added per head, adjusted for profit outflows, overtook the EU15 average around 1999, while the BMW region converged strongly on the EU15 average over the Celtic Tiger period (Barry, 2005).

In terms of innovation, Ireland is far from being a world leader in terms of either patent counts or new product and process developments. The European Innovation Scoreboard (2008), however, classifies Ireland along with Austria, Luxembourg, Belgium, France and the Netherlands as an "innovation follower" – with innovation performance below those of the innovation leaders but above the EU average – and notes that Ireland's performance has been increasing fastest within this group.[7] Given the structure of the two regional economies in Ireland, as discussed below, this performance is likely to have been driven primarily by developments in the S&E region.

A.3.1 The South East Region: Overview

The S&E region exhibited a very strong growth performance between 1995 and the recent onset of the current downturn. The average annual rate of growth of gross value added per head over this period was around 10 per cent. Regional GVA per head in the S&E region overtook the EU15 average in 1996 and when foreign-profit outflows are subtracted the region overtook the EU15 average in 1999. In 2006, disposable income per person in the S&E region was 3% above the State average, while income in the capital city sub-region of the S&E region, where most of the indigenous software sector is located, was 12% above the national average.[8]

Table A.3.1.1: Persons aged 15 years and over classified by NUTS2 regions and ILO Economic Status

Region (NUTS2)	In employment	Unemployed	In labour force	Unemployment rate	Participation Rate
	'000	'000	'000	%	%
Border, Midland and Western					
Sep-Nov 2006	530.4	24.6	555.0	4.4	61.3
Jun-Aug 2007	555.1	30.8	585.9	5.3	63.3
Sep-Nov 2007	556.9	27.2	584.1	4.7	62.7
Dec-Feb 2008	549.5	31.0	580.5	5.3	61.8
Mar-May 2008	541.5	34.8	576.3	6.0	61.8
Jun-Aug 2008	541.8	47.4	589.2	8.0	62.8
Sep-Nov 2008	520.8	52.0	572.8	9.1	60.9
Southern and Eastern					
Sep-Nov 2006	1,541.7	65.7	1,607.4	4.1	64.0
Jun-Aug 2007	1,590.9	76.5	1,667.5	4.6	65.3
Sep-Nov 2007	1,582.0	73.8	1,655.8	4.5	64.3
Dec-Feb 2008	1,585.6	71.1	1,656.7	4.3	64.1
Mar-May 2008	1,567.0	80.7	1,647.6	4.9	63.9
Jun-Aug 2008	1,579.0	113.2	1,692.2	6.7	65.4
Sep-Nov 2008	1,531.2	118.7	1,649.9	7.2	63.5
State					
Sep-Nov 2006	2,072.1	90.3	2,162.4	4.2	63.3
Jun-Aug 2007	2,146.0	107.3	2,253.3	4.8	64.8
Sep-Nov 2007	2,138.9	101.0	2,239.9	4.5	63.9
Dec-Feb 2008	2,135.1	102.1	2,237.2	4.6	63.5
Mar-May 2008	2,108.5	115.5	2,223.9	5.2	63.4
Jun-Aug 2008	2,120.8	160.6	2,281.4	7.0	64.7
Sep-Nov 2008	2,052.0	170.6	2,222.7	7.7	62.8

Source: Quarterly National Household Survey Quarter 4 2008, Central Statistics Office, Ireland

[7] The scoreboard ranks countries in terms of a Summary Innovation Index, which is a composite of 29 indicators embracing relevant elements of human resources, finance and support, firm investments, linkages and entrepreneurship, throughputs such as patents and trademarks, firm-level innovations, and high-tech, knowledge-intensive and new-to-market characteristics.

[8] CSO (2009) County Incomes and Regional GDP 2006

The S&E region consists of a number of large urban centres including the capital city, Dublin. There has been a large increase in the population over the past number of years, particularly in Dublin and the other major urban centres, leading to a situation where infrastructural services have been placed under increasing strain. As a result investment has been directed into areas such as housing, water supply, roads, public transport, telecommunications, education and energy.

The data provided in Barry (2005) support the following characterisation of the strengths and weaknesses of the S&E region relative to the rest of the country:

Relative Strengths

- A relatively well-qualified and skilled workforce
- Extensive training and educational facilities
- A strong base of industry and services
- Generally good agricultural land and a strong agri-food sector
- A strong and vibrant urban network
- A relatively well-developed infrastructure, including an inter-urban road network that has been substantially improved with the assistance of EU Regional Aid, and access to import/export gateways.

Relative Weaknesses

- Congestion and infrastructural capacity constraints
- Unsustainable development in the major urban centres
- High levels of economic and social exclusion in urban centres

Overall, there is a concentration of both third-level institutions and third-level students in the Southern and Eastern region. The latter holds even when one accounts for differences in population size. While participation rates in third level education among young people from the lagging BMW region is disproportionately high, many migrate to educational institutions in the Southern and Eastern region and do not return. This is reflected in a lower level of educational achievement among the population of the BMW region, where the proportion with third-level qualifications is about 25% below that for the S&E region.

Table A.3.1.2: Numbers of Third Level Institutions

Type	Border, Midland and Western	Southern and Eastern
University	1	6
Institute of Technology	6	10
Other	1	7
Total	**8**	**23**

Source: Department of Education and Science, Statistical Report 2000/2001

A4. ICT Usage at the National and Regional Levels

While Ireland, as will be seen below, is strong in ICT production, the situation with respect to ICT use is different. Table A.4.1 shows that Ireland has until recently has been below the EU27 average in terms of the percentage of enterprises with a broadband connection. While the data for households (not shown) reveal that the proportion of households having access to the internet at home marginally exceeds the EU average, the proportion of those with a broadband connection is far lower.[9]

Table A.4.1: Percentage of enterprises with a broadband connection, 2005-2008

	Unit	2005	2006	2007	2008
European Union (EU27)	**%**	**62**	**73**	**77**	**81**
Belgium	%	78	84	86	91
Bulgaria	%	32	57	61	62
Czech Republic	%	52	69	77	79
Denmark	%	82	83	80	80
Germany	%	62	73	80	84
Estonia	%	67	76	78	88
Ireland	**%**	**48**	**61**	**68**	**83**
Greece	%	44	58	72	71
Spain	%	76	87	90	92
France	%	:	86	89	92
Italy	%	57	70	76	81
Cyprus	%	40	55	69	79
Latvia	%	48	59	57	62
Lithuania	%	57	57	53	56
Luxembourg	%	64	76	81	87
Hungary	%	48	61	70	72
Malta	%	78	83	89	89
Netherlands	%	71	82	87	86
Austria	%	61	69	72	76
Poland	%	43	46	53	59
Portugal	%	63	66	76	81
Romania	%	:	31	37	44
Slovenia	%	74	75	79	84
Slovakia	%	48	61	76	79
Finland	%	81	89	91	92
Sweden	%	83	89	87	89
United Kingdom	%	65	77	78	87

Source: Eurostat, data reported in *Information Society and Telecommunications, 2008*, Central Statistics Office, Ireland, May 2009.

While Irish businesses were less likely until 2008 to have had a broadband connection, they were more likely (compared to the EU average) to have received orders on-line (Table A.4.2).

[9] By 2007 over 65% of households had a home computer, representing an increase of 11 percentage points over the previous two years, of which some 87% were connected to the internet. The most common purchases made by households over the internet were travel and holiday accommodation and tickets for events such as concerts. Almost 66% of persons aged 16-24 used the internet in 2007, while 18% of those aged 65-74 indicated that they had used the internet in the same period.

Table A.4.2: Percentage of enterprises who received orders on-line over the previous year, 2005-2008

	Unit	2005	2006	2007	2008
European Union (EU27)	**%**	**12**	**14**	**15**	**16**
Belgium	%	16	15	18	16
Bulgaria	%	:	2	1	2
Czech Republic	%	13	8	9	15
Denmark	%	32	34	33	20
Germany	%	16	18	24	:
Estonia	%	8	14	7	11
Ireland	**%**	**21**	**23**	**27**	**25**
Greece	%	7	7	6	6
Spain	%	3	8	8	10
France	%	:	:	:	13
Italy	%	3	3	2	3
Cyprus	%	4	6	7	7
Latvia	%	1	2	2	6
Lithuania	%	6	13	14	22
Luxembourg	%	10	11	13	10
Hungary	%	4	9	4	4
Malta	%	16	14	16	13
Netherlands	%	14	23	26	27
Austria	%	10	15	18	15
Poland	%	5	9	9	8
Portugal	%	9	7	9	19
Romania	%	:	2	3	3
Slovenia	%	12	11	10	8
Slovakia	%	7	:	5	5
Finland	%	17	14	15	:
Sweden	%	23	24	27	19
United Kingdom	%	25	30	29	32

Source: Eurostat, data reported in *Information Society and Telecommunications 2008*, Central Statistics Office, Ireland, May 2009

By 2007, virtually all enterprises in the manufacturing, construction and services sectors used a computer and had access to email and the internet, while 64% had a website or homepage. While 82% had used the internet to obtain forms from public authorities, 68% had used it to return a completed form to a public authority. Fifty five percent on enterprises, furthermore, had made purchases via e-commerce while 27% had made e-commerce sales.

Haller and Siedschlag (2007) find that the adoption of ICT in Irish manufacturing has been uneven across firms, industries and space. On average, *ceteris paribus*, firms with more skilled workers, operating in ICT-producing and ICT-using industries and located in the capital city region have been relatively more successful in adopting and using ICT. To a certain extent, patterns of ICT adoption have been different for domestic and foreign-owned firms, in particular with respect to the effects of international competitive pressures and firm size.

The 2008 e-readiness index published by the Economist Intelligence Unit ranks Ireland at number 21 of 70 countries and 9th amongst EU countries.[10] Inspection of the subcategories which make up the overall e-readiness score shows that Ireland is ranked relatively highly in terms of business environment, social and cultural environment, legal environment and consumer and business adoption. However, Ireland's relative performance in terms of the connectivity and technology infrastructure and government policy and vision is less satisfactory.

The OECD European Innovation Report (2006) ranks Ireland 11th out of 25 EU member states. Ireland scores poorly in terms of broadband roll-out, an important component in maximising the benefits of ICT use. In response to the slow roll-out of broadband by the privatised former semi-state telecommunications company, the Government has recently committed to investing in open access broadband structure in all cities and towns with more than 1,500 inhabitants over the next few years.

Data on internet usage by businesses at the regional level is limited, though there is some evidence that enterprises in the S&E region participate more in e-commerce activities than do those in the rest of the country. Broadband is clearly less widely available in the poorer BMW region, where only 15% of households had a broadband connection in the first quarter of 2007, compared to 37% of households in the Southern and Eastern region. In the latter, over 68% of households owned a computer, of which 88% were connected to the internet. In the Border, Midland and Western region, on the other hand, only 58% of households owned a computer, of which 82% were connected to the internet.

A5. ICT Production at the National and Regional Levels

International comparisons show that ICT production in Ireland has one of the highest shares of business-sector value added, roughly even with Korea and Finland. This is largely ascribable to the use of Ireland as an export platform by many of the world's leading ICT-sector Multinational Enterprises.

The vast bulk (some 70%) of Business Expenditures on R&D (BERD) in Ireland is accounted for by MNEs in ICT and the life sciences (pharma and medical technologies), and though Ireland still lags slightly behind the EU15 or OECD in terms of BERD as a share of GDP, both BERD and Gross Expenditures on R&D (GERD) have increased more rapidly than in the case of these two other entities over recent years, as seen in Table A.5.1.

Table A.5.1: Gross expenditures on R&D (GERD): Ireland, EU15 and OECD

	1987	1991	1997	2004	2007
Ireland as share of EU15	0.30	0.37	0.71	0.88	1.03
Ireland as share of OECD	0.10	0.12	0.21	0.26	0.29

Source: Main Science and Technology Indicators 2009, OECD

Note: Evaluated in millions of current PPP dollars.

The most recent Irish Central Statistics Office report on Information Society and Telecommunications (2008) highlights the contribution of the ICT sector to Ireland's economic performance. The sector employed just over 87,160 people in 2006, which accounted for 8.3% of total employment in industry and services. The sector accounted for the much larger figure of 21% of gross value added. With 28,646 jobs, the ICT manufacturing sector made up 13% of total industrial employment, while the 58,514 jobs

[10] See "The 2008 e-readiness rankings", The Economist Intelligence Unit", http://a330.g.akamai.net/7/330/25828/20080331202303/graphics.eiu.com/upload/ibm_ereadiness_2008.pdf

in ICT services represented over 7% of total employment in services. The composition of the sector is as shown in Table A.5.2.

Table A.5.2: Composition of the ICT sectors by NACE code, 2006

NACE Division	Sector	Number of enterprises	Persons engaged	Turnover	Gross value added
	Unit	No.	No.	€m	€m
	ICT Manufacturing	**166**	**28,646**	**38,195**	**7,611**
30	Manufacture of office machinery and computers	39	12,864	19,198	1,427
32	Manufacture of radio, television and communication equipment and apparatus	39	8,513	4,336	2,670
3320	Manufacture of instruments and appliances for measuring, checking, testing, navigating and other purposes, except industrial process control equipment	40	2,470	642	215
3330, 2233, 3130	Manufacture of industrial process control equipment. Reproduction of computer media. Manufacture of insulated wire and cable	48	4,799	14,019	3,300
	ICT Services	**5,236**	**58,514**	**37,175**	**7,882**
72	Computer and related activities	4,435	34,816	15,398	3,875
5143, 5184, 5185, 6420, 7133	Wholesale of electrical household appliances and radio and television goods. Wholesale of computers, computer peripheral equipment and software. Wholesale of other office machinery and equipment. Telecommunications. Renting of office machinery and equipment (including computers)	801	23,698	21,777	4,007
	Total ICT	**5,402**	**87,160**	**75,370**	**15,493**

Source: Census of Industrial Production and Annual Services Inquiry, data reported in *Information Society and Telecommunications 2008*, Central Statistics Office, Ireland, May 2009

Foreign-owned enterprises represented about 43% of all ICT enterprises in Ireland in 2006, but accounted for 81% of total employment and 94% of turnover in the sector. Foreign-owned enterprises accounted for 39% of ICT manufacturing enterprises and 45.2% of ICT services enterprises. In each segment however, the foreign-owned enterprises are far larger, as detailed below, and output per employee, measured in terms of gross value added, is more than five times and two times higher than in indigenous ICT companies in each segment respectively.

Irish-owned ICT manufacturing enterprises employed almost 2,948 people in 2006 while foreign-owned enterprises employed 25,698 at that time. Average employment in foreign-owned ICT manufacturing enterprises stood at 395, while the equivalent figure for Irish-owned ICT manufacturers was 29.

In the ICT services sector, Irish-owned enterprises had 10,741 persons in employment while foreign-owned enterprises employed 32,799 people. In this segment, average employment in foreign-owned enterprises stood at 195, while Irish-owned enterprises employed an average of 53 persons.

The principal aggregates for manufacturing local units and services local units at the regional level are as outlined in Tables A.5.3 and A.5.4.

Table A.5.3: Principal Aggregates for Manufacturing Local Units by Region, 2006

	Unit	Border, Midland and Western	Southern and Eastern
ICT Manufacturing			
Number of local units	No.	46	124
Persons engaged	No.	4,432	24,125
Average persons engaged per local unit	No.	96	195
Total Manufacturing			
Number of local units	No.	1,374	3,315
Persons engaged	No.	61,254	158,568
Average persons engaged per local unit	No.	45	48
ICT Manufacturing as a % of Total Manufacturing			
Number of local units	%	3.3	3.7
Persons engaged	%	7.2	15.2

Source: **Census of Industrial Production,** data reported in *Information Society and Telecommunications 2008*, Central Statistics Office, Ireland, May 2009

Table A.5.4: Principal Aggregates for Services Enterprises by Region, 2006

	Unit	Border, Midland and Western	Southern and Eastern
ICT Services			
Number of enterprises	No.	707	4,529
Persons engaged	No.	5,569	52,945
Average persons engaged per enterprise	No.	8	12
Total Services			
Number of enterprises	No.	22,522	68,770
Persons engaged	No.	167,710	656,188
Average persons engaged per enterprise	No.	7	10
ICT Services as a % of Total Services			
Number of enterprises	%	3.1	6.6
Persons engaged	%	3.3	8.1

Source: Annual Services Inquiry, data reported in *Information Society and Telecommunications 2008*, Central Statistics Office, Ireland, May 2009

In 2006, almost 15% of persons engaged in manufacturing local units in the Southern and Eastern region were working in ICT manufacturing local units, compared to 7% in the Border, Midlands and West. Similarly, while 8% of persons working in services local units in the S&E region were engaged in ICT services local units, the corresponding figure for the BMW region was 3%. In total, an average of 17 people were engaged in ICT local units (manufacturing and services) in the S&E region in 2006, compared to 13 in the BMW region in the same period.

A6 The Innovation System

A.6.1 Main Actors

Forfás is a statutory body which advises the government on issues relating to enterprise, trade science and innovation. It is also responsible for coordinating IDA, Enterprise Ireland and Science Foundation Ireland (SFI)

The Industrial Development Agency (IDA) is responsible for the support and promotion of inward foreign direct investment (FDI). It role is to attract foreign companies to Ireland. It provides set-up support and incentives for expansion and investment in innovative activities.

Enterprise Ireland is responsible for the promotion of Irish-owned companies and the food sector. It actively supports high potential start-ups and encourages the internationalisation of its client companies. It also focuses on regional development and promotes involvement in Business Innovation Centres. These centres contribute significantly to regional economic development through the provision of a comprehensive range of business supports to the micro enterprise sector, including the provision of business information, advice, counselling and mentoring. They are also involved in the development and management of enterprise space and the promotion of an enterprise culture. Enterprise Ireland has also played an important role in providing seed-funding for the emergence of a strong venture capital industry in Ireland.[11] *The precise role that Enterprise Ireland plays in the local innovation system is analysed in detail in Sections B (State Support to the Emergent Indigenous Software Cluster) and C1 (Conclusions) below.*

There are also a number of **Business Innovation Centres**, including:

Dublin Business Innovation Centre - www.dbic.ie

Cork Business Innovation Centre - www.corkbic.com

South East Business Innovation Centre - www.sebic.ie

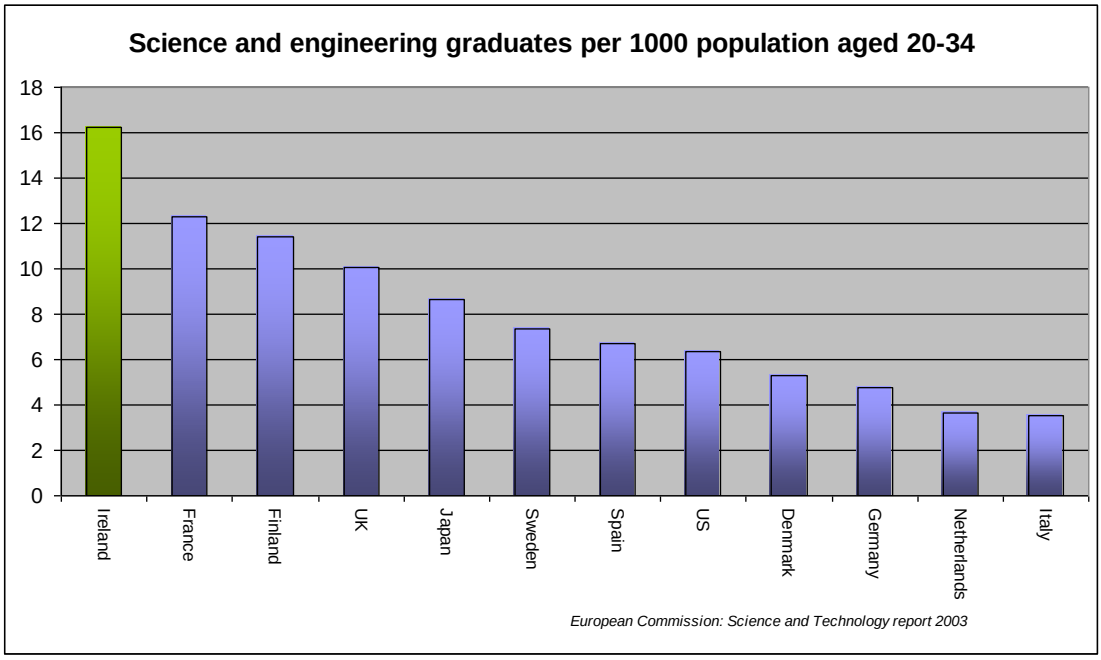
The country has over recent years been seeking to expand the traditionally low levels of university-industry cooperation. The *Innovation Partnership* initiative is intended to support collaborative applied research between industry and third-level colleges, the *FUSION* programme seeks to develop partnerships between companies and third-level institutes or research centres, and the *Advanced Technologies Research Programme* aims to develop innovations that can improve the competitiveness of Irish industry and lay the foundation for new start-up companies.

A.6.2 The Education System

As well as conducting innovative research, educational institutions have supplied a large proportion of science and engineering graduates which are crucial to the innovation system. The Irish post-secondary-level system – driven by the country's FDI-focused strategy – has produced one of the highest proportions of young people with science and engineering qualifications in the world (Figure A.6.2.1).

[11] Barry and Topa (2008) show that while Irish indigenous industry is less concentrated in the high-tech sectors that typically attract venture capital than is the case for the average Western European EU economy, venture capital investments as a share of national income have grown to match the Western European average.

Figure A.6.2.1: Science and Engineering Graduates per 1000 Population aged 20-34



Note: For further elaboration see Barry (2007b).

More recently, Ireland has begun to support sharply increased numbers of PhD students to support movement up the industry value chain. The position as of 2004 is as shown in Table A.6.2.1. Taking the number of new doctorates (PhDs) produced per million of population as an indicator of trained researchers, the table shows that Ireland has been performing well in terms of overall doctoral graduates and science and engineering doctoral graduates. Ireland is ahead of the Netherlands, Norway, Denmark and the US, though still some way behind the three leading nations.

Table A.6.2.1: Output of PhDs per Million Populations (2004)

	Total PhDs	Science/Eng. PhDs
Switzerland	398	173
Finland	356	183
UK	254	152
Ireland	166	100
Netherlands	164	92
Norway	164	27
Denmark	146	98
US	144	90

Source: NSF Science and Engineering indicators 2008.

An innovation-system actor that has become hugely important since it was established in 2000 is **Science Foundation Ireland**. Its establishment, and the launching of the **Programme for Research in Third Level Institutions** (PRTLI) in 1998, followed the release in 1996 of the first-ever Irish Government White Paper on Science, Technology and Innovation (STI). The increased commitment to STI was reflected in a five-fold increase in investment in these areas under the 2000-06 National

Development Plan. The PRTLI represented an initiative to support high quality basic research in third level institutions in Ireland. Its funding allocations support the national sectoral priorities in biosciences, biomedicine and ICT and the programme has established

more than twenty major research centres supported by Science Foundation Ireland as well as major programmes in human genomics and computational physics.

The origins of Science Foundation Ireland lay in a Technology Foresight Exercise organised by the state agency Forfás with the very substantial participation of executives from foreign MNCs located in Ireland as well as indigenous firms. The executives were asked about how they viewed their companies' evolution over coming decades and what the Irish government could do to respond to those changes.[12] The essence of the response was that as Ireland was no longer a low-cost manufacturing location it would have to develop more highly trained engineers and research scientists in order to become a centre for innovation, research, design and development.

The exercise proposed the establishment of a Technology Foresight Fund to promote and finance new basic and applied scientific and technological research in Ireland, and Science Foundation Ireland was established to administer this fund. The net result was the aforementioned five-fold increase in science, technology and innovation funding, the establishment of a host of joint partnerships between third-level research institutions and industry, and a US National Science Foundation-type system to support scientists and engineers working in designated fields, principally in ICT and the biosciences.

Amongst the campus-industry partnerships established thus far are:

- **The Centre for Research on Adaptive Nanostructures and Nanodevice (CRANN)**

CRANN, based at Trinity College Dublin, is Ireland's first purpose-built research institute with a mission to advance the frontiers of nanoscience, where the disciplines of physics, chemistry and biology converge. The first phase of CRANN's scientific programme is supported by a five-year, €10 million grant from SFI awarded in 2004.

CRANN's scientific programme focuses on advancing three of the key areas related to visualising and manipulating such tiny structures: magnetic structures and devices, bottom-up fabrication and testing of nanoscale integrated devices and nano-biology of cell-surface interactions. By developing tools and techniques that allow atom-by-atom assembly of structures and devices, CRANN will develop technologies that impact the next generation microelectronics, new drug delivery systems and other discoveries with potentially life-changing implications in the coming decades.

Industry Collaboration: Principal partner: Intel Ireland Ltd; others include Hewlett Packard, Deerac Fluidics, Commergy, Magnetic Solutions and Eblana Technologies.

Academic Collaboration: The centre also has close links with departments across the science, engineering and health science faculties at Trinity College Dublin, as well as with University College Dublin and University College Cork.

- **Lero – The Irish Software Engineering Research Centre**

Lero, the Irish Software Engineering Research Centre, advances the state-of-the-art in software engineering for specific domains. Lero is a partnership of academic researchers and industry, led by the University of Limerick. SFI has committed €11.7 million to Lero. Lero takes a domain specific approach. Initially, it will focus on the automotive software domain. Focusing on research challenges that are of relevance to a specific domain facilitates more rapid uptake and more effective use of the research results produced. Lero will research, develop and validate theories, technologies, methods and notations that help make software production more predictable and more efficient and the software itself more reliable, more flexible and more easily changed.

[12] Collins and Pontikakis (2006) discuss the unusual FDI-focus of the Irish national innovation system.

Industrial Partners: Analog Devices, Ashling Microsystems, Beaumont Hospital,

Robert Bosch, Brightwork, IBM Ireland, Intel Ireland, Iona Technologies, KUGLER MAAG CIE, Motorola, Piercom Ltd, QAD Ireland Ltd, and Silicon & Software Systems.

Academic Partners: University of Limerick (Consortium Leader), Dublin City University, Trinity College Dublin and University College Dublin.

- **The Digital Enterprise Research Institute:**

Based at the Galway campus of the National University of Ireland and with Hewlett Packard as industrial partner

- **The Centre for Telecommunications Value-Chain-Driven Research:**

Headquartered at Trinity College Dublin and with Bell Labs as industry partner

- **The Regenerative Medicine Institute:**

Based at National University of Ireland-Galway and with industry partners including Medtronic Vascular

A.7 Summary of Section A on General Background

Having completed this discussion of the general background to the case study, we now provide a summary of the key elements that will elucidate our study of the emergence and evolution of the indigenous software cluster.

Ireland, and the South-East region in particular, has experienced dramatic growth – by Irish historical as well as average EU standards – over the last two decades. Due to the range of factors discussed above, Ireland is now one of the most FDI-intensive economies in the world, while the concentration of inward FDI in high-tech sectors means that ICT production has attained an abnormally large share in business-sector value added. Much of this export-platform activity, furthermore, is concentrated in the richer South-East region. Ireland scores far higher in ICT production than in ICT diffusion however.

The third-level education system has played an important role in attracting high-tech FDI to Ireland. It is only in relatively recent times however – as Ireland began to converge on and then surpass average EU15 levels of income per head – that attention has focussed on fourth-level (i.e. postgraduate) education and the development of the national innovation system. Though Ireland still lags behind the EU15 and OECD averages in terms of Business Expenditures on R&D as a share of GDP, both Business and Gross Expenditures on R&D have increased more rapidly than in these other two cases in over recent years.

B. Specific Study

B1. Introduction

As detailed in Part A, the Southern and Eastern region, centred around the capital city of Dublin, is by far the richer of Ireland's two NUTS 2 regions. Most of the country's high-tech and largely foreign-owned sectors are clustered in this region. These include computer hardware and components, computer software, and international financial services. Of the remaining high-tech sectors, pharma-chem is clustered around Cork city and medical devices around Galway. Galway also has a smaller ICT cluster, as does Limerick, with hardware and/or components predominant in both locations.

These high-tech clusters comprise both ICT-producing and heavily ICT-using firms. The present case study is concerned with the impact of the strong presence of ICT-using firms, which in the Irish case are almost entirely foreign-owned, on the emergence of a dynamic indigenous ICT-producing (computer software) sector.[13] Hence, our focus is not on IT-use *per se*. In terms of the supplier/customer/knowledge perspective adopted for the regional case studies, our focus will be on the role that the ICT-using foreign-owned high-tech sectors played both as early-stage customers and as suppliers of experienced personnel, and on the knowledge spillovers between the ICT-using and producing sectors, as well as on how the emergence of the indigenous software sector has changed the extent and spatial configuration of knowledge interactions between national and international innovation partners.[14]

Ireland is the most FDI-intensive economy in the EU and the bulk of employment in virtually all of the country's high-tech sectors is in foreign-owned firms. Computer software is the sole exception. Indigenous firms employ as many as foreign firms do in this sector, and both segments are about equally highly export-oriented. The indigenous segment is even more strongly clustered – almost completely so – in Dublin. The present case study focuses on the crucial role of the ICT-using high-tech sectors in the emergence of this key ICT-producing cluster.

Prior to Ireland's recent convergence on EU15 living standards, there was little discussion or recognition of the concept of a regional or national innovation system. Policy was largely focused on creating the conditions necessary to attract MNCs and to draw higher stages of the value chain to Ireland. Massive (EU-funded) development of the telecommunications system was one component of this policy. Another focused on science and engineering-oriented third-level education. Indigenous software entrepreneurs emerged through both of these channels, while others emerged with experience accumulated through working in the foreign high-tech sectors. The demand-side of the process was represented by the diverse ICT-using high-tech sectors in the Dublin region, as the customised and niche software products these sectors required were, in the early stages, largely non-tradable.

---

[13] International studies tend to group sectors into *either* ICT-using *or* ICT-producing (or neither). It is clear from the data in Van Ark et al. (2002, Appendix Table A.2) however that the Office and Data Processing Equipment and Computer Services sectors are intensive users as well as producers of ICT. Of the various high-tech FDI sectors in Ireland, only Pharma does not show up as heavily ICT-using (Milana and Zeli, 2002, table 4).

[14] A related question that cannot be explored here concerns whether the emergence of an indigenous software sector has increased Ireland's attractiveness as a location for ICT-using foreign-owned industry. Barry, Gorg and Strobl (2003) draw a distinction between agglomeration and demonstration effects. The strengthening of Ireland's image as a centre of innovative technology can work via demonstration effects to enhance its attractiveness as an FDI location, even if agglomeration effects prove less relevant to the case.

Thus a dynamic indigenous software sector emerged as an unanticipated by-product of the country's focus on attracting FDI.

Once the indigenous software sector emerged, the stage agency Enterprise Ireland stepped in with support. EI support is heavily oriented towards the development of products for the export market; hence the transition over time from non-traded computer services to traded software products. State support, funded by EU regional aid, was key to the emergence of the necessary venture capital funding, though the fact that the basic pre-condition for the successful establishment of a state-supported VC industry had been met – i.e. that the high-tech sectors requiring VC were already in place – is crucial. As the cluster matured, local demand conditions became less relevant and the newer firms spun off by the cluster could be increasingly characterised as "born global".

As the report represents a case study, it is useful to begin with a brief discussion of the case-study method. Case studies illustrate rather than prove. They provide a heightened understanding of why particular cases evolved as they did, and offer suggestions as to what factors and processes it might be important to look out for in future research. The present study charts the interactions between the various economic actors (foreign-owned firms across a number of sectors, Irish indigenous software firms, and the relevant state agencies) and illustrates how the nature of these interactions changed over time.

Background factors specific to the Irish case study include the FDI-intensity of the Irish economy, the benign macroeconomic conditions prevailing over most of the period studied, and the fact that the Irish state agencies are generally recognised as exemplary of good practice in the industrial promotion field. If other regions differ substantially along any of these dimensions, their local software sectors might be expected to evolve differently. These are some of the insights that the present study throws up and that might be amenable to future econometric research.

The groups of firms studied in the present case illustrate one particular aspect of the economic transformation and growth dynamics of the region studied; i.e. how the sector emerged as a consequence of spillovers both from inward FDI and the country's FDI-oriented development strategy. It is not argued here that the sector's performance is emblematic of the Celtic Tiger era of strong Irish economic growth, though authors such as Ó Riain (2004) and Breznitz (2008) present it as such.

There are nevertheless a number of possible limitations and biases to the present analysis. For example, while FitzGerald and Kearney (2000) and Barry and Devereux (2006) accord FDI a high degree of importance in driving the Celtic Tiger boom, and this is the position taken in the present paper, others such as Ó Gráda (2002) and Honohan and Walsh (2002) downplay its significance. Ó Gráda indeed terms the FDI-friendly policy environment a "distortion", writing that: "What emerged (in the 1960s) was hardly free trade. Instead Ireland shifted from one form of trade distortion to another: export-subsidising industrialisation replaced import-substituting industrialisation. A trade sector bloated by FDI replaced one shrunk by ISI".

Partly related to this is the question of whether Ireland's low corporation-tax regime is necessarily an optimal strategy. While there is widespread agreement that the corporation tax rate can have a significant effect on FDI inflows when competing countries are similar in other significant respects, low corporation taxes can be detrimental when these conditions are not fulfilled (FIAS, 2001).

Even when a low corporation tax strategy is effective, this does not necessarily imply that the benefit-cost ratio associated with the policy is advantageous. As Blomstrom and Kokko (2003) point out, while the benefits may be transparent the costs (termed "tax expenditures") may be hidden, distributed over long periods of time and hard to measure. Consequently, there is a tendency for competing countries to overbid for FDI projects, which

shifts surplus to the MNCs. The implicit subsidy may surpass the level of spillover benefits, resulting in welfare losses. An alternative policy of enhancing the local supply of human capital and modern infrastructure would also increase the country's attractiveness to FDI and increase the likelihood that domestic firms benefit from foreign participation through spillover effects.

Another possible bias arises in the study's discussion of venture capital. The position adopted here is similar to that of Avnimelech, Kenney and Teubal (2005), that "a vibrant VC industry is dependent upon a flow of investment opportunities capable of growing in value quickly enough to provide capital gains justifying the investment risks". Others argue for the state provision of VC based simply on a lack of available funds.

Section B is organised as follows. The aggregate data on the indigenous software sector is first reviewed. The emergence and growth of the sector are then charted and detail is provided of the forms of state support offered. A final section leading up to the conclusions focuses on the character and structure of the sector as it appears today. The concluding Section C then discusses the theoretical perspectives on regional development on which the present case study sheds light. A note on data sources is provided in an appendix.

B2. Overview of the Indigenous Software Sector

The computer software sector stands out as being the only high-tech sector in Ireland in which indigenous-firm employment almost matches that in foreign-owned MNCs. As shown in Table B.2.1, domestic firms account for less than 20% of employment in most high-tech sectors, whereas the equivalent figure for software is closer to 50%.[15]

Table B.2.1: Foreign-firm employment as share of sectoral total; high-tech sectors; 2006

	Employment in foreign-owned firms	Employment in domestic firms as % of sectoral total
Chemicals	20,000	*20*
…. of which Pharmaceuticals	9,500	*15*
Office and data processing	12,000	*8*
Electrical machinery and apparatus	5,000	*36*
Radio, TV and communications;		
Medical and optical equipment	30,500	*10*
Software Development	14,000	*42*

Source: Irish Census of Industrial Production (2006) for manufacturing;

Source for software development: Forfás (2007) Annual Business Survey of Economic Impact (Appendix).

The software sector, furthermore, is very heavily clustered (around Dublin, the capital city); far more so than are any other of the high-tech sectors, which are in turn more tightly clustered than Manufacturing or Services more generally. Table B.2.2 illustrates the extent of clustering by showing the proportion of the state's manufacturing and market-services employment in the main regions – along with the main city in each region – and the regional employment proportions in the sectors of interest to this paper.

[15] This is consistent with the higher entry barriers that Oakey (1995) finds for manufacturing sectors.

The extent of sectoral clustering can be measured by comparing a region's share of a particular manufacturing sector relative to its share of total manufacturing employment, and its share of software employment relative to its share of all market services. This suggests a clustering of medical and precision instruments in the West, of office and data processing (ODP) and electrical and electronic equipment in the Mid West, of chemicals (and particularly pharmaceuticals) in the South West, and of ODP and software – particularly domestic software – in the Dublin region. It is apparent from the table furthermore that the concentration of the software sector is much greater than for any of the manufacturing sectors, with the Dublin software cluster comprising virtually the entire industry.

Table B.2.2: Sectoral employment distribution across regions in Ireland

	Manufacturing and Utilities	Market Services	Chemicals	Pharma	Office and computing equip.	Electrical and electronic	Medical and precision instruments	Foreign Software	Indigenous Software
Segments of S&E region									
Dublin & Mid-East (Dublin)	35	52	37	39	54	32	13	78	87
Mid-West (Limerick)	10	8	10	6	21	20	12	≈5-6	3
South-West (Cork)	15	13	24	25	18	18	7	≈5-6	5
Segment of BMW Region									
West (Galway)	10	7	9	13	4	14	32	≈5-6	2
Other									
Rest of Country	30	20	21	17	3	16	36	≈ 5	3

Sources: CSO (QNHS, Q1, 2000) for Manufacturing & Utilities and Market Services; Crone (2002) for Software.

Note 1: Foreign software refers to top 60 foreign companies; domestic software to the leading 126 indigenous companies. These firms comprise the vast bulk of employment in the two segments.

Note 2: Clusters are appropriately defined over relatively small geographic areas such as cities or drive-to-work regions.[16] The appropriate regional categorisation for Ireland is at the Regional Authority or EU NUTS 3 level. There are eight Regional Authority areas in Ireland, though Dublin and the Mid East are generally aggregated since the latter is within the Dublin catchment area.

Note 3: This is the latest date for which the distribution of software employment is available at this level of disaggregation. For this reason, the contemporaneous distribution of employment in other sectors is used.

[16] Jaffe et al. (1993), for example, using data on patent citations, find that most spillovers occur within a metropolitan area, though some spread to the encompassing (US) state. Henderson (1986) shows that, within cities, output per labour-hour is higher in firms that have other firms from the same industry located nearby. The analyses of Glaeser et al. (1992) and Feldman and Audretsch (1999) are also based on metropolitan areas, since, in the words of the former, "if geographical proximity facilitates the transmission of ideas then we should expect knowledge spillovers to be particularly important in cities". Braunerhjelm and Borgman (2004), in an analysis of cluster effects in Sweden, work at the level of the 70 component regions of the country, and show that concentrations of knowledge-based industries within these relatively small regions exert an impact on regional growth over and above the industry effect itself. Finally, Feldman (1999), in a review of the empirical literature, finds that knowledge spillovers, whether inter or intra industry, are strongly bounded in space.

How large is the Irish sector relative to that in other European countries? Table B.2.3 reports on the importance of computer software employment as a share of manufacturing and services. Software employment records its highest shares in Sweden, the UK and Ireland.[17]

Table B.2.3: Computer Software Employment as a Share of Manufacturing and Services, 2007

Austria	1.51	Ireland	2.54
Belgium	1.57	Italy	1.91
Czech Rep. (2006)	1.37	Netherlands	2.07
Denmark	1.75	Poland	0.98
Finland (2006)	1.99	Portugal	1.07
France (2006)	1.6	Spain	1.48
Germany	1.34	Sweden	2.72
Greece (2006)	0.62	UK	2.67
Hungary	1.87		

Sources: All data from Eurostat, other than "civilian employment in services" from OECD.

These figures, however, include all software employment, which in Ireland is roughly evenly divided between huge global MNCs such as Microsoft and IBM and very much smaller indigenous companies which operate in very different sectors of the global market. Previous studies – such as Giarratana et al. (2005), Sands (2005) and Barry and Curran (2004) – have focused on the dual-economy nature of the Irish sector, emphasising the disparity between the indigenous and foreign components and the weak linkages between them. The focus of the present paper is solely on the indigenous segment, with the foreign software MNEs entering the picture only to the extent that they have impacted on the development of this cluster.

The packaged software sector, dominated in Ireland by the foreign MNEs such as Microsoft, is classed in Eurostat as NACE 2233 – "reproduction of computer media" – and included as part of manufacturing. The other software segments, with which we are concerned, are classed as NACE 72 (computer services and related activities). In this segment, countries like Sweden, Denmark, Finland, the Netherlands and the UK have higher weights than the rest of Europe. These are all countries with high computer penetration rates and other attributes associated with the "information society".[18] The strength of these countries in this sector reflects the fact that many computer services are essentially non-tradable.

[17] Software employment here includes the manufacturing sector, NACE 2233, as well as NACE 72. NACE 2233 refers to the reproduction of recorded media; i.e. the production of software CD Roms. This sector is significant only in Austria (employment of 1,080), Ireland (4,718) and Poland (1,331). The services sector NACE 72 is far larger in each of these economies; in Ireland, for example, the 2007 NACE 72 employment level is 36,917.

[18] The precise measure referred to here is the Networked Readiness Index for 2008–2009 (Dutta and Mia, 2009). This is a measure of countries' preparedness to leverage ICT advances for increased competitiveness and development.

Hence, while UK software and computer services companies are found to obtain only around one-third of their revenues from exports, and French and German companies from 25 to 30%, exports accounted for 66% of the sales of Irish indigenous firms in 2007.[19]

What explains the strong export orientation of the Irish indigenous software sector? While the overall EU market for (largely non-tradable) IT services is about twice the size of the market for (tradable) software products (European Commission, 2003), Irish indigenous firms have a disproportionately strong weight in the tradable segment. Ó Riain (2004) notes that around half the indigenous firms are engaged in product development rather than services provision – a figure similar to that for the US industry and very much greater than in the Indian software sector for example – and that this orientation is strongly supported by state development agency policies.

Table B.2.4 provides details of IT software and services exports along with population data for comparison purposes.

Table B.2.4: Software Exports and Population Size; selected European countries

	Exports of Computer and Information Services (2007); USD millions	Population (millions)
Austria	1848	8.2
Belgium	3001	10.3
Cz. Rep.	792	10.3
Denmark	1354	5.4
Finland	1809	5.3
France	1805	60.8
Germany	12,120	82.2
Greece	236	10.6
Hungary	722	10.1
Ireland	**29,533**	**4.2**
Ireland, indigenous	**1,400 - 2,700**	
Italy	870	59.7
Netherlands	6,389	16.5
Norway	1848	4.7
Poland	657	38.6
Portugal	269	10.1
Slovakia	209	5.4
Spain	5286	45.1
Sweden	6497	9.1
UK	13,902	60.6

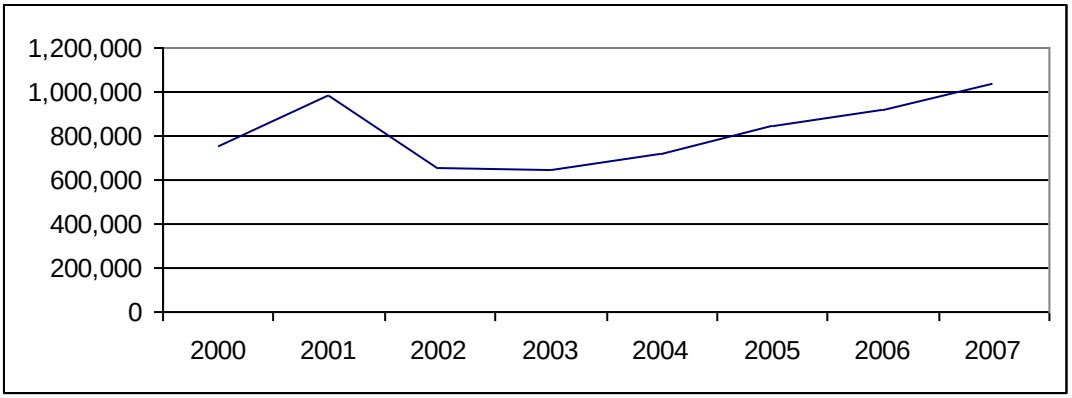
Sources: Country data: http://stats.oecd.org; Irish indigenous software exports: the lower figure of €1.034 billion from Forfás (2007); the higher figure of €2 billion from industry sources as reported in the Irish Times (special supplement of 4 December 2008), and trade magazine Silicon Republic (2008); population data from Wikipedia.

The table shows that while foreign MNCs are by far the predominant exporters of software from Ireland, Irish indigenous software exports perform very strongly against most of the other comparator countries, particularly when account is taken of population size.

[19] The source for Ireland is Forfás (2007) Annual Business Survey of Economic Impact (Appendix). Data for the UK, France and Germany come from *Software and Computer Services*, available on the UK government website: http://www.culture.gov.uk/creative/pdf/Computers.pdf. These data come from a specially commissioned report and are substantially higher than the official balance of payments figures. (On the difficulty of correctly evaluating software exports see OECD, 2002, page 37).

Figure B.2.1 shows developments over time in Irish Indigenous Software Development Exports, from state agency Forfás, the source of the lower figure in the above table.

Figure B.2.1: Irish Indigenous Software Development Exports, €000

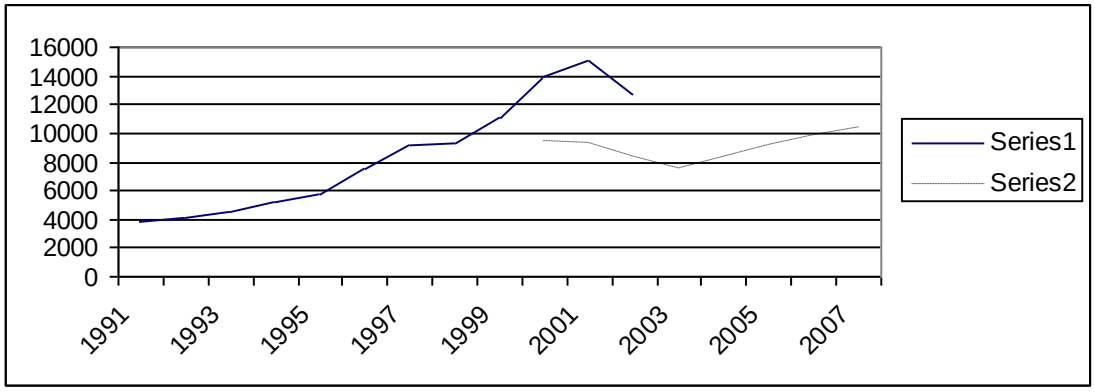


Source: Forfás, 2007, Annual Business Survey of Economic Impact

B3. Emergence and Growth of the Indigenous Software Cluster

According to one data source, employment in the indigenous software sector grew steadily from a level of around 3,800 in 1991 to 15,000 in 2001, before shedding several thousand jobs in the wake of the dot.com collapse. Over the second half of the 1990s, employment in the sector had grown at 24% per annum, revenues at 30% and exports at 37% (Crone, 2004). A new data source shows a slight decline in employment post 2001 being more than recovered to stand at its highest level, of 10,400, in 2007 (Forfás, 2007, Annual Business Survey of Economic Impact). These two data sources are charted in Figure B.3.1.

Figure B.3.1: Data Series on Employment in Indigenous Software Sector



Series 1: National Software Directorate

Series 2: Forfás, 2007, Annual Business Survey of Economic Impact

Relating the history of the indigenous software cluster is complicated by the fact that it is rare for a software company to survive for even a decade under the same name and the same leadership. Company builders jump from one venture to the next, each major company generates numerous spin-offs, and the industry expands by capitalising on its accumulation of development skills and its store of international contacts. Our focus is then on the company builders, the genesis of the sector and the emergence of key market

niches rather than on individual companies.[20] Our mention of particular companies is largely confined to those which were listed at one stage or another on the NASDAQ.[21] An indicative timeline for the sector's emergence and evolution in provided in Table B.3.1.

Table B.3.1: Timeline for Emergence and Evolution of Irish Indigenous Software Cluster

While most US parent companies ran mainframe computers, the advent of the minicomputer saw smaller subsidiaries in Ireland being computerised, which created a demand for locally-customised services, e.g. for multi-currency, multi-country operations which would have been far less important in the US. Different local companies began to provide software for IBM, DEC, and ICL machines, and the computer-hardware parents then helped these companies market their products internationally. (The importance of this link diminished as the cluster matured. Changing patterns as the cluster evolved are indicative of path-dependence: spillover effects remain even after the initial firms leave).

1968 System Dynamics (SD) becomes first software company in Ireland. Founded by former IBM Ireland employees as IBM unbundled software and services in response to US anti-trust case. Tom McGovern as long-term boss. SD followed traditional model of local firms providing services to local computer installations.

1976 Chaco Computer Consultants set up by former SD employee Michael Purses who had become lecturer in computer science at TCD.

1984 Communications software design company, Baltimore Technologies, established with equal shareholdings held by SD and Chaco, and with Jim Mountjoy (with background in telecommunications and with NBST) as MD.

1990 Mountjoy leaves Baltimore to establish Euristix, which initially offered high-skill contracting services but later moved into software product development.

As product trade grew, there was less demand for custom-written applications; local firms spent most time supporting packaged software. Package creators such as Euristix, on the other hand, were exporters with global reach.

Many of the new firms in the early 1990s belonged to one of three clusters: computer-based (e.g. CBT Systems), telecomms software (e.g. Aldiscon Information and Euristix), and middleware (Iona). By 1998 some 40 Irish software firms had set up subsidiaries in the US.

As the Irish indigenous industry became successful, teams would break away from established firms – both indigenous and from the Irish offices of international software firms – to start new businesses. Furthermore, more and more of these new firms displayed the characteristics of "born globals".

Source: largely drawn from Sterne (2004)

Global opportunities in software development emerged with the demise of the mainframe computer. Prior to this, the computer industry had been highly vertically integrated, under IBM dominance, with most components produced in-house and in the US. The industry

[20] Our treatment in this section is based on the account provided by IT journalist John Sterne (2004). The structure of our account however, while largely chronological, is informed by the theoretical issues with which we are concerned.

[21] Seven indigenous companies have been listed on the NASDAQ. These are SmartForce, IONA Technologies, Baltimore Technologies, Trintech, Riverdeep, Parthus and Datalex. Of these, Baltimore, Riverdeep and Datalex de-listed in the wake of the dot.com collapse while Parthus and SmartForce merged with overseas firms. In line with convention we treat companies established in Ireland as indigenous even when merged or taken over, as it is the factors associated with their origins in Ireland that is of primary interest. These seven firms account for around half of all indigenous software revenues.

fragmented into separate hardware and software sectors as more widely affordable minicomputers became available. Then came IBM's unbundling of software and hardware in 1969 and the emergence of the open architecture of the IBM-compatible PC. These developments had huge, and divergent, implications for the global geography of what were now two separate industries. Computer production became a relatively low-tech activity, migrating progressively to lower-cost economies, while high-tech software development also began to disperse, though primarily to more advanced economies and regions (Barry and Curran, 2004).

The advent of the minicomputer led to the computerisation of many MNC subsidiaries in Ireland, since few could have justified the use of mainframes in their smaller satellite facilities. Since vendors did not provide as broad a range of customer services as the mainframe makers, this presented independent local service companies in Ireland and elsewhere with new business opportunities.

Though a subsidiary of the state airline company became Ireland's first home-grown software exporter, the country's first software company had been established by former IBM Ireland employees and won an early contract in the late 1970s for an Irish subsidiary of Barclays Bank.[22] This company was ultimately instrumental in the establishment of Baltimore Technologies. The second was a spin-off of the Irish operations of German white-goods manufacturer Braun. Braun had been one of the world's most advanced users of IBM's Maapics manufacturing applications and the Irish firm, which produced multi-currency functions for the accounting and order entry sections of Maapics, began to sell across sectors in Ireland and made its first foreign sale with the help of IBM Ireland.

A similar process occurred through interactions with local subsidiaries of US computer hardware companies. Digital, which had a substantial assembly operation in Ireland in the early 1980s, appointed about a dozen OEMs in the country, which allowed a number of Irish software companies to establish themselves by mastering Digital's minicomputer system at an early date. Another US MNC Zenith, which had established an assembly operation in Ireland in 1983, hired an Irish company to develop financial software to run on its PCs. Zenith eventually implemented the software in Britain, Germany and the Netherlands, while the Irish firm established a subsidiary in the UK that began to sell the software into other organisations. When the company eventually disintegrated, its employees fanned out and created a new cluster of Irish-based technology firms. In similar fashion, an Irish company that won a contract development project to set up a dealer management system for General Motors Ireland was later able to sell the system to most of the car-maker's subsidiaries across Europe.

One final example from this early era concerns one of the most successful indigenous companies of the time, which would become known as Kindle Banking Systems. According to Ó Riain (2004, p.92) the original company received a contract in 1981 from Ansbacher, a US bank in Dublin, to develop a multi-currency banking product for a platform developed by UK hardware company ICL. ICL then noticed that it would suit banking practices in developing countries and it assisted Kindle in selling its product into former British colonies across Africa and Asia, with hardware supplied by ICL. In the late 1990s former Kindle employees were still developing successful banking applications – by this stage for the internet.[23]

---

[22] A later spin-off of the IT development team from the state airline company saw Datalex established as a provider of IT solutions to the airline and travel industry (Crone, 2003).

[23] Ó Riain (page 92) comments that "multinational investment and access to multinational technologies were important to the early history of the industry, not so much by creating direct spin-offs from computer companies locating in Ireland as the architects of the FDI model had hoped, but by providing a marketing link to the outside world".

Similar direct interactions with foreign *software* MNCs in Ireland led to the country's emergence as the pre-eminent European centre for software localisation as a support service for software developers. This began in 1981 when MicroPro, the California company that produced the word-processing package WordStar, opened a development office close to Dublin. The Irish operation initially planned and produced versions of WordStar that used new Intel architecture and then expanded to translate the software into various European languages. Lotus followed MicroPro into Ireland and began to develop similar services. Localisation companies now offer a full spectrum of consulting, translating, engineering and testing services for software products and websites, though much of the work since the 1990s has shifted to India, China and Central and Eastern Europe. Dublin however has become the centre for the conception of new processes and technologies through the cluster of "language ware" expertise that has evolved.

Only one of the NASDAQ-listed indigenous companies emerged directly from a foreign MNC subsidiary. When Digital Electronics closed its computer hardware operations in the west of Ireland in 1993, with massive job losses, the company co-operated with the local business chamber and national and regional development agencies to assist in job search and new business start-ups. The new business support, training and "incubator" facilities along with the informal networks maintained by key ex-Digital staff eased the adjustment of the regional economy (Barry and Van Egeraat, 2008). One of the new companies to emerge was Parthus, founded by a former Digital engineer, and engaged in the design of integrated circuit chips.

Many of the new indigenous companies established in the early 1990s belonged to three clusters – middleware (consisting of developers' toolkits and software to integrate existing pieces of code), computer-based training and telecommunications software.

The development of the middleware cluster is strongly linked with Trinity College Dublin (TCD), but its genesis was associated with a company called Glockenspiel, whose founder provided advice on the curriculum when TCD established its first full-time undergraduate course in computer science. Glockenspiel provided consulting, training and development services in particular programming languages and operating systems and was a very early user of inter-company email to sell its services to the US, on the basis that software developers in Ireland were less costly than in the US. Thus emerged a new strategy for software development in Ireland. This depended on early access to emerging software technologies and required networking with the leading players in the US-based industry.

Glockenspiel developed a flagship product that enabled other developers to make their applications run on different operating systems and under different graphical user interfaces. Students and staff at TCD then began to spin off companies, the most well-known of which – in the middleware area – is Iona, arguably the most successful Irish indigenous software firm to date. Baltimore and Trintech also had strong TCD connections. Baltimore, which has been established in 1984, was partly financed and later fully owned by a company established by a TCD Professor of Computer Science. The latter became the company's chairman, while the MD left to found telecommunications network company Euristix, to be discussed below. Trintech, which would later be listed on NASDAQ, was founded in 1987 by two TCD students to commercialise the results of an undergraduate research project on payments software.

IONA was founded in 1991 and underwent an IPO on the NASDAQ stock exchange in 1997. Between 1985 and 1991, the company's founder had been a researcher in TCD's Department of Computer Science and was engaged in leading edge research on distributed computing, part of the open systems revolution in the field, which was funded by the EU Esprit programme. Trinity College in that period was attracting more research grants from this programme than any other European university.

IONA was a founding member of the Object Management Group – the industry standards body set up in the early 1990s to seek consensus-based standards for object technology. The company played an influential role within OMG since "people from smaller companies and countries were often elected to chair technical groups because the big corporations accept them as neutrals" (Sterne, 2004, P.148). The OMG established the CORBA standard, and the company's core product built on the CORBA industry standard for open systems-based middleware. Sterne comments that "engagement with technical decision makers now became a hallmark of the Irish software industry".

Contact with foreign MNCs operating in Ireland continued to be of importance however. UK MNC ICL, which has been mentioned above, hired Iona to teach object-oriented programming to its employees in Ireland. The first copy of a new Iona product was supplied to ICL's Dublin centre and the companies ran a joint demonstration of their new technology in San Francisco, which attracted the attention of Sun Microsystems who then took a minority shareholding in IONA.

The flagship indigenous firm in the computer-based training field was established by a former Trintech employee in 1993 and underwent various name changes before settling on SmartForce. This provided technology-based workforce training. The same entrepreneur established Riverdeep in 1995 to provide training for school classrooms, and set up another firm in 2003 to develop self-study e-learning materials for sale to individuals rather than institutions. The first package offered screen-based training for money market dealers, with the financial expertise and funding coming from a well-connected Irish entrepreneur who is credited with having originated the idea for the establishment of the International Financial Services Centre in Dublin in the mid-1980s. The package was ultimately sold into dealing rooms from New York to Hong Kong.[24]

Of the two major indigenous companies in the telecommunications software field, Euristix, which focuses on telecommunications network management, was set up in 1990 by the former Managing Director of Baltimore, who had developed a strong relationship with Irish network operator Telecom Eireann, the body which had been established to commercialise the state telephone service at the behest of the IDA in 1979, under Albert Reynolds as government minister. The other company, Aldiscon, which focuses on mobile applications, was established in 1988 as an offshoot of a company built on the associated expansion of cable-laying for public networks. Officiating at the reception to launch the company were the minister and a former chief executive of Telecom Eireann who had moved to Litel Communications, a long-distance carrier in the US. As Sterne (2004, P.216) notes: "the business and political establishment that had fixed the phones in Ireland was making a statement. Now that the trenches had been dug and the fibre optic lines were laid, the time was right to begin cutting code for communications software". Aldiscon developed one of the earliest systems for what would become known as text messaging and by 1997 had sold its messaging centres to more than 100 wireless operators across the globe.[25]

---

[24] The company later set up in Silicon Valley, partnering with the larger software and hardware development firms and selling its training products to their customers. A Silicon Valley presence is deemed crucial in this field, since product differentiation among courseware developers requires getting early access to new subject matter and launching the training software as soon as the new products are shipped.

[25] Roche et al. (2008) comment that "the presence in Ireland of a number of telecommunications software development operations of major telecommunications technology companies appears to have facilitated the formation of telecommunications software ventures in Dublin through developing a supply of people with knowledge of telecommunications technology and the telecommunications industry. It also provided entrepreneurial ventures with opportunities to undertake contract work."

Taking the account up to the present time, Sterne argues that the indigenous software companies which have performed best since the turn of the century have returned to the model at the beginning of the story. They combine their knowledge of software architecture and design with an understanding of their customers' lines of business, differentiating their products through a combination of software technology and software functionality.

This might be taken to suggest that the evolving diversity of foreign MNC firms in Ireland will continue to play a role both as entrepreneurial incubators and as sophisticated sources of early stage demand. Recent work by Crone (2006) however has documented the extent to which more recent firms emanating from the cluster since the mid-1990s, when the rate of new company formations in Ireland increased markedly, display the characteristics of "born globals" or 'international new ventures'. These characteristics, as identified in the recent international business, marketing and entrepreneurship literatures, include early exporting to a range of international markets and rapid establishment of overseas offices.

A particularly notable feature of this wave of software start-ups is that a significant number of them attracted venture capital funding and might therefore be characterised as following "the Silicon Valley" model of high technology development.[26]

Drawing on the "Celtic Tiger" metaphor, Crone (2006) describes as 'Celtic Tiger Cubs' the group of software firms founded since the beginning of 1996 and in receipt of venture capital funding between January 1999 and December 2001. Twenty six such firms were identified, of which nineteen were investigated in his study.

Data obtained from the web-sites of eight of the companies yields an insight into their international market reach. Of the 119 key customers identified, only 13 were located in Ireland and nearly half were located outside Europe. Three of the eight firms listed no key customers in Ireland. The area with the most customers was North America. His analysis confirms that many of the firms were winning export contracts within their first few years and that they had numerous international Blue Chip clients spread across a range of important vertical market segments (notably telecommunications and Internet services and banking and financial services).

The other evidence concerns their global offices. Sixteen of the nineteen firms in Crone's study group had overseas offices, with an average per firm of 3.5 and a maximum for an individual firm of nine. Several of the firms established their first overseas office very early in their life, suggesting that they had an international outlook from the outset. These overseas offices were spread across the globe with a significant presence in each of the three 'Triad' markets (Europe, North America and Asia-Pacific), with North America the most common location.

The main purpose of the overseas offices is to give firms a local market presence to support local customers and to help them win contracts. Several firms also use their overseas offices as a base for forming strategic alliances in key markets, particularly the US.

[26] Broadly speaking, this model entails a group of entrepreneurs creating a technology-based firm that is designed to grow rapidly. The entrepreneurs then seek to persuade venture capitalists and business angels to invest in return for an equity share in the firm, which it is hoped can later be sold on at profit via an initial public offering or trade sale (Kenney, 2000).

B4. State Support to the Emergent Indigenous Software Cluster

As mentioned earlier, EU restrictions on state aids encouraged the state agency Enterprise Ireland to shift its focus from 'capacity' to 'capability' support, while, in response to the recommendations of an external review by the Industrial Policy Review Group (1992, p.12) – that the agency should shift from grants to equity "to meet gaps in financial markets for venture capital and seed capital" – it progressively increased the proportion of support provided through equity, in the form of both ordinary shareholdings and preference shares.[27] Equity participation increased from 5% of total financial supports in 1989 to 28% in 1998 (Forfás, 2000, Table 5.2).[28]

The shift in emphasis towards capability development requires firms to reach agreement with the state agency on an integrated development plan before aid can be accessed. This encourages emerging firms to assess as objectively as possible their own strengths and weaknesses. The agency then customises a support package that may include helping companies to monitor markets and exploit new market opportunities, encouraging process and operations improvement and the development of better products and services through improved access to appropriate research, and promoting increased management and employee training levels.

The agency is particularly supportive of what it terms high-potential business start-ups (HPSUs), which are primarily in the software sector. HPSUs are defined as export-oriented firms that, in the case of international services, (i) are located in a product market that has grown by at least 20% in the previous year; (ii) are based on technological innovation or the exploitation of a rapidly developing market niche; (iii) are founded and promoted by experienced managers, entrepreneurs, academics or highly skilled technical graduates, either from within Ireland or returning from abroad; (iv) are deemed to have the potential to grow within two years to have annual sales of EUR1.3 million and employ 10 or more people; and (v) show clear evidence of being able to continue to grow substantially and of being in a position to fund such growth.

The agency works intensively with such firms to ensure access to the best external management advice; it helps them to attract expertise to their boards – e.g., through appointment of experienced non-executive directors – and to build an appropriate management team; it provides support for in-company training and for product and process development through direct support for in-company R&D and through establishing technology innovation networks, and it helps them in developing contacts with private-sector financiers. It may also, where necessary, offer direct financial support (Forfás, 2000).

The firm-assessment process operates to rigorous standards. To be deemed eligible for funding (though with no automatic entitlement), projects seeking support must first successfully pass a formal cost-benefit analysis. Qualitative and other factors that are difficult to quantify are then taken into account in a Quality Ranking Matrix which focuses

---

[27] The Review Group – one of a number of periodic external assessments of the state's development agencies – recommended that the agency should become much more an "aggressive venture capitalist" and should be prepared to take stakes as high as 50-60% (IPRG, p.72).

[28] Preference shares with a low coupon rate are used to provide a form of long term finance at low cost to SMEs that are unable to raise development finance from the market on similar terms. Evidence on the significant returns earned by Enterprise Ireland from dividend income, the redemption of preference shares and the sale of ordinary shareholdings in client companies is provided in Forfás (2000, Table 5.3).

in particular on projects from well-managed innovating companies in high-growth, high-productivity export-oriented sectors.[29]

Ó Riain (2004, pps. 98-105) provides further details of the hands-on approach that has operated in the case of indigenous software firms, suggesting that the mentoring programmes that pair small companies with experienced industry figures and the Enterprise Development Programme that provides one-on-one support and advice in terms of business plan development have been of particular importance. Indeed, according to Walsh (1985), the latter had been instituted in 1978 partly in response to the lack of venture capital finance available at that time. The state has also provided a substantial proportion of the R&D funding for indigenous software companies and, more recently, as discussed below, of venture capital funding as well.[30]

As the only significant indigenous high-tech sector, computer-related activities (which in Ireland equates largely to software) attract a relatively very high proportion of VC funding. This is charted for 2003 and for the most recent period in Tables B.4.1 and B.4.2 below.

Table B.4.1: Sectoral distribution of VC investments (%) in the US, Europe and Ireland, 2003

Sector	**US**	**Europe**	**Ireland**
Communications	23.1	16.9	11.1
Computer related	***36.7***	***6***	***83.3***
Electronics	1.3	1.9	1.1
Biotech	18.8	2.3	0.3
Medical	9.2	6	2.2
Industrial/energy	3.9	11.9	0
Consumer related	1.3	19.4	0
Financial services	2.1	2.3	0.4
Other	3.5	33.3	1.5

Source: Barry and Topa (2008), based on calculations from EVCA Yearbooks for Ireland and Europe and PricewaterhouseCoopers, Thomson Venture Economics, NVCA Money Tree Surveys for the US.

Table B.4.2: Sectoral distribution of VC investments (%) in the US, Europe and Ireland, 2007-09

Period	Quarters 1-3, 2009	Quarter 2, 2009	2007-2008
Sector	**US**	**Europe**	**Ireland**
Software	16.4	7.2	75.4
Life Sciences	35	30	15.5
Remainder	48.6	62.8	9.1

Sources: Enterprise Ireland Seed and Venture Capital Programme 2008 Report for Ireland; Butcher (2009) for Europe; NVCA Money Tree Survey for the US

[29] The focus of the development agencies on export development has been criticised in some quarters as overly mercantilist. It has been pointed out in defence however that non-traded-sector firms are likely to be competing largely with each other, which would put the state in a vulnerable position were it to support some and not others. In the case of software, the strong focus of the relevant agency has always been on software products, which tend to be much more export-oriented than software services.

[30] State expenditure on capacity and capability support is a multiple of state investments in the privately-managed VC funds discussed below.

The Irish VC industry expanded dramatically from 1994 when two major government initiatives were announced. The first was the issuing of guidelines that pension funds should place 0.08% of their assets annually into venture capital funds over the following five years. These guidelines were issues on foot of a report commissioned by the Irish Association of Pension Funds (IAPF), the Irish Insurance Federation and the Department of Finance, at the request of the Minster of Finance, which found that pension-fund investments in the domestic market were negligible in comparison with levels prevailing in the US and the UK. Since then, the proportion of new funds accounted for by the Pension Funds sector has hovered around the European average (Barry and Topa, 2008).

The second major step taken in 1994 was the establishment by Enterprise Ireland of the Seed and Venture Capital Measure (1994-1999), co-financed by EU regional aid. The programme was targeted at establishing venture/seed capital funds. Financing was provided on condition that a minimum of 50% of the capital would be privately funded. The EU and national funding amounted to a total of €44 million and this was matched at the beginning by €40 million in private investments. Returns were fed back into further investments. Although at the inception there were difficulties in securing the participation of the private sector, by 2003 a sum of €119 billion had been invested in 130 companies (Enterprise Ireland, 2002). Crucially, from a governance point of view, these VC funds are run on a purely commercial basis, with investment decisions taken solely by private-sector VC fund managers.

In 2001, the Seed and Venture Capital Fund Scheme was recommenced under the National Development Plan 2001-2006 with funds amounting to €95 million. The objective of the programme was to leverage €400 million in private funding. This had already been achieved by 2002, and by 2004 the 15 funds established under the programme has raised about €500 million and had made investments of €133 million in 75 companies (Enterprise Ireland, 2005).

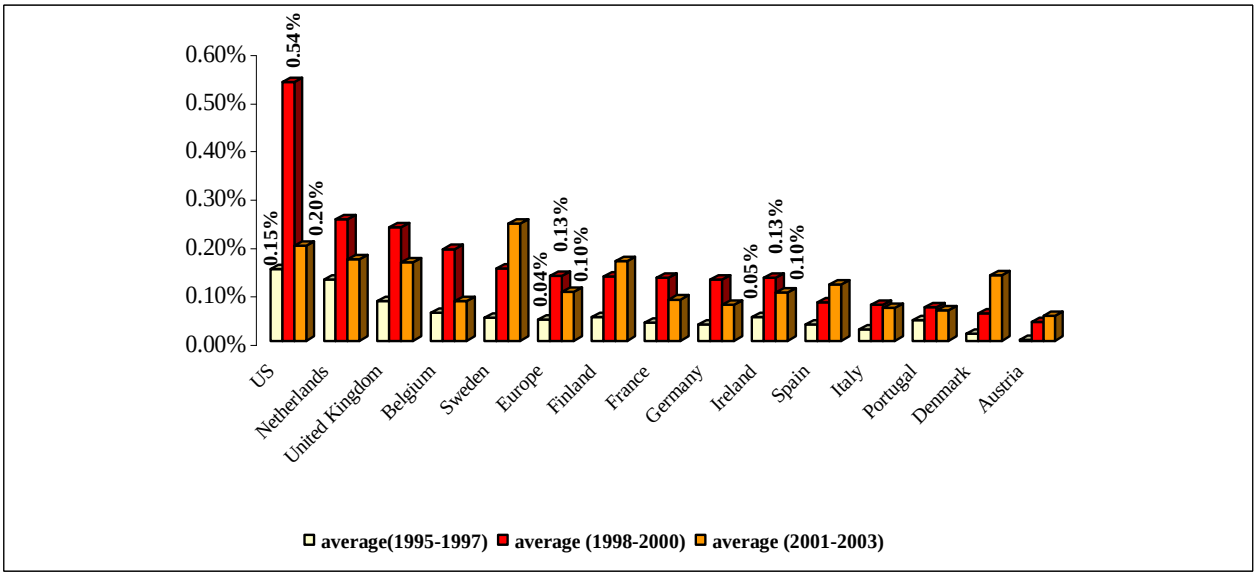
Over the entire period since these government initiatives were taken in the mid-1990s, government funds as a share of total new funds in Ireland have typically been greater than is the case for Europe on average (Barry and Topa, 2008).

The Irish authorities, furthermore, have been commended on establishing a fiscal and legal framework conducive to the development of venture capital. The 2003 report of the European Venture Capital Association published an evaluation of the extent to which member countries maintained an environment which was favourable both for the demand side (venture capital investors) and the supply side (entrepreneurs) of the industry. On a scale running from 1 (most favourable) to 3 (least favourable), the average composite score for the Western European EU was 2.04. Ireland achieved a score of 1.58, placing it second to the UK, which had a score of 1.2. The report highlighted as beneficial aspects of the Irish environment: (i) overall tax policy, with a low corporate tax rate and tax incentives for private individuals – including the Business Expansion and Seed Capital schemes discussed earlier – as well as R&D incentives; (ii) the most favourable entrepreneurial environment in the EU, with the lowest time, cost and capital requirements for setting up private or public limited companies; (iii) the lack of restriction on pension funds' investments in private equity; and (iv) the availability and optimal regulation of limited partnership funds which represent a legal structure particularly suited to venture capital funds.

Ireland's achievements in establishing a VC industry are reflected in the fact that, even though indigenous industry is less concentrated in high-tech sectors than is the case for the

average Western European EU economy, venture capital investments as a share of national income have matched the Western European average (Figure B.4.1).[31]

Figure B.4.1: Venture capital investments as a percentage of national income; various countries and regions; average values for 1995-1997, 1998-2000 and 2001-2003.



Source: Own calculations on the basis of EVCA Yearbooks and NVCA Yearbook (2004[32]), OECD data (GDP and GNP measures-at current prices); exchange rates: Eurostat.

B5. Characteristics of the Indigenous Irish Software Sector

Size, Export-Orientation and R&D Spend

Indigenous software companies are generally small. 50% of the 630 firms recorded by the National Software Directorate in 1998 has 10 employees or less and accounted for only 11% of revenues and 6% of indigenous exports, while the 34 largest firms employing 50 workers or more accounted for 56% of revenues and 68% of indigenous exports (Sands, 2005, Table 3.4).

Crone (2006) analyses the location of key customers for 8 of his group of later-stage "Celtic Tiger cub" firms. Of the 119 key customers identified, only 13 were located in Ireland (with three of the eight firms listing no key customers in Ireland) and nearly half were located outside Europe. The area with the most customers listed was North America.

[31] GNP is conventionally used as the national income denominator for Ireland in order to exclude the vast profits recorded by foreign MNCs in the country (because of its low corporation-tax regime), which are included in GDP. In none of the other countries shown is there a substantial difference between the two measures.

[32] Europe and Ireland: early stage investments include: "seed" and "start-up", the US- early includes: "start-up/seed" and "early". To make comparison between European and American data possible, the category "later" was excluded from the US VC activity.

Table B.5.1: Geographic Analysis of 'Key Customers' for 8 VC-funded Software Start-ups

	Number of key customers by geographic area						
	Ireland	UK	Europe	N Amer	A-P	Other	Total
Percentage of total	*11%*	*24%*	*19%*	*39%*	*1%*	*6%*	*100%*

Notes: geographic areas: Ireland = Republic of Ireland; UK = United Kingdom; Europe = Europe (excluding UK and Ireland); N Amer = North America; A-P = Asia-Pacific.

Source: Crone (2006, table 5)

In terms of R&D spend per employee, only in the knowledge-intensive sectors (software, other internationally traded services, electronics and electrical equipment, and precision instruments) are the data for both Irish and foreign-owned industry in Ireland above the OECD average. In software, significantly, R&D spend per employee is higher in the Irish-owned than in the foreign-owned segment (Ó Riain, 2004, Tables 3.3 and 3.4).

Product Development versus Service Provision

While Arora et al. (2001) and Ó Riain (1997) found that firms were about evenly divided between product development and service provision, the proportion of revenues derived from products has increased over time (Sands, 2005; ICT Ireland, 2003). Export activity is also more prevalent among product-oriented firms, who typically target niche (or vertical) markets and hence avoid competition with the large established market players.

Ó Riain (2004, pps. 102-03) shows that the increasing industry-wide orientation towards product development is augmented by state intervention, if not driven by it. Firms producing software products are more likely to receive high levels of grant aid, and product orientation is strongly associated with export orientation. Indeed the mission statement of the state agency Enterprise Ireland is "to accelerate the development of world-class Irish companies to achieve strong positions in global markets resulting in increased national and regional prosperity".

It is worth pointing out that domestic software firms in EU countries are not generally in competition with the high-profile Indian software industry, which is primarily engaged in customised programming for large multinational corporations. For example, almost one half of *Fortune 500* companies are said to have outsourced their software requirements to India, with North America accounting for over 60 per cent of India's software exports (Barry and Curran, 2004).

Background Work Experience of Irish Software Entrepreneurs

O'Malley and O'Gorman (2001) were the first to explore in any detail the work background of indigenous software entrepreneurs. Most of the founding entrepreneurs that they interviewed had been working in indigenous firms immediately prior to establishing their companies; about half of these in other software companies and the other half in a range of industries including, notably, hardware and software distribution companies. While a minority of about one third had been working in foreign-owned TNCs immediately prior to start up, a majority of about two thirds had experience of working in a foreign-owned TNC at some stage in their careers. About half of them had also worked abroad in software or a related sector at some stage, and about half had at some time worked in a sector that now constituted a major customer for their company.

Sands (2005) revisited this issue in her survey of 58 entrepreneurs from 38 different software companies (Table 3.5). She found that 66% of the companies were established by founders who had worked for MNCs in Ireland at one stage in their careers.

Table B.5.2: Work Experience of Irish Software Entrepreneurs

	% of companies (n=38)	% of founders (N=58)
Foreign-owned MNC in Ireland	66	55
Abroad	76	57
Indigenous software company	42	40
Studied abroad	21	17
Academia	5	7
Other	18	22

Source: Sands (2005)

Crone (2006) provides similar evidence for his group of "Celtic Tiger cub" companies. Of the seventeen out of his study group of nineteen firms for which data are available, he found that only three had former or current academic faculty or researchers among their founding team. Nine of the firms had at least one founder with previous work experience at a software/IT multinational in Ireland, supporting O'Malley and O'Gorman's proposition about the existence of human capital spillovers from software multinationals to the indigenous software industry.[33] For twelve of the thirteen firms for which a definitive judgement can be made, at least one of the founders had previously worked for another Irish indigenous software/IT firm. Thus the founders of the "Celtic Tiger Cubs" group of companies have learnt from their experiences in earlier phases of the indigenous industry's development. His finding for another number of firms that their founders had work experience in sectors other than software/IT suggests that they had experience in targeted vertical markets such as banking and financial services and telecommunications.[34]

Key Specialisms and Technology Areas

The following specialisms are widely recognised to have emerged in the indigenous sector (see e.g. Crone, 2002):

- Financial services applications/solutions
- E-security/secure payments solutions
- E-learning/computer based training
- Open systems-based middleware
- Mobile telecomms software development

A slightly different classification is provided by Arora et al. (2001), as follows:

[33] Thus ICT Ireland (2003) does not appear to be correct in asserting that "the presence of foreign owned multinational ICT companies has been good for the Irish economy, and for the companies involved, but it has not been a factor in the emergence of the indigenous sector…. Multinationals and indigenous Irish companies have developed independently of one another and the only real link is in the movement of staff between the two."

[34] See also Crone (2003, table 8).

Table B.5.3: Specialisation of Indigenous Software Firms in 1999

	N	%
Bespoke software (customised development services)	300	58%
Software products (i.e. applications)	227	44%
Internet-related services (on-line services, Internet-access services, development of portals)	135	26%
Multimedia services (e.g. outsourced video, desktop publishing, CBT)	77	15%
Other services (professional services including customer support)	76	15%
Localization	70	14%
System software/tools (e.g. CASE tools, C++ or Java compilers)	54	10%

Notes: Firms could be included under more than one category (total population of 520 firms analysed). For comparison note that HotOrigin (2001) estimate that there were approx. 250 companies developing and marketing software products in 2001.
Source: Arora et al (2001) – elaborations on the NSD database and web-sites information

The key technology areas within the sector as identified by ICT Ireland (2003) are:

Table B.5.4: Key Technology Areas in the Indigenous Software Sector

Technology area	**%**	**Technology area**	**%**
Enterprise applications	31	Intelligent content	19
XML based tools/Java	27	Knowledge management	18
Wireless Applications	27	Security Payment	12
Telecommunications	22	Wireless Infrastructure	11
CRM	20	Enterprise Resource	10

Again, a slightly different classification is provided by the Hot Origin Consulting Report Survey (2002), as reported in Table B.5.5.

Table B.5.5: Key Technology Areas in the Indigenous Software Sector

Technology area	**%**	**Technology area**	**%**
Enterprise application integration (including middleware)	43	Wireless infrastructure	19
Wireless applications	41	Payments systems	18
Niche specific applications development (CRM, e-learning)	41	Advanced applications (AI and mathematical modelling)	14
Java components	31	Operating systems	14
XML-based tools	30	Graphics and visualisation	11
Intelligent-content management	24	Speech processing (incl. language and translation)	8
Telecomms (incl. CTI and IP telephony)	23	Search technologies	8
Knowledge management (incl. Groupware and Coll apps.)	20	GIS and mapping	3
Security (incl. encryption and PKI)	19	Other	27

Networking, Alliances and Strategic Partnerships

The issue of alliances and strategic partnerships formed by indigenous firms has been explored by Ó Riain (2004, pps. 112-116) and Crone (2006). Ó Riain found that there were significant levels of contracting of labour and programming services among indigenous firms, and there was also extensive co-operation in more advanced relationships such as co-development, sharing of technology, co-marketing and joint ventures. However, international networks were more common than local alliances in these advanced business and technical areas, especially in the first and third of these activities, while local networks were more important for labour- and services-contracting. Some of his interviewees suggested that their ties with local firms had been stronger when they were younger and less established.[35]

Crone (2006) explores the geography of these strategic alliances and partnerships for his group of "Celtic Tiger cub" firms. He too finds extensive networking, with eighteen of his nineteen firms having formed strategic alliances or partnerships.[36] From a total of two hundred and four alliance partners that he managed to identify for sixteen of his group of nineteen firms, only eighteen of these were with other Irish companies. The most important location for alliance partners was North America, but alliances were also common in all the other key geographical markets of the global economy.

Table B.5.6: Geography of Strategic Alliances/Partnerships for 16 VC-funded Software Start-ups

	Number of alliances/partnerships by geographic area						
Company	Ireland	UK	Europe	N Amer	A-P	Other	Total
Total (n=16)	**18**	**12**	**33**	**106**	**19**	**16**	**204**
Percentage of total	*9%*	*6%*	*16%*	*52%*	*9%*	*8%*	*100%*

Notes: geographic areas: Ireland = Republic of Ireland; UK = United Kingdom; Europe = Europe (excluding UK and Ireland); N Amer = North America; A-P = Asia-Pacific.

Source: Crone (2006, Table 7)

Crone (2006) further finds that firms participate selectively in various 'communities of interest' such as industry standards bodies – which are an important means of keeping abreast of technological developments and influencing the direction of technological trajectories – and industry associations, both national and international.

[35] In terms of *informal* networks, ICT Ireland (2003, footnote 12) suggests that while these are good at the CEO and technical levels, they are poor in the areas of sales and marketing.

[36] Alliances, he points out, are formed for a number of purposes including the achievement of scale/reputation effects, access to distribution channels and overseas markets, and collaboration on technical issues and new product/service offerings.

C. Conclusions

C1 Knowledge Spillovers and Clustering

Innovative industrial clusters have been the subject of much research and attention in recent years, in part because of a renewed interest in agglomeration economies stimulated by Krugman (1991), and the association of agglomeration economies with localised learning processes. These processes are assumed to arise both through informal information spillovers and local inter-firm labour mobility, representing two of the three types of Marshallian externalities.[37,38] Since these innovative clusters are associated with highly advanced regions (with Silicon Valley as the leading example), these localised learning processes are seen as potential catalysts for regional development and hence are of intense interest to the policymaking community.

Many elements both of the analysis of innovative clusters and of the policy implications to be drawn are the subject of debate however. Researchers disagree, for example, as to whether knowledge spillovers between firms in the same industry or coming from outside the core industry are more important. Glaeser et al. (1992) refer to the first type as "Marshall-Arrow-Romer externalities". These also influence the Porter (1990) perspective, though Porter emphasises, in addition, the role of competition between firms in fostering the pursuit and rapid adoption of innovation. In the work of Jacobs (1969), by contrast, the second type as seen as being of more general importance, suggesting that it is the diversity of geographically proximate industries rather than geographic specialisation that will more generally be associated with innovation and growth.

The analysis of Glaeser at al. (1992) of growth in city/industry pairs (e.g. New York electrical equipment, Philadelphia electrical equipment, etc.) finds that industries grow more slowly in cities where they are overrepresented, which goes against MAR and Porter, and that industries grow more rapidly in cities which are less specialised, which supports Jacobs. Feldman and Audretsch (1999) also find in favour of the Jacobs perspective in contrasting the links between innovative output (measured as number of product innovations) and a city's industrial diversity and/or specialisation. Specifically, they find that diversity *across complementary economic activities sharing a common science base* is more conducive to innovation than is specialization.[39]

Our analysis suggests that in the case of the Irish indigenous software cluster, the Jacobs perspective again appears to be the relevant one. The diversity in the range of FDI-intensive industries in Ireland appears to have been an important contributory factor in the cluster's emergence and success.[40,41]

---

[37] See Glaeser (1999) on localised learning processes and Jaffe et al. (1993) on informal information spillovers.

[38] In terms of inter-firm labour mobility in the indigenous software sector, Ó Riain (2004, p. 135) points to the fact that a quarter of firms in his software industry survey had employee turnover of 25% or more in the mid-to-late 1990s, while the local labour market was almost as important a route into senior technical and management positions as internal labour markets.

[39] Porter (2003) suggests that "a diverse array of overlapping clusters should be associated with better performance than a diversity of clusters that are unrelated."

[40] The basic argument of the paper, expressed in terms of types of agglomeration economies, is that the extent of high-tech FDI led to a strong demand for software services and skills, generating a "thick" software labour market. This is a form of pecuniary externality. The diversity of FDI impacted on the type of software sector that developed, since software sectors in different locations are differentiated. Because much software knowledge is "tacit" – highly contextual and difficult to codify – knowledge spillovers (a form of technological externality) occur through face-to-face contacts and personal relationships and are thus *local* public goods.

C2 Tacit Knowledge and Modular Production Networks: The Interaction between Localisation and Globalisation

Section B of the paper charted the evolution of Irish indigenous software activity into an export-oriented and increasingly "born-global" set of companies. Some elements remain embedded in locality, in the sense of remaining clustered in Dublin, while other elements can be supported at a distance, particularly by the use of ICT. It is key, therefore, to identify how these elements coexist and interact, particularly because of the frequently encountered assumption that modern communications eliminate the need for members of teams or groups to work in close proximity to each other.

The role of tacit knowledge as a "glue" that holds clusters together is widely recognised in the academic literature. Sturgeon (2003) advances the concept of "modular production networks" to explain how localisation and globalisation relate to each other. Such a network comprises "nodes of tacit activity, clustered in particular geographic locations and/or within the confines of integrated firms, linked through the exchange of codified information between firms and/or across space". He concurs with Storper's (1995) suggestion that the geographically-constrained un-traded interdependencies – or "glue" – outlive geographically-constrained input-output linkages.

A brief review of the literature on human communications and collaborative work elucidates the role of tacit knowledge.[42] The importance of informal communications is pointed to by the findings of Herbsleb and Grinter (1999) that greater distances between teams of programmers results in issues that arise over the course of a project taking longer to resolve.

Kraut *et al* (1990) discuss the role of informal communications by identifying four types of conversations, as follows:

- Scheduled: where A and B plan to meet;
- Intended: where A sets out to find B;
- Opportunistic: where A needs to talk with B and happens to meet him;
- Spontaneous: where A and B meet by chance and a discussion develops.

They show that the probability of the latter two types occurring increases with office proximity, and diminishes progressively as A and B are located on different floors of the same building, are in different buildings, or are separated by longer distances. While scheduled meetings are found to be more productive than chance encounters, much important work is nevertheless done in the last three types of meetings.

Trust is also found to be positively correlated with physical proximity, and is known to result in more open communication, cooperation, and improved decision-making (Lipnack and Stamps, 2000). It is slower to emerge and more fragile (reflected in a higher perceived vulnerability to opportunistic behaviour) when communications are mediated through technology rather than occurring face-to-face (Bos et al., 2002, and Jensen et al., 2000).[43]

Campbell (1997) finds that some non-verbal forms of communication are lost, no matter how sophisticated the technological medium employed. A higher frequency of misunderstandings are also found to arise when communications are conducted

---

[41] Note also the finding of Mickiewicz et al. (2000), that diversity in FDI inflows in Central and Eastern Europe has been associated with more rapid economic and employment recovery in both local and foreign owned firms.

[42] This review draws largely on Bannister and Connolly (2009).

[43] Wilson *et al* (2005) note that some geographically dispersed teams, such as in the development of Linux, work effectively. They speculate that this may be related to the narrow scope of the objectives of the project as well as a shared set of values among the team.

electronically (Hallowell, 1999, 2005) and it is more difficult to maintain engagement under these circumstances (Anson and Munkvold, 2004). Storper and Venables (2004) also argue that, while certain types of business can be done remotely, anything that involves serious/major deals requires face-to-face contact.

In Sturgeon's words, "the exchange of tacit information between autonomous economic actors is best handled at the local level, where social and spatial propinquity substitute for the failure of market mechanisms in the exchange processes. The trust, reputational effects, and personal ties that build up at the local level help to overcome the 'exchange inability' of tacit knowledge."

"Because of the fixity and longevity of built and institutional infrastructure, labour markets and the like", he continues, "path dependency causes local clusters to grow more idiosyncratic over time, not less... Place-based routines tend to become more idiosyncratic over time." This explains why Southern and Eastern Ireland and similar regions can maintain their positions as innovative locations.

What then of the globalisation dimension? Globalisation in the case of the present study manifests itself particularly in Irish software companies' links with Silicon Valley. As charted in Section B5, newly emerging Irish firms move rapidly to establish Silicon Valley offices and operations.

As Sturgeon notes, "Silicon Valley is *the* key location for standard-setting activity in software. During an interview an IT manager at a leading contract manufacturer stated, 'Being in Silicon Valley is a huge advantage. This is where it is happening. All the big players are here, lead firms, dotcoms, venture capitalists'."

Barry, Gorg and McDowell (2003) note that without a presence in Silicon Valley, there is little possibility of Irish software firms being featured in the US press, of developing relationships with computer vendors or of attracting the attention of local specialist venture capitalists. Section B4 has identified the importance of these various factors in the case of particular software firms. By way of example, we noted in footnote 24 above that a Silicon Valley presence was crucial for a particular courseware development company since product differentiation among courseware developers requires getting early access to new subject matter and launching the training software as soon as new products are shipped.

This illustrates Sturgeon's point that "locations in advanced economies (such as Silicon Valley) support the set of important interactions between lead firms and suppliers that resist codification, such as codesign, prototype development, and manufacturing processes validation."

C3 FDI and Clustering

Another debate to which the present study contributes relates to the possible role that inward foreign direct investment (FDI) can play in the emergence of clusters. In Porter's (1990) view, only *outward* FDI functions as a source of competitive advantage, though he does allow that, for developing regions, foreign TNCs might serve to "seed" a cluster, by acting, for example, as sophisticated customers. Markusen (1996) argues that external multinational firms can shape and anchor successful industrial districts in more profound ways, and that the external relationships in which firms, workers and public-sector institutions and agencies are embedded condition the ability of the region to prosper.[44]

[44] Amsden and Chu (2003), in writing on Taiwan, point to the important role that the public authorities play in successful late industrialising regions in promoting network development (and, less controversially of course, in ensuring that the appropriate conditions are in place for agglomeration processes to take hold.)

Rugman and various co-authors also critique Porter by suggesting that external MNEs can exhibit *purposeful* cluster-development as well as cluster-exploiting behaviour.

We have clearly established the role of inward FDI in seeding the development of the Irish indigenous software cluster. The role played seems to have been far more extensive than was envisioned by Porter (1990), though there is little evidence of the *purposeful* cluster-development and cluster-exploiting behaviour that Rugman and Verbeke (1993) suggest can arise. In critiquing Porter however, Rugman and Verbeke (2003) allow that the Porter perspective may be more appropriate to "organically growing" and path-dependent clusters than to calculative ones.

C4 Industrial Policy: The Role of the State in Cluster Development

A third debate relates to the role of the state in the process of cluster development. Rodrik (2004) contrasts those who believe in the ubiquity of market failures that call for government intervention with those who believe that government failures are more pervasive and that intervention to promote technological dynamism is best avoided.

While Irish industrial policy as described might appear to be quite interventionist, it adheres quite closely to Rodrik's (2004) design principles for policy to avoid the common pitfalls of waste, clientelism, rent seeking and poor decision making. His design principles fall into three groups. The first, concerning the activities to be promoted, include the criteria:

- Incentives should be provided only to "new" activities designed to diversify the economy and generate new areas of comparative advantage.
- The activities subsidised should be capable of generating spillovers and demonstration effects
- Public support should target activities rather than sectors in order to address market failures directly

With reference to this first set of principles, Ireland's revealed comparative advantage has indeed changed as a result of inward FDI, and there is empirical evidence of spillovers and demonstration effects. The development agencies, furthermore, can only administer aid in line with the European Commission's "State Aid Guidelines" which limit the provision of aid to activities such as R&D and innovation, employment creation, investment in capacity (plant & equipment and capabilities), and training and management development.

Rodrik's second group concerns the implementation of criteria for success:

- There should be clear benchmarks for success in order to monitor the effectiveness of industrial policy and to prevent poor policies from becoming endemic.
- There should be built-in sunset clauses so that support is withdrawn if the criteria for success are not being met.

Sunset clauses are in place in Ireland; e.g. a failure to meet employment and export sales targets will disqualify High-Potential Start Up companies from further supports unless an acceptable reason can be provided for underperformance. While Rodrik deems productivity to be the best target measure, he recognises that exports – one of the main measures employed in Ireland – can provide a rough and ready but effective gauge as it is indicative of achievement in the international marketplace.

His third group of criteria refers to the agencies involved:

- Industrial policy authority should be vested in agencies with demonstrated competence.
- The implementing agencies should be monitored closely by principals with a clear stake in the outcomes and with political authority at the highest level.
- Agencies must maintain strong channels of communication with the private sector.

- Agencies should have the capacity to reinvent themselves and to change to meet new and emerging productive opportunities in the economy.

With respect to these criteria, Barry (2007) documents how Ireland's industrial development agencies have developed to become widely-recognised examples of best-practice in the investment promotion field.

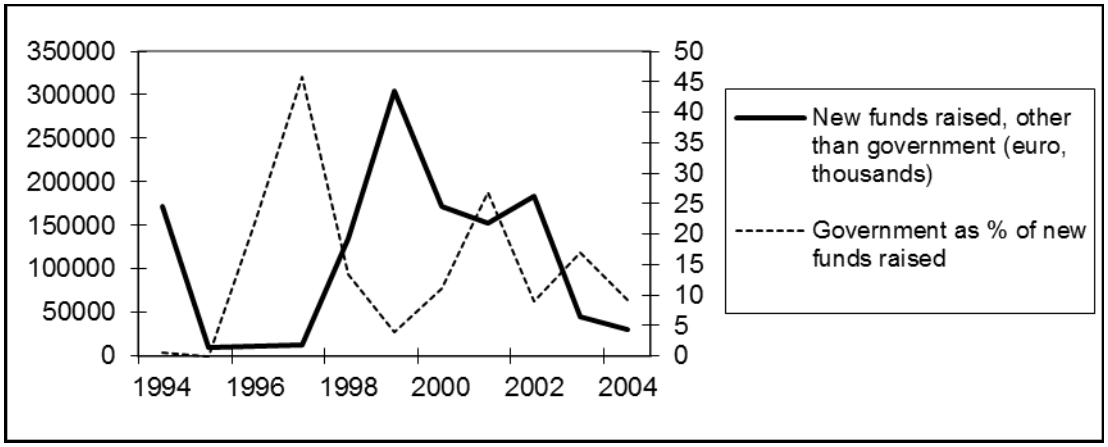
C5 Industrial Policy: The Role of the State in Venture Capital Provision

The classic case for public provision of venture capital funds is provided by Stiglitz and Weiss (1981), who show how the informational asymmetries that can preclude access to external capital for new small firms may be counteracted by the signalling effect of public funds. Some analysts however point to government failure as the cause of the poor record of public attempts around the world to establish venture capital industries. Avnimelech, Kenney and Teubal (2005), by contrast, suggest that the fault may frequently lie with how the problem is conceptualised. The absence of VC is frequently seen as a supply-side deficiency (a lack of available funds). They note however that "a vibrant VC industry is dependent upon a flow of investment opportunities capable of growing in value quickly enough to provide capital gains justifying the investment risks". Hence the failure of a local VC sector to emerge may instead reflect the absence of the necessary demand-side factors.

VC support in Ireland followed closely on the pattern established by Israel. The innovation capabilities emerged first and public provision of VC funds followed, which, as in line with Stiglitz and Weiss (1981), triggered a private sector response.

Figure C.1.1, which plots privately-raised new funds on the left-hand scale and the government percentage share of new funds on the right, suggests that this indeed appears to have been the case. Michael Murphy, chairman of the Irish Venture Capital Association, concurs, noting that "Enterprise Ireland acted as a catalyst; it helped draw in matching funds faster and accelerated the on-going development of the market" (quoted in Cowley, 2003).

Figure C.5.1: Government Intervention and Privately Raised New Funds



Source: Barry and Topa (2008); calculations on the basis of EVCA data.

As Barry and Topa (2008) emphasise however, the successful application of the kinds of interventionist strategies followed in the Irish and Israeli cases is heavily dependent on strong standards of public-sector governance. Otherwise, the possibilities of abuse that arise in state investments or subsidies of any kind may mean that awareness of the likelihood of government failures should take precedence over the desire to correct market failures.

C6 Concluding Comments

Ireland is the most FDI-intensive economy in Europe. The production, employment and export activities of foreign-owned MNCs give the country a disproportionate European and global weight in such high-tech sectors as ICT, pharmaceuticals, medical devices and international financial services. There is little evidence of the kinds of activities associated with clustering in these FDI-dominated sectors however. The strong FDI presence should instead be categorised as *co-location* (Barry, 2006).

The presence of these MNCs however, and the country characteristics and policies that have generated Ireland's FDI intensity, have led – as an unanticipated by-product of the country's inward FDI-oriented development strategy – to the emergence over time of a genuine upstream cluster in indigenous software development. The substantial stock of inward FDI in a diverse range of high-tech sectors influenced the growth of the indigenous software sector through three channels: as a sophisticated source of early-stage demand, as a repository of external contacts, and as an incubator of managerial and sectoral experience. Sterne (2004, P. 237) furthermore notes that "Irish software suppliers who have sold products into North America often say that the process was made easier by their familiarity with the way that US corporations operated inside Ireland." The FDI focus of the authorities led to substantial improvements in the country's telecommunications infrastructure and in the scientific orientation and throughput of the educational system, which further supported the emergence of the cluster.[45]

As the cluster matured, the new firms it spun off relied less and less on the early-stage demand that Irish-based foreign MNCs had represented in the earlier phase, and could increasingly be classified as "born global". The Irish experience sheds new light on the role that FDI can play in cluster development and on the potential for infant-industry growth in an outward-oriented as opposed to protectionist environment.

As interventionist a strategy as has been adopted in the Irish case would be far more problematic, however, were institutional capacity and standards of governance of poorer quality.[46]

---

[45] Amsden and Chu (2003), in their work on Taiwan, point to the important role that the public authorities play in successful late industrialising regions in promoting network development. The notions of organisational and institutional learning are also of importance here, with the former referring to learning within a given organisation and the latter to improvements in the quality of interactions between organisations that relate to each other in a given context. The organisational learning that appears of importance in the account of the present paper refers to the ability of the state agencies to extract, accumulate and use effectively the insights that become available to them.

[46] Measures of Governance/Institutional Capacity are available from: http://info.worldbank.org/governance/wgi2007/ and measures of the Regulatory Environment from: http://www.doingbusiness.org/EconomyRankings/

References

Barry, F., ed. (1999). *Understanding Ireland's Economic Growth*, London: Macmillan Press and New York: St. Martin's Press, 1999.

Barry, F. (2002). "The Celtic tiger era: delayed convergence or regional boom?". Economic and Social Research Institute (Quarterly Economic Commentary), pp. 84-91.

Barry, F. (2005) *European Union Regional Aid and Irish Economic Development*, report to the World Bank (Decentralization and Subnational Thematic Group) and the UK Department for International Development.

Barry, F. (2006) "The Emergence and Evolution of Ireland's ICT Clusters", in Pontus Braunerhjelm and Maryann Feldman (eds.) *Cluster Genesis: Technology-Based Industrial Development*, Oxford University Press.

Barry, F. (2006) "Foreign Direct Investment and Institutional Co-Evolution in Ireland", *Scandinavian Economic History Review*, 55, 3, 262-288, 2007.

Barry, F. (2007) "Foreign Direct Investment and Institutional Co-Evolution in Ireland", *Scandinavian Economic History Review*, 55, 3, 262-288.

Barry, F. (2007b) "Third-Level Education, Foreign Direct Investment and Economic Boom in Ireland", *International Journal of Technology Management*, 38, 3, 198-219, 2007.

Barry, F., and D. Curran (2004) "Enlargement and the European Geography of the Information Technology Sector", *World Economy*, 27, 6, 901-922, 2004.

Barry, F. and Devereux, M. (1995). "The expansionary fiscal contraction hypothesis: a neo-Keynesian analysis", *Oxford Economic Papers*, (47), pp. 249-264.

Barry, F., and M. Devereux (2006) "A Theoretical Growth Model for Ireland", *Economic and Social Review*, 37, 2, 245-262.

Barry, F, H. Görg and A. McDowell (2003) "Outward FDI and the Investment Development Path of a Late-Industrialising Economy: Evidence from Ireland", *Regional Studies*, 37, 4, 341-349, 2003.

Barry, F, H. Görg and E. Strobl (2003) "Foreign Direct Investment, Agglomerations and Demonstration Effects: An Empirical Investigation", Weltwirtschaftliches Archiv/Review of World Economics, 139, 4, 583-600.

Barry, F., and B. Topa (2008) "A Comparative Analysis of the Development of Venture Capital in the Irish Software Cluster", in P. Phan, S. Venkataraman and R. Velamuri (eds.) *Entrepreneurship in Emerging Regions around the World: Theory, Evidence and Implications*, Cheltenham (UK) and Northampton (USA): Edward Elgar, 2008.

Barry, F., and C. Van Egeraat (2008) "The Decline of the Computer Hardware Sector: How Ireland Adjusted", ESRI Quarterly Economic Commentary, Spring, 2008, 38-57.

Blanchard, O. (2002) "Comment on Honohan and Walsh", Brookings Papers on Economic Activity, (1), 58-66.

Blomstrom, M., and A. Kokko (2003) The Economics of Foreign Direct Investment Incentives, in H. Herrmann and R. Lipsey (eds.) *Foreign Direct Investment in the Real and Financial Sector of Industrial Countries*, Berlin and New York: Springer.

Bos, N., J. Olsen, D. Gergel, G. Olsen and S. Wright (2002) "Confidence and Trust: Effects of Four Computer Mediated Communications Channels on Trust Development", Proceedings of the SIGCHI conference on Human Factors in Computing Systems: Changing Our World, Changing Ourselves, April 20-25th, Minnesota, USA.

Braunerhjelm, P., and B. Borgman (2004) "Geographical Concentration, Entrepreneurship, and Regional Growth: Evidence from regional data in Sweden 1975–1999", *Regional Studies*.

Breznitz, D. (2008) Innovation and the State: Political Choice and Strategies for Growth in Israel, Taiwan and Ireland, New Haven: Yale University Press.

Butcher, M. (2009) "VC Investment in Europe Recovers", TechCrunch Europe, October 27: http://eu.techcrunch.com/2009/10/27/vc-investment-in-europe-recovers-but-its-still-not-great-especially-for-early-stage/

Campbell, J., (1997) "The Impact of Video Conference Meeting on the Patterns and Structure of Organisational Communication", *Singapore Management Review*, 19(1), 77-93.

Collins, P., and D. Pontikakis (2006) "Innovation systems in the European periphery: the policy approaches of Ireland and Greece", *Science and Public Policy*, 33, 10, 757–769.

Commission of the European Communities (2003), *European Business: Facts and Figures, Part 6: Business Services, 1991–2001* (Luxembourg: Office for Official Publications of the European Communities).

Contractor, F. J., and S. Kundu (2004) "The role of export-driven entrepreneurship in economic development: A comparison of software exports from India, China, and Taiwan", *Technological Forecasting and Social Change*, 71, 8, 799-822.

Cowley, L. (2003), *Irish venture: a winning formula?* European Venture Capital Journal, London, September.

Crone, M. (2001) Software And Computer Services Employment In The UK Regions And Ireland, 1995-99, Report 19, Belfast: Northern Ireland Economic Research Centre.

Crone, M. (2002) A Profile of the Irish Software Industry, Belfast: Northern Ireland Economic Research Centre.

Crone, M. (2003) "Clustering and Cluster Development in Knowledge-intensive Industries: A 'Knowledge and Learning' Perspective on New Firm Formation and Firm-building/Firm Growth in Ireland's Indigenous Software Industry", unpublished ms, Queen's University, Belfast.

Crone, M. (2004) "Celtic Tiger Cubs: Ireland's VC-Funded Software Start-ups", paper presented at Institute of Small Business Affairs National Entrepreneurship and SME Development Conference, Newcastle-Gateshead, November.

De la Fuente, A., and X. Vives (1997). The sources of Irish growth, in Alan Gray (ed.), *International Perspectives on the Irish Economy*, Indecon, Dublin, Ireland. Also available as CEPR Discussion Paper No. 1756.

Djankov, S., C. McLiesh and R. Ramalho (2006) Regulation and Growth, unpubl. ms., World Bank.

Dutta, S., and I. Mia (2009) The Global Information Technology Report 2008-09, INSEAD and World Economic Forum. http://www.weforum.org/en/initiatives/gcp/Global%20Information%20Technology%20Report/index.htm

Enterprise Ireland (2002) *Seed and Venture Capital Programme*, report available at: http://www.enterprise-ireland.com

European Commission (2007) *Growing Regions, Growing Europe: Fourth Report on Economic and Social Cohesion*, Luxembourg: Office for Official Publications of the European Communities.

European Innovation Scoreboard (2008), produced by the Maastricht Economic and Social Research and Training Centre on Innovation and Technology (UNU-MERIT); available at: http://www.proinno-europe.eu/EIS2008/website/docs/EIS_2008_Final_report.pdf

EVCA (2003) *Benchmarking European Tax & Legal Environments: Indicators of Tax and Legal Environment Favouring the Development of Private Equity and Venture Capital in European Union Member States*.

Feldman, M. (1999) "The New Economics of Innovation, Spillovers and Agglomeration: A Review of Empirical Studies, *Economics of Innovation and New Technology*, 8, 5-25.

Feldman, M., and D. Audretsch (1999) "Innovation in cities: Science-based diversity, specialization and localized competition", *European Economic Review*, 43, 409 - 429

Ferreira, L., and P. Vanhoudt (2004) Catching the Celtic Tiger by Its Tail, *European Journal of Education*, Volume 39 Issue 2

FIAS (2001) Using Tax Incentives to Compete for Foreign Investment: Are They Worth the Costs? Occasional Paper 15, Washington: Foreign Investment Advisory Service.

FitzGerald, J. and I. Kearney (2000) Convergence in living standards in Ireland: the role of the new economy. Seminar Paper 134. Dublin: Economic and Social Research Institute.

Forfás (2000) *Enterprise 2010: New Strategy for the Promotion of Enterprise in Ireland in the 21st Century*, Dublin: Forfás.

Forfás (2007) *Annual Business Survey of Economic Impact*. Dublin: Forfás.

Giarratana, M., A. Pagano and S. Torrisi (2005) The Role of the Multinational Companies, in A. Arora and A. Gambardella, eds. (2005) *From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland and Israel*. Oxford: Oxford University Press.

Glaeser, E. (1999) Learning in Cities, *Journal of Urban Economics*, 46, 254-277, 27

Glaeser, E.L., Kallal, H.D., Scheinkman, J.A., and A. Shleifer (1992) "Growth in Cities", *Journal of Political Economy* 100, 1126-1152.

Haller, S. and I. Siedschlag (2007) "The Adoption of ICT: Firm-level Evidence from Irish Manufacturing Industries", ESRI Working Paper No. 204

Hallowell, E.M., (1999) "The Human Moment at Work", *Harvard Business Review,* 77(1), 58-64.

Hallowell, E.M., (2005) "Overloaded Circuits: Why Smart People Underperform", *Harvard Business Review,* 83(1), 54-62.

Henderson, J.V. (1986) Efficiency of Resource Usage and City Size, *Journal of Urban Economics*, 19, 47-70.

Herbsleb, J., and R. Grinter (1999) "Architectures, Coordination and Distance: Conway's Law and Beyond", *IEEE Software*, September/October, 63-70.

Honohan, P., and Walsh, B. (2002). "Catching up with the leaders: the Irish hare", Brookings Papers on Economic Activity, (1), pp. 1-57.

ICT Ireland (2003) *Creating a World Class Environment for ICT Entrepreneurs*; Dublin: Irish Business and Employers Confederation.

Industrial Policy Review Group (1992) *A Time for Change: Industrial Policy for the 1990s*, Dublin : Stationery Office.

Irish Times (2008) Special Supplement, December 4.

Jacobs, J. (1969) *The Economy of Cities*. New York, NY: Random House.

Jaffe, A. B., M. Trajtenberg and R. Henderson (1993) Geographic Localization of Knowledge Spillovers as Evidenced by Patent Citations, *Quarterly Journal of Economics*, 108, 577-598

Jensen, C., S. Farnham, S. Drucker, and P. Kollock (2000) "The Effect of Communication Modality on Cooperation in Online Environments", *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*, The Hague, The Netherlands, 470 – 477.

Kenney M., ed. (2000) *Understanding Silicon Valley: The Anatomy of an Entrepreneurial Region.* Stanford University Press.

Koedijk, K., and J. Kremers (1996) "Market Opening, Regulation and Growth in Europe", *Economic Policy*, 445-467.

Kraut, R., S. Fish, R. Root and B. Chalfonte (1990) "Informal Communications in Organizations: Form, Function and Technology", in I. Oskamp and S. Spacapan (eds.)

People's Reactions to Technology, Sage Publications, Beverly Hills, CA, 1990, pp 145-199.

Krugman, P. (1991) *Geography and Trade*, MIT Press: Cambridge, Mass.

Lipnack, J., and J. Stamps (2000) *Virtual Teams: People Working Across Boundaries with Technology*, New York: Wiley.

MacSharry, R. and White, P. (2000). *The Making of the Celtic Tiger: the Inside Story of Ireland's Booming Economy*, Mercier Press, Dublin, Ireland.

Mickiewicz, T., S. Radosevic and U. Varblane (2000) "*The Value of Diversity: Foreign Direct Investment and Employment in Central Europe during Economic Recovery",* University of Sussex, ESRC 'One Europe or Several?' Programme, Working Paper 05.

Milana, C., And A. Zeli (2002) "The Contribution Of ICT to Production Efficiency In Italy: Firm-Level Evidence using Data Envelopment Analysis and Econometric Estimations", STI Working Paper 2002/13, OECD Directorate for Science, Technology and Industry.

Mowery, D. (1999) The Computer Software Industry, in D. Mowery and R. Nelson (eds) *Sources of Industrial Leadership: Studies of Seven Industries*, Cambridge: Cambridge University Press.

Markusen, A. (1999) "Sticky Places in Slippery Space: A Typology of Industrial Districts," Economic Geography, 72(3), 293-313

Oakey, R. (1995) High-Technology New Firms: Variable Barriers to Growth, London: Chapman Publishing.

O'Connor, H. (2005) The Industrial Development Agency and "Targeting" Policy, MA thesis, School of Economics, University College Dublin.

OECD (1999). *Economic survey of Ireland*, OECD, Paris, France.

OECD (2002) *Information Technology Outlook*, Paris: OECD

OECD (2005) *Science, technology and industry scoreboard*, OECD, Paris, France.

OECD (2006) *European Innovation Progress Report* , OECD, Paris

Ó Gráda, C. (1997) *A Rocky Road: the Irish Economy since the 1920s*, Manchester and New York: Manchester University Press.

Ó Gráda, C. (2002). "Is the Celtic Tiger a Paper Tiger?", *ESRI Quarterly Economic Commentary*, Spring, 51-62.

O'Malley, E., and C. O'Gorman (2001) Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment", *European Planning Studies*, 9 (3), 303-321.

Ó Riain, S. (2004) *The Politics of High-Tech Growth: Developmental Network States in the Global Economy*, Cambridge: Cambridge University Press.

Porter, M. (1990) *The Competitive Advantage of Nations*, London: Macmillan.

Porter, M. (2003) "The Economic Performance of Regions", *Regional Studies,* 37, 6&7, 549–578.

Roche, F., R. O'Shea, T. Allen and D. Breznitz (2008), "The Dynamics of an Emerging Entrepreneurial Region in Ireland", in P. Phan, S. Venkataraman and R. Velamuri (eds.) *Entrepreneurship in Emerging Regions around the World: Theory, Evidence and Implications*, Cheltenham (UK) and Northampton (USA): Edward Elgar, 2008. Pps. 185-205.

Rodrik, D. (2004) "Industrial Policy in the Twenty-First Century", background paper prepared for UNIDO; available at: www.ksg.harvard.edu/rodrik/

Rugman, A., and A. Verbeke (1993) "Foreign Subsidiaries and Multinational Strategic Management: An Extension and Correction of Porter's Single Diamond Framework", *Management International Review*, 33, (2), 71-84.

Rugman, A., and A. Verbeke (2003) "Multinational Enterprises and Clusters: An Organizing Framework", *Management International Review*, Special Issue, 3, 151-169.

Sands, A. (2005) "The Irish Software Industry", in A. Arora and A. Gambardella, eds. (2005) *From Underdogs to Tigers: The Rise and Growth of the Software Industry in Brazil, China, India, Ireland and Israel*. Oxford: Oxford University Press.

Silicon Republic (2008), available at: http://www.siliconrepublic.com/news/article/11585/business/irish-software-industry-worth-2bn-in-exports

Sterne, J. (2004) *Adventures in Code: the Story of the Irish Software Industry*, Dublin: Liffey Press.

Stiglitz, J., and A. Weiss (1981) "Credit Rationing in Markets with Imperfect Information", *American Economic Review* 71, 393-410.

Storper, M. (1995) "The Resurgence of Regional Economies, Ten Years Later: The Region as a Nexus of Untraded Dependencies", *European Urban and Regional Studies* 2(3): 191-221.

Storper, M., and A. Venables (2004) "Buzz; Face-To-Face Contact and the Urban Economy", *Journal of Economic Geography*, 4(4) (2004), 351-370.

Sturgeon, T.J. (2003) "What Really Goes on in Silicon Valley? Spatial Clustering and Dispersal in Modular Production Networks", *Journal of Economic Geography*, 3, 199-225.

UNCTAD (2004) *World Investment Report: the Shift towards Services*. New York and Geneva: UN.

Van Ark, B., R. Inklaar and R. McGuckin (2002) "Changing Gear" Productivity, ICT and Services: Europe and the United States", Research Memorandum GD-60, Groningen Growth and Development Centre.

Walsh, M. (1985), Venture Capital in Ireland, *Irish Journal of Irish Business and Administrative Research*, 7, 1, 33-45.

Wilson, J., M. Boyer O'Leary, A. Metiu, and Q. Jett (2005), "Subjective Distance in Teams", INSEAD Working Paper Series 2005/38/OB.

Appendix

A NOTE ON THE DATA USED IN THE REPORT

In common with all other analyses of the indigenous software sector, this paper has made extensive use of the frequent surveys carried out by the National Software Directorate, a sub-group within the stage agency Enterprise Ireland, and latterly by state agency Forfás, and by IT consultancy firm HotOrigin. The aggregate data for the sector are provided by the National Software Directorate, Enterprise Ireland and Forfás, the national policy advisory body for enterprise and science

The paper has also drawn extensively on a book detailing the history of the software sector by technology journalist John Sterne, the desk-based investigations of individual companies' web-sites carried out by geographer Mike Crone, and firm-level surveys conducted and reported upon by sociologist Séan Ó Riain (2004), public-policy academic Anita Sands (2005) and business analysts Roche, O'Shea, Allen and Breznitz (2008) and O'Malley and O'Gorman (2001).

O'Malley and O'Gorman's research is based on exploratory interviews with "key informants" in relevant state agencies and the industry's trade association, followed up by semi-structured interviews with senior managers or owners of 36 indigenous companies accounting for one-third of indigenous employment

The analysis of Sands is based on a survey of 55 firms in the sector, where the bias is towards smaller firms, 75% of which employed fewer than 25 people.

Ó Riain reports on numerous surveys of various sizes, conducted over the course of his doctoral research. Depending on the topic explored, these ranged from interviews with 50 managers and executives to a survey of some 250 firms.

The most recent survey was conducted by Roche, O'Shea, Allen and Breznitz (2008) who interviewed thirty entrepreneurs as well as three venture capitalists, one angel investor and one policymaker.

Further data drawn upon for the present research came from the free-access newswire (www.electricnews.net), which focuses on the Irish IT and telecoms sector, and from interviews and discussions with policymakers who have had experience of the sector throughout the period under discussion.

European Commission
EUR 26063– Joint Research Centre – Institute for Prospective Technological Studies

Title: The Knowledge Economy, Economic Transformations and ICT in the EU25+: Regional Dynamics in the Deployment Phase. Case Study: Southern and Eastern Ireland

Author: Professor Frank Barry

Luxembourg: Publications Office of the European Union

2013- 58 pp. – 21.0 x 29.7 cm

EUR – Scientific and Technical Research series – ISSN 1831-9424 (online)

ISBN 978-92-79-32385-0 (pdf)

doi:10.2788/66281

Abstract
Ireland has been one of the global economic success stories of the last 20 years. National income rose from less than 65% of the EU15 average in the mid 1980s to well above parity today. Ireland is also the most FDI-intensive economy in Europe.
Section A of the present report provides an analysis of the rapid economic development of the "Celtic Tiger" era and how Ireland's status as a successful export platform for foreign Multinational Corporations was achieved. Though the production structure of the economy is heavily weighted towards (largely foreign-owned) high-technology and ICT-using industries, the country lags behind in terms of personal ICT use. The remainder of Section A presents regional and national data on ICT production and diffusion across the economy. The main focus of the report in on the more advanced Southern and Eastern region of the two NUTS II regions into which the country is divided. The indigenous software sector, the emergence and growth of which is the subject of Section B, is very heavily clustered in this region. Section B charts the role played by the foreign-owned high-tech ICT-using sectors in seeding this ICT-producing cluster and provides details of the types of state interventions that emerged through a process of trial and error to support the cluster. The conclusions presented in Section C reflect on the implications of the case study for the roles that FDI and different types of knowledge spillovers can play in the emergence of a knowledge-intensive cluster and on the types of policies that can play a role in assisting its evolution.

LB-NA-26-063-EN-N

As the Commission's in-house science service, the Joint Research Centre's mission is to provide EU policies with independent, evidence-based scientific and technical support throughout the whole policy cycle.

Working in close cooperation with policy Directorates-General, the JRC addresses key societal challenges while stimulating innovation through developing new standards, methods and tools, and sharing and transferring its know-how to the Member States and international community.

Key policy areas include: environment and climate change; energy and transport; agriculture and food security; health and consumer protection; information society and digital agenda; safety and security including nuclear; all supported through a cross-cutting and multi-disciplinary approach.

ISBN 978-92-79-32385-0

Publications Office