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The Eastward Shift of Computer Hardware Production: How Ireland Adjusted

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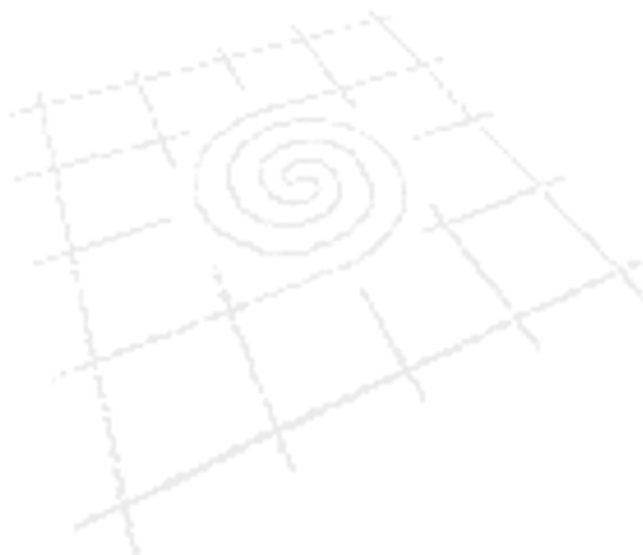
The Eastward Shift of Computer Hardware Production:
How Ireland Adjusted

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Abstract

Computer and component assembly operations tend to service each of the triad markets (the Americas, Asia and EMEA – Europe, the Middle East and Africa) from locations within each triad. Over the course of the 1990s, assembly shifted to lower-cost locations within each triad region. Within the Americas, operations shifted from the US and Canada to Mexico. In Asia they shifted from Japan to Singapore and in Europe from the richer core countries to the Western EU periphery of Ireland and Scotland. Two thirds of all computers sold in Europe in the 1990s were assembled in either Ireland or Scotland. More recently the sector has been shifting again. In Asia the shift has been from Singapore to lower-cost economies such as Thailand, Malaysia and the Philippines. In Europe the shift has been from Scotland and Ireland to Central and Eastern Europe. Electronics component production, meanwhile, has also been shifting eastwards – primarily to Asia. The purpose of the present paper is to chart how Ireland adjusted as computer hardware jobs shifted abroad.

Introduction

Computer and component assembly operations tend to service each of the triad markets (the Americas, Asia and EMEA – Europe, the Middle East and Africa) from locations within each triad. Over the course of the 1990s, assembly shifted to lower-cost locations within each triad market. Within the Americas, operations shifted from the US and Canada to Mexico. In Asia they shifted from Japan to Singapore and in Europe from the richer core countries to the Western EU periphery of Ireland and Scotland. Two thirds of all computers sold in Europe in the 1990s were assembled in either Ireland or Scotland. More recently the sector has been shifting again within the latter two triad markets. In Asia the shift has been from Singapore to lower-cost economies such as Thailand, Malaysia and the Philippines. In Europe the shift has been from Scotland and Ireland to Central and Eastern Europe. The purpose of the present paper is to chart how Ireland adjusted to this sectoral outmigration.

We find that adjustment took several forms: (i) As hardware assembly firms pulled out, they were frequently replaced by firms operating in related though higher-wage or higher-tech segments, as Barry and Curran (2004) have shown. (ii) The assembly firms that remained tended to shift their Irish operations from assembly into higher value-added non-manufacturing functions such as sales and technical support call centres and logistics, as shown by van Egeraat and Jacobson (2004). (iii) Some workers of course lost their jobs as assembly plants closed or firms migrated. We assess the available evidence on the subsequent employment experiences of these workers, both at the micro and at the macro level. The fact that both short-term and long-term unemployment rates remained low even as the hardware sector shed jobs indicates that most displaced workers were able to move to other jobs without too much difficulty because of the continuing economic boom in Ireland.

The paper is structured as follows. Section 2 begins with a overview of trends in the global and European geographies of the computer hardware sector. Section 3 looks at aggregate employment trends in ICT-related sectors in Ireland. Section 4 traces the history of computer hardware production in Ireland, while Section 5 looks at the outcome of labour shedding within a number of important hardware firms. Section 6 analyses the overall performance of the Irish labour market over the period under discussion. This is followed by some concluding comments on the evolution of Ireland's industrial development strategy.

2.   The Changing Economic Geography of the Computer Hardware Sector

Table 1 charts the shares of various countries in world computer hardware exports. In the case of each of the triad regions we see over the course of the 1990s a decline in the importance of the more advanced countries and an increase in the share of world exports accounted for by the periphery. Thus, in Europe, Ireland's share expanded while that of France, Germany and the UK declined. In Asia, the large decline in Japan's share is readily apparent, while in the America's the shares of the US and Canada declined while that of Mexico and Costa Rica rose.

Table 1: Country Shares in World Computer Hardware Exports

Shares of world exports		SITC 752 Computers		SITC 75997 Elec components	
		1992	2000	1992	2000
Europe	France	0.05	0.04	0.04	0.02
	Germany	0.07	0.05	0.05	0.04
	Ireland	0.02	0.05	0.05	0.06
	Italy	0.03	0.01	0.03	0.01
	Netherlands	0.04	0.08	0.05	0.05
	United Kingdom	0.09	0.08	0.07	0.04
	Hungary	0.00	0.01	0.00	0.01
Asia	Japan	0.21	0.08	0.16	0.09
	Taiwan	0.07	0.09	0.04	0.09
	Hong Kong	0.02	0.02	0.06	0.07
	Korea Rep.	0.03	0.05	0.02	0.07
	China	0.00	0.06	0.01	0.04
	Singapore	0.13	0.11	0.06	0.08
	Thailand	0.01	0.01	0.03	0.05
	Malaysia	0.00	0.04	0.04	0.00
	Philippines	0.00	0.03	0.00	0.02
Americas	USA	0.23	0.17	0.23	0.18
	Canada	0.02	0.01	0.04	0.02
	Mexico	0.01	0.04	0.01	0.02
	Costa Rica	0.00	0.00	0.00	0.01

Source: UN Trade Statistics.

Notwithstanding the decline in the UK's share, computer hardware production prospered in Scotland over this period. The Western EU periphery countries of Ireland and Scotland have been major players in the sector, with around two-thirds of computers sold in Europe in the 1990s assembled in one or other of these countries.

Table 2 charts the relative importance of computer hardware employment in EU15 countries, illustrating, for example, that computer-equipment employment as a share of manufacturing is 10 times larger in Ireland and 8 times larger in Scotland than in the overall EU15.

Table 2: The relative importance of computer sector employment in EU15 countries

	Computer Equipment	Electronic components
	Nace 3002	Nace 321
Belgium	0.21	0.79
Denmark	0.55	0.65
Germany	0.82	0.90
Spain	0.48	0.44
France	1.48	1.80
Ireland	**10.42**	**3.77**
Italy	0.48	0.69
Austria	0.15	1.75
Portugal	0.06	0.71
Finland	0.31	1.07
Sweden	0.46	0.79
United Kingdom	1.79	1.10
Of which: ……**Scotland**	**7.90**	**3.05**
Netherlands	1.54	0.54

Source: Eurostat New Cronos.

Both countries also record far higher than average shares of manufacturing employment in electronic components, though on a lower scale than in the case of computer equipment. The reason for this is that while computers tend to be assembled in each of the triad markets for home triad consumption, electronics components production is more globalised.[1]

Since the computer hardware sector does not tend to be highly concentrated globally, Irish and Scottish success has more to do with factors such as infrastructure and government incentives rather than Marshallian agglomerations. Both countries share a number of relevant characteristics:

- English speaking environments;
- relatively low labour cost locations within the EU15;
- abundant supplies of skilled labour.
- Ireland: lowest effective rate of corporation tax in Europe
- Scotland: benefited from UK regional grants and other financial and fiscal incentives.
- Both countries were already established locations for computer assembly even before the era of the personal computer.

More recently Hungary has also been growing in importance within the sector. While there was a loss of 34,000 European jobs in the production of Computers and Peripherals between 1995 and 2000, Ireland, Scotland and Hungary all gained against the trend. By the end of the period Ireland and Scotland had around 20,000 each in

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[1] Thus most Irish computer exports go to the EU while the bulk of components exports goes to the US.

Computers and Peripherals while Hungary had around half the 20,000 CEE jobs in the segment.

The data up to the year 2000 reveal little hard evidence that Hungary and the rest of the CEEC have been displacing Ireland within the sector. Barry (2004a), for example, compares the product structure of Ireland's trade with 4 different regions: Western Europe, the US, Asia and the CEEC. While Ireland's trade with the CEEC in 1992 had borne least similarity to Ireland's trade with Asia, by 2000 Irish-CEE trade had become most similar in structure to Ireland's trade with Asia. This suggests that the CEEC are entering the European value chain (or the chains in which Ireland participates) at levels closer to Asian than to US or Western European levels.

This is supported by looking in detail at Irish trade with the CEEC in Office and Data Processing Equipment (SITC Division 75). Ireland runs a trade surplus with all the CEEC other than Hungary in this category. The vast bulk of Irish imports from Hungary, however, are in (five-digit SITC) sub-sectors in which Ireland has always run trade deficits with the rest of the world. Barry (2004) shows that these particular sub-sectors were migrating from elsewhere in Western Europe and the US to Asia, suggesting again that Hungary has been displacing potential Asian rather than Irish ICT jobs.

There are indications however that computer assembly is now in the process of migrating from Ireland and Scotland to the CEEC. Equivalent shifts have been taking place in each of the triad markets. In the North American case the shift has been to Mexico. Within Asia, computer assembly has been shifting from Singapore to lower cost locations such as Thailand, Malaysia and China. Extrapolation of these trends would clearly suggest that the sector is likely to migrate from Ireland and Scotland to the CEEC.

Recent employment shifts in computer hardware – comprising, in EU data, NACE 30 (manufacturing of office machinery and computers) and NACE 3210 (manufacturing of electronic valves, tubes and other electronic components) – are reported in Figures 1 and 2. Taking 1999 as our base year, we see that in the case of both hardware segments Ireland suffered worse than either the US or the EU15. CEEC employment in NACE 30 continued to rise even with the collapse of the high-tech bubble, while employment levels in electronic components were also relatively insulated.

Figure 1: Employment Trends in Office and Data Processing Equipment

NACE 30 Employment
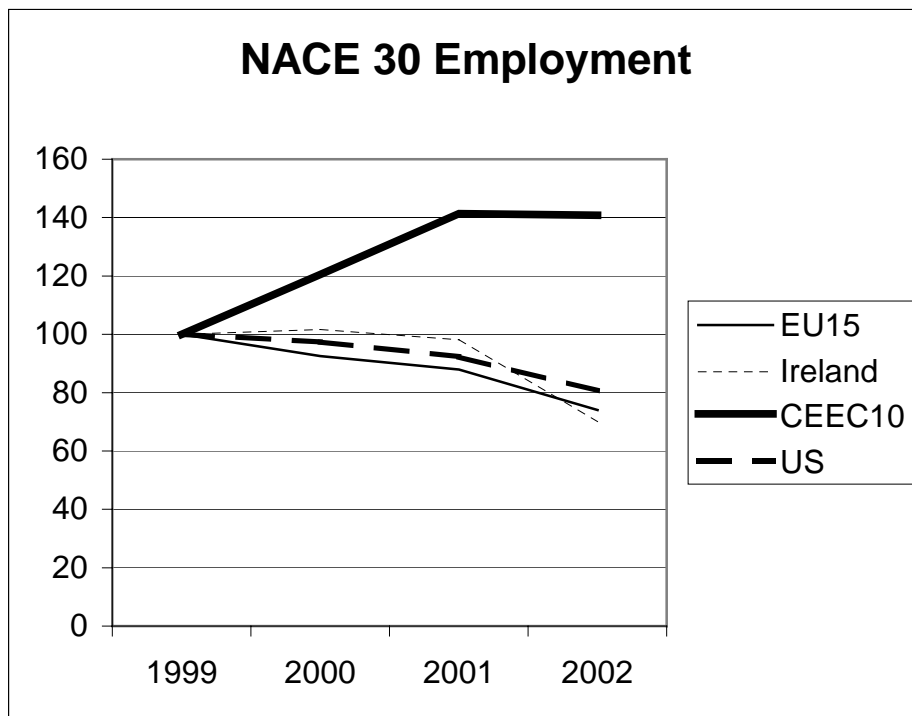
Source: Eurostat New Cronos and US BLS.

Figure 2: Employment Trends in Electronic Components

NACE 3210 Employment
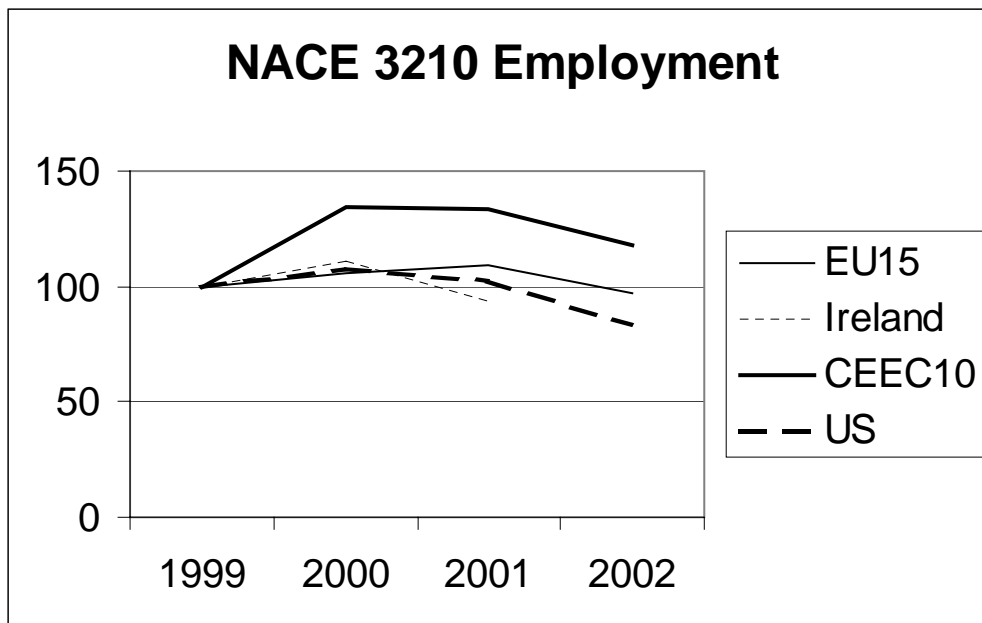
Source: Eurostat New Cronos and US BLS.

As recently as June 2005, furthermore, the international press reported that the Dell corporation was on the verge of choosing Poznan in Poland as a location for its first European manufacturing plant outside Ireland. The new EU base would be likely to be initially positioned to manufacture lower end Dell products, but Dell Ireland would

in the future compete against its Polish sibling for investment and product manufacturing contracts within the group

3.   Recent Aggregate-Level Developments in Irish ICT Production

Longer employment series for NACE 30 and NACE 3210 in Ireland are plotted in Figure 3.

Figure 3
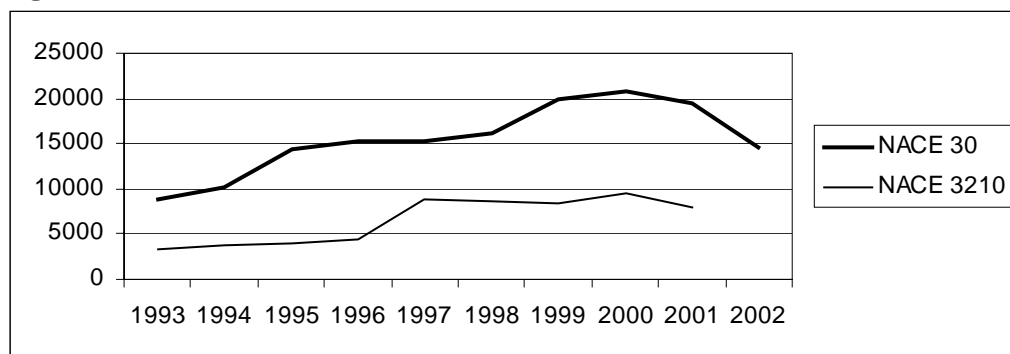
Source: Irish Central Statistics Office

It is clear that the Irish decline cannot be ascribed solely to the high-tech downturn. Note though that NACE 3210 (electronic components) has been growing relative to NACE 30 (computers) in Ireland over the course of the 1990s. The NACE 3210 sub-sector records higher wage levels in Ireland than NACE 30, suggesting that this shift represents a movement up the value chain within computer hardware.

Since about one-third of current employment in Ireland in the former sector is in Intel, it is of interest to note the continuing commitment of the company to the development of its Irish operations. Intel recently opened a new IT innovation centre in Ireland and resumed work on its €2.5 billion FAB 24 fabrication facility. In May 2004, it announced a further €1.6 billion investment to build a Fab 24.2 plant, which will reduce the size of microprocessors by a further 40 per cent. Ireland had been in competition with the company's Israeli and US plants for this investment. Highly skilled semiconductor design engineers will fill most of the new positions. Following construction in 2006, Intel will have invested €6 billion in Ireland since it first set up operations there in 1989.

 We discuss later in the paper the evolution of Irish industrial policy as it applies to the ICT sector. A major factor in attracting high levels of FDI to Ireland has been the country's generous corporation tax regime, which for many years offered a special
10 percent rate for manufacturing industry; Barry (2004b).   The European Commission had been pushing for some time for tax harmonisation across sectors, implicitly hoping that Ireland's rate would be pushed much closer to the EU average. The government instead decided in 1998 on a harmonised rate of 12.5 percent –
to be instituted from 2003 – which yielded substantial benefits to most services sectors, which had been taxed at a rate of 28 percent, in order to cushion the impact on manufacturing. This made the country more attractive to services-sector FDI.

Ireland's strong showing in the field is illustrated by the number of new services-sector FDI projects it has captured in recent years, as shown in Table 3.[2] The table also illustrates the experiences of a number of other EU countries that also performed strongly in these areas.

**Table 3**: Number of FDI Projects by Destination Countries, 2002-2003

	Call centres	Shared services	IT services	Regional HQ
EU	169	38	198	185
Irl	29	19	14	15
UK	43	7	73	64
Germany	20	1	34	22
Netherlands	13	3	16	20

Source: UNCTAD (2004, p 162).

Unsurprisingly, developments in internationally-traded services segments have been more positive than in hardware in the years following the dot-com collapse. Figure 4 shows that employment in Software and Other Computer Services remained constant between 2000 and 2002 while employment in other business process offshored or outsourced (BPO) services, excluding those associated with the International Financial Services Centre in Dublin, grew by 3,500 from an initial level of around 23,400 in the year 2000.

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[2] The Finance Act 2004 established a new headquarters regime aimed at attracting international corporations to establish their regional HQ in Dublin. This would often serve to attract other activities including shared services and treasury management; Finance Dublin Yearbook (2004).

Figure 4
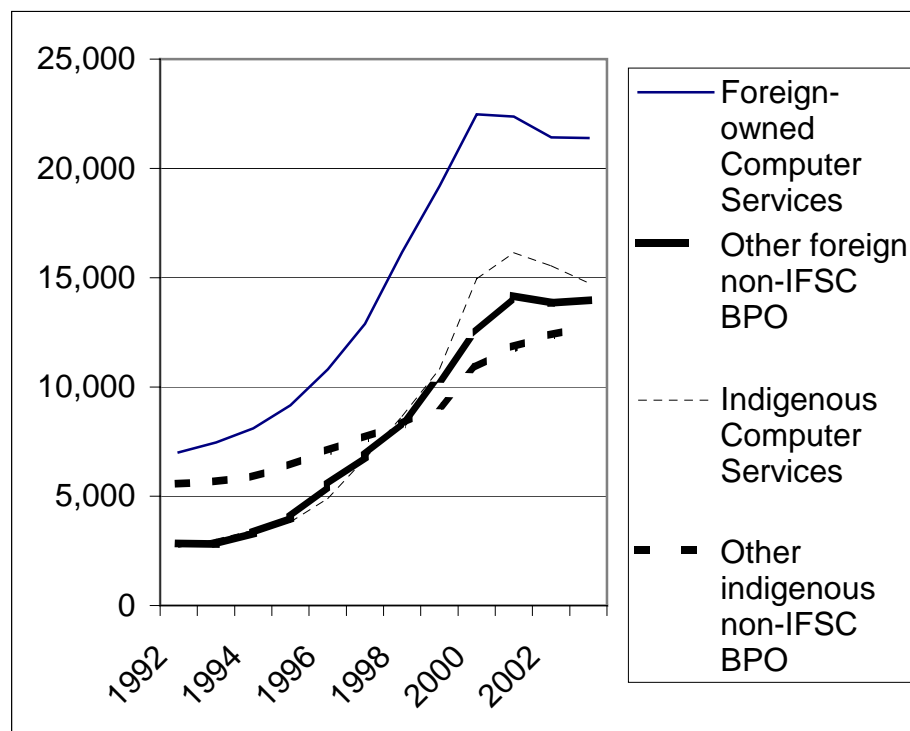
Source: Forfás

Many of the somewhat adverse developments in ICT sub-sectors in the early years of the new millennium are associated with the global downturn in ICT rather than with any shift of the sector out of Ireland. The main segment that does appear to be shifting is computer assembly and peripherals. We track developments in these sub-sectors in the next section of the paper.

4. The Rise and Decline of Computer Hardware Production in Ireland: Firm-Level Analysis

Computer Assembly

In 1971 Digital Equipment Corporation, one of the pioneers in the minicomputer industry, set up a large-scale minicomputer manufacturing plant in Ireland. In the latter half of the 1970s five other minicomputer companies – Prime, Nixdorf, Computer Automation, Concurrent and Wang – set up assembly facilities in Ireland, while Amdahl started assembling mainframes. With the shrinking market for minicomputers however, due to the increasing popularity of the PC, most of these firms closed their Irish plants in the 1980s. Prime and Computer Automation exited in the first half of the decade with Nixdorf and Concurrent following in 1989.

The first PC assembler to arrive in Ireland was Apple in 1980. In 1983 Zenith followed with another PC assembly facility. Wang added microcomputer manufacturing lines to its existing facility in the mid-1980s. Wang and Zenith were ultimately out-competed however and finally closed their Irish facilities in the early 1990s. Digital, which had started assembling workstations and PCs in Ireland, decided to consolidate its assembly operations in Scotland and closed its Irish

assembly plants in 1993. However, these losses were more than offset by the investment of three new PC assemblers, Dell, Gateway and AST, while an indigenous subcontractor, Horman Electronics, diversified its activities with full system assembly for Apple. A major breakthrough came in 1989 with the decision of Intel to invest in a sophisticated microprocessor wafer manufacturing plant as well as a PC and motherboard assembly plant. A large number of computer related companies followed in the early 1990s.

According to IDA calculations, 33 per cent of PCs sold in Europe in 1999 were manufactured in Ireland. The manufacturing activities of most companies were restricted to the final assembly and test of PCs and low-end servers however. Intel ESSM and Apple also assembled motherboards, partly for internal use. Most operations included other functions, such as sales and technical support call centres, European logistics centres or, in some cases, regional headquarters.

Between 1998 and 2002, the Irish microcomputer assembly sector experienced serious job-losses and plant closures due to both a competition induced shake-out of branded microcomputer makers and a shift of production activity to lower-wage economies. Intel ceased system assembly in Ireland and consolidated assembly activities in Malaysia, Puerto Rico and, to some extent, in the USA. Apple shed 450 jobs when the production of I-Mac systems was out-sourced and shifted: first to LG Electronics in Wales, subsequently to LG in the Far East, and finally to Foxconn in the Czech Republic. Horman Electronics lost its system assembly contract with Apple. AST and Gateway were both out-competed and closed their European operations. Thus, of the five microcomputer companies in 1998, by 2002 only Dell and Apple were still assembling microcomputers, and Apple's system assembly operation was seriously downsized.

Components

The computer component and peripheral sector in Ireland was slow to develop. In the second half of the 1970s less than a dozen foreign companies produced a range of products such as memory, printers, components for disc drives, cables/interconnect material and floppy drives. Digital had opened a plant to produce network components for in-house use. Most cases involved relatively unsophisticated operations. In addition, a handful of existing or newly established indigenous companies started to capture a small part of the market for enclosures and printed matter.

The economic crisis of the early 1980s saw some component manufacturers such as Mostek and Centronics close their Irish plants while the period saw very few new investments. One of the main developments was Western Digital's decision to open an automated controller circuit board manufacturing facility. The Keyboard Company set up a facility to supply Apple, but this plant was taken over by Apple and closed soon afterwards in 1985.

During the second half of the 1980s, a handful of foreign companies started assembling keyboards, mice and cables for the expanding local and European markets. BG Turnkey, a new indigenous company started carrying out simple sub-

assembly activities for Apple in Cork. Apart from these low-tech projects, Apple started automated motherboard assembly for in-house use. The percentage of total components sourced from suppliers in Ireland remained around six per cent.

More substantial progress was made in the early 1990s. Existing and newly established indigenous companies captured an increasing share of the market for enclosures, cables, printed matter, packaging and supply-chain management services. Furthermore, the IDA was attracting an increasing number of foreign companies investing in medium-tech manufacturing facilities for the production of motherboards, network cards and hard disc drives. One of the most significant developments was Intel's decision to invest in a high-tech microprocessor wafer fabrication plant. The accumulated base of component suppliers and system assemblers fed the perception of the creation of an integrated PC cluster (Carey, 1996; Casey, 1995; Trench, 1995). By 1995 computer assemblers were thought to source 27 per cent of their material inputs in Ireland, up from only 6 or 7 percent a decade earlier.

Ireland the began to experience increasing competition from low-wage economies, particularly in the Far East, however. In 1996 the IDA started to actively discourage large companies from locating certain manufacturing operations in Ireland where the main attraction was a lower cost base. In its 1996 policy review the IDA decided to drop the sub-sector 'peripherals and media' as a key target sector. New sub-sectors to be targeted included software development, contract manufacturing and computer networking/data-communication.

Ireland continued to attract a number of high-tech, high output, manufacturing and service projects, notably successive Intel wafer fabrication plants. Furthermore, a substantial number of foreign contract electronics manufacturers (CEMs) continued to invest in enclosure manufacturing and subassembly plants. In most cases this involved the take-over of existing indigenous companies and plants. However, between 1995 and 1998, a large number of low- and medium-tech component manufacturers closed their Irish plants and shifted production abroad, notably to the Far East.

At one stage roughly 90 per cent of the mice sold in Europe were manufactured in Ireland but that stopped when Logitech closed its Irish plant and shifted production to the Far East. In a period of two years, keyboard manufacturers Keytronics, Alps and Mitsumi shifted the actual manufacturing of keyboards from Ireland to the Far East and continued in Ireland as distribution operations, retaining only a limited localisation capability. Plastic component manufacturer Acco closed due to competition from Asia. Seagate closed its hard disk drive assembly facility and consolidated production in the Far East. Disk drive component supplier Applied Magnetics closed. Both Intel and Apple shifted their labour intensive motherboard assembly activities from Ireland to the Far East. Intel also ceased its cartridge assembly activities that it had carried out in Ireland since 1998. It consolidated cartridge assembly in its plants in the Philippines and Puerto Rico and the Irish plant was refitted for wafer production.

The shift of component plants to the Far East continued at the start of the new millennium. MKIR Panasonic closed Europe's last remaining hard disk drive manufacturing plant near Dublin under severe price competition from manufacturers in Asia. Volex transferred the main part of its cable assembly activities to Eastern

Europe and Asia. However, the problems related to competition from low wage economies were now compounded by a drop in business from local customers such as Gateway, Apple and Dell – in turn the result of the downturn in the global computer industry and the shift of system assembly activity to lower cost regions. As a result, in the period 1999-2003, six enclosure manufacturing and subassembly plants closed their doors while other plants suffered job losses.

Local Linkages between Assembly and Components

According to Forfás figures, local sourcing of components increased rapidly from the mid-1980s, when computer assemblers were found to source only 6 to 7 percent of their material inputs in Ireland, to the mid-1990s when they were found to source 27 per cent. There was a much smaller increase thereafter, to a figure of 28 percent in 1999.[3]

These figures, however, include expenditure on items bought from local supply-chain-managers but manufactured in other regions as well as expenditure on complete systems manufactured by contract manufacturers with local operations. These are not vertical production linkages however.[4]

More careful analysis by van Egeraat and Jacobson (2005) which excludes these suggests that, on average, only ten per cent of the parts and components sourced by assemblers in Ireland were manufactured in the country. Equivalent data for Scotland suggests that seven per cent of the material inputs was manufactured there, with items manufactured in the rest of Britain and Ireland making up another nine per cent.

The vast majority of components and parts were imported from elsewhere, notably from the Far East and, to a lesser extent, the USA. The only items characterized by significant sourcing in Ireland and/or Scotland were: enclosures, motherboards-backpanels (mainly from Scotland), network cards (from Ireland only), non-English language keyboards, digital/printed media, cables/interconnect and packaging materials, and accessory kits.[5] Furthermore, England and Wales figured to a small extent in the area of monitors while England played a role in the supply of motherboards as well. However, most of these components were imported from other regions as well. Thus, the majority of motherboards/backpanels, network cards, cables, keyboards and monitors, were manufactured in other regions, notably in the Far East. Only enclosures, packaging, media, kits and non-English language keyboards were sourced primarily from suppliers in Ireland or Scotland.

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[3] Similar numbers were found for Scotland by Turok (1997).
[4] Few Irish companies other than Apple/Horman Electronics were involved in the activity. The problem with considering this as a local supply relationship is that these days many of the big outsourcing contracts are organised on a global level, e.g. Apple outsourcing the manufacture of systems to LG. The fact that LG would produce Apple systems in Ireland would have little to do with the fact that Apple has a plant in Ireland. Hence this should not be treated as a local development linkage. It is different in the traditional subcontracting model where a particular OEM plant employs local subcontractors.
[5] Items such as media, mice, cables and connectors were typically packaged in a 'country' or 'accessory' kit. Some focal companies had subcontracted the packaging of these kits to local supply-chain-managers that were also responsible for the sourcing of the items.

Furthermore, the actual production activities in many plants were very limited or added limited value to the product. Apart from limited digital printing activity, 11 kitting plants merely packaged media and other language specific parts into a box. Similarly, five keyboard localization plants merely laser printed (non-English language) keyboards manufactured overseas, while the production activities of the turnkey suppliers involved in rework activities were of a very limited nature.

The decision to source locally depended on issues such as bulkiness and component variety. The effect of bulkiness of individual components is most clearly illustrated by packaging material. Packaging material, although of low unit value, required much warehouse space, thereby incurring extremely high inventory holding costs. Therefore, packaging tended to be sourced locally on a true JIT basis involving buffer levels of less than one to two days and one or more shipments a day. In this case the characteristic of bulkiness weighed stronger than the characteristic of low unit value, resulting in true JIT supply. Similar issues arise with respect to enclosures. Sourcing bulky enclosures in the Far East incurred high inventory holding costs due to the space costs of local warehousing and high in-transit inventories associated with ocean freight. This strong force for proximity was not offset by the labor cost savings associated with production in the Far East. [6]

The variety of options per component category was a relevant issue as well. The research showed that the components with a high variety of options – country kits, shrink-wrapped media, non-English language keyboard models and the customer configured hard disk drives of Quantum – were indeed produced on a true JIT or virtually true JIT basis, generally by local suppliers. Holding standard target buffer levels of these components in all their possible configurations and languages would greatly increase the inventory holding costs. The local supplier facilities were involved in the delayed or postponed final assembly or configuration activities, while they were generally committed to holding higher buffer levels of unfinished or non-configured components, often produced in other regions; Table 4.

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[6] A number of companies imported their volume enclosure models from the Far East. The reason for this lay in the relatively limited volumes required – volumes that did not warrant the costs of developing a local source and the cost of a second tool. Two of the companies that used imported enclosures were in the process of contracting a local supplier. Less current enclosure models and server racks were often imported from the USA. Again, the reason was that the volumes involved did not warrant the development of a second source locally.

Table 4: Summary of Geographical Sources of Material Inputs of Focal Companies in Ireland, 1998-1999

Material input	Main geographical sources*
Enclosures and racks (high volume models)	Mainly Ireland and to a lesser extent Far East
Enclosures and racks (less current models)	USA and, to a lesser extent, Ireland and UK
Motherboards, backpanels and riser cards	For most focal companies: Mainly Far East and, to a lesser extent Puerto Rico. For one focal company: mainly Scotland and England and to a lesser extent Far East
Microprocessors	Mainly South-East Asia, small amounts from Ireland; One company sourced proprietary technology in USA
Floppy drives; CD-ROM drives; CD-RW drives; DVD drives; low-end technology high capacity disc and tape drives; Batteries and AC-adapter (for portables); Digital cameras; Hard disk drives; Speakers and microphones; Docking stations; Keyboards; mice; joysticks; low-end power supply; portable computers (contract manufacturing)	Far East
Heatsinks; Cooling fans	Mainly Far East
Modems and network components	Mainly Far East and USA, although four suppliers were manufacturing part of this material in Ireland
Graphics, video and sound cards; Printers; Other semiconductors; Capacitors and resistors; Memory	Mainly Far East
Cables and interconnect	Mainly the Far East and, to a lesser extent, Ireland
Displays	Mainly Far East; For selected models Wales and England and, to a lesser extent, Europe and USA
Media	Printed manuals: Ireland CD replication: Ireland, Scotland, France and USA; Wrapping of digital and printed media: Ireland
Accessory kits; Packaging material; Sub-assembly and rework services; Printing of non-English language key-board models	Ireland
Screws, fasteners and other c-class items	USA and Far East and, to a lesser extent, Ireland
Complete computer systems (contract manufacturing)	Far East and to lesser extent Ireland

Source: Company interviews by van Egeraat and Jacobson (2005)

5. Inter- and Intra-Firm Adjustments within the ICT Sector in Ireland

As seen earlier, employment in computer hardware in Ireland declined in the early years of the new millennium, with NACE 30 (manufacturing of office machinery and computers) shedding 6,000 jobs (almost 30 percent of the 2000 figure) between 2000 and 2002, and NACE 32 (TV, radio transmitters and receivers and electronic components) shedding 5,000 jobs (or 33 percent of the 2000 total).

There was some restructuring into related services sectors. Again, as seen earlier, employment in Software and Other Computer Services remained largely constant over this period, while employment in other business process offshored or outsourced (BPO) services – excluding those associated with the International Financial Services Centre in Dublin – grew by 3,500 (or 15 percent).

The following sections detail the experiences of several ICT companies in transforming their Irish operations and trace, to the extent possible, how individual workers fared in the face of job displacements.

Digital Electronics Corporation (DEC)

Some indication of possible long-term effects of jobs losses may be gleaned from analysis of the demise of the Digital Electronics Corporation's operations in Galway City in the early 1990s.[7]

Digital established manufacturing operations in Ireland in 1971, producing computers for the local market and eventually moving into software, systems and support engineering.[8] By the early 1990s Digital had become not simply the major employer in the local economy, with an estimated "net worth" to local business and the community of £100 million a year, but also a provider of advanced training and development for its workforce, a large employer of third-level graduates and a source of broader research linkages and collaboration.

The closure of the manufacturing plant in 1993, which resulted in 760 redundancies, was seen as devastating for the Western region of Ireland.[9] However, the response of Digital, the local business chamber and national and regional development agencies to the closure of the manufacturing operation set the pace for European regional policy. In particular, it created new opportunities in the Galway region for the pool of skills and professionalism within Digital's workforce. The continued operation of Digital's European Software Centre, subsequently absorbed by Compaq, also played an important role in subsequent developments.

In addition to provision of generous redundancy packages, Digital itself established in-house programmes for job search, career change, new business start-ups and relocation. This approach was supplemented by an Inter-Agency Task Force established by the Department of Enterprise and Employment, comprising the Industrial Development Agency, FÁS (the national employment agency) and Enterprise Ireland as well as local government, business, trade unions, Udarás na Gaeltachta (the development body for Irish language area) and WESTBIC (business innovation centre) with the support of the National University of Ireland, Galway, and institutes of technology.

The most significant outcome of these discussions was the establishment of Galway Technology Centre, the provision of additional training support and advisory services and funding for business start-ups, including via the conversion of tax on redundancy pay into a seed capital grant.

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[7] This was not of course due to relocation to Eastern Europe but the research undertaken into this particular episode suggests possible policy responses that may have resonances elsewhere.
[8] The material on the response to the closure of DEC comes from Green et al. (2001) and Giblin, Ryan and Moroney (2003).
[9] The following year, Digital opened a PC support centre in Dublin. It later opened a multi-million pound call centre at a new site. Before the closure of the Galway plant the company employed 1700 in Ireland. By 1998 its numbers were back up to 1400, divided between its HQ in Dublin and its European Software Centre in Galway.

No single measure could be identified as responsible for the subsequent growth of Galway's software cluster, but business support, training and "incubator" facilities together with informal networks among key ex-Digital staff all played their part in an ongoing transformation of the local economy. Nor did all ex-Digital staff enter the software sector. It required some high-profile successes, however, exemplified by Toucan Technology, to create the momentum necessary to encourage other start-ups and to attract major new investors such as Siebel Systems while at the same time persuading existing ones such as Nortel and Compaq (which absorbed the software and computer engineering areas of Digital) to expand their operations.

These investors have in turn generated local supply chains, and have had to co-operate as well as compete for skills, infrastructure and market opportunities, both with each other and with the simultaneous emergence in Galway of Europe's leading medical instruments cluster, which is anchored by the presence of Medtronics AVE and Boston Scientific.

Apple

In January 1998 Apple closed its Claris subsidiary in Dublin with the loss of 125 jobs.[10] In July of that year, in the face of losses of $1 billion over recent years, the company announced it was shifting its printed circuit board facility to the Far East, leading to the shedding of 150 full-time jobs and as many as 400 temporary posts from the corporation's Irish operations. The news came as a mixed blessing for the firm's 1,800 Irish employees in that the final assembly and test processing of the new low-cost and versatile iMac, on which the company pinned its hopes of recovery, would move to Ireland (as opposed to Singapore which had also been under consideration as a location) to service the European market. The Irish operations were also focused on the production of the company's latest powerful G3 processor products for Europe, the Middle East and Africa (EMEA).

Ironically, however, the subsequent success of the iMac led the company to outsource its production to the Korean electronics company, Lucky Goldstar, which shifted production to its facilities in Singapore, Mexico and Wales. This led to the announcement of a further 500 job losses in the Irish plant in January 1999. Production of the more powerful G3 desktop computer, designed for the business market and with a much higher profit margin that the iMac, was to remain in Ireland and the company's European HQ would continue to be located there.

By 2001, of the 1,200 workforce remaining, only 400 were involved in manufacturing. European customer support services and finance functions had recently been transferred to Ireland, which also served as a logistics centre for the company, and the company's Cork location was transformed from a manufacturing base to a campus of services provided to Apple. Local management was responsible for sourcing and logistics etc., and acted as landlord for R&D groups engaged in localisation and software – the latter managed from the US.

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[10] This material is based on reports carried in the Irish Times of July 2 and Sept 18, 1998; Jan 30 and Feb 2, 3 and 5, 1999, and Jan 13, Feb 16 and July 5, 2001.

Apple was the only unionised plant in the sector and workers were organised by the trade union SIPTU. No follow-up study of displaced workers was conducted by the union. However, SIPTU reports that the market was still quite buoyant at the time of the job losses in the late 1990s and most workers had no difficulty finding new employment. A union contact recalls one incident during the writing of redundancy cheques when one person requested to be allowed "to jump the queue because otherwise he would be late for work". Quite a number of people went to EMC (storage hardware manufacturing) that was recruiting at the time and Flextronics (although this company closed down shortly afterwards and later began production in Hungary). Both companies were looking for similar skills. Apart from this, quite a few people were working part time and would have had other jobs besides their work at Apple. This would have included painters etc. Finally, quite a number of women were said to have used their redundancy payments as an opportunity to stay at home with their children.[11]

Gateway

Gateway established a manufacturing and support hub for the European, Middle Eastern and Africa region in Dublin in 1993. The operation was closed in summer 2001 when the company decided to refocus on the US market. 900 staff were employed at its European HQ in Ireland at the time, 400 of whom were in lower skill manufacturing jobs and 250 in technical support. This was the single biggest redundancy announcement since US tech firm Seagate closed its operations in Clonmel, Co Tipperary, in 1997.

The closure of Gateway's plant in Dublin would cost the Irish economy around €50 million a year in lost salaries and a further €10 million a year in payments to local supply firms and contractors who did business with the multinational. Telecom suppliers were expected to be particularly adversely affected.[12]

Under European regulations introduced in 2001 a company was required to negotiate with elected employee representatives if it planned to make more than 30 staff redundant. Although the plant, like most foreign-owned high-tech operations in Ireland, is not unionised, the Irish Congress of Trade Unions and SIPTU offered their services to the Gateway employees facing redundancy.[13]

The only compensation required of the company is statutory redundancy of half a week's pay per year of service for each employee under 41 years, and a full week for those over 41. The previous year, when 200 staff were let go, they received five weeks' pay per year of service, including statutory entitlements. Gateway workers at the time of the plant closure eventually received 6 weeks of pay per year of service,

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[11] It is understood that initially management queried why any severance pay should be offered to temporary employees, but were persuaded to do so by SIPTU. The company also acceded to requests to allow a number of permanent employees to leave on voluntary redundancy conditions.

[12] The information on Gateway is gleaned, amongst other sources, from Irish Times articles of July 21, August 1, 9 and 17, Oct 30, Nov 22 and Dec 21, 2001.

[13] SIPTU provided free administrative back-up and advice to 1,600 Seagate workers when they lost their jobs in Clonmel four years ago. Like Seagate, Gateway has avoided recognising unions.

plus bonus payments.[14]   This redundancy package was generally considered one of the most generous on offer within the industry.

Gateway also agreed to repay Irish government grants of IE£19 million (€24 million), a figure that would be reduced if the company outsourced some of the displaced workforce to other firms (such as Clientlogic, discussed below) which were also located in Ireland.

What became of the displaced Gateway workers?

Telecom suppliers were hopeful that Gateway would outsource its technical support services for its customers to an Irish company. At least 15 companies – based in the Republic, Britain and Europe – contacted Gateway to express interest in providing these services to its EMEA customers. Ultimately Gateway signed an outsourcing deal with a Dublin-based Canadian-owned firm, Clientlogic, that saved about 150 technical support jobs in the Republic. [15]   Though demand for Gateway customer support services would fall over time because of Gateway's decision to exit the EMEA region, Clientlogic expected to be able to then shift these workers to other client accounts such as British Telecom, Boots (Chemists) and Dublin-based electronics group Palm.

The Gateway staff who transferred to Clientlogic did quite well, since as well as receiving 75 per cent of Gateway's redundancy package, they would transfer to the new firm with exactly the same work conditions as before.[16] Even given this lucrative offer to 115 of Gateway's technical support team of more than 200 people, just 60 took it up, revealing the buoyancy of the sectoral jobs market.

Many of the staff from Continental Europe were reported to have taken their redundancy payment and returned home, according to the Gateway human resources manager reported. Other foreign-language call centre workers would have taken their highly transferable skills to other local call centres such as Hertz. Many of the younger Irish staff were reported to have gone travelling or to have taken a few months off. An IDA Ireland spokesman said it reflected a new psychology among the younger generation and more skilled elements of the Irish workforce. "The younger generation, who have gone through college, tend to be more flexible and optimistic than workers in traditional industries," he said.

Unlike in the case of previous large redundancies, no government task force was set up on this occasion. There were initiatives however from FAS (the national training authority), Enterprise Ireland, Local Area Partnership and Local Authority Training and Job Placement programmes. FÁS established an on-site employment office for

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[14] For junior employees with five years' service this would work out at around £10,000 but the bulk of staff could expect somewhere between £15,000 and £20,000 each. Employees were also required to sell their company shares within 90 days however.   Within the previous year they had fallen from a high of $75 to a low of $9 at the time of the closure of Irish operations. Most had been bought by employees at around $25. Company loans to employees to buy a PC were written off however.

[15] The deal between Gateway and Clientlogic mirrored that agreed by Motorola and Celestica the previous year, when the two firms signed an international alliance. Under this agreement, most of the Motorola staff transferred to the electronics manufacturing firm.

[16] Gateway also agreed to cover the tax liability on the once-off payments for employees transferring to Clientlogic.

one month at the time of the closure, with 21 companies from North Dublin attending a jobs fair in Gateway to recruit staff for their operations.[17] About one-quarter of staff who completed outplacement courses were reported to have already found jobs even before the plant's official closure.

A further 250 Gateway staff indicated that they wished to take up FÁS evening classes, in a range of skill areas. Many of these – a number of whom were veterans of previous redundancies by Amdahl, Motorola and others – secured employment within months.

These positive developments for those with technical and managerial skills should not mask the fact that production-line operatives, who tended not to have tertiary-level educational qualifications fared less well according to the specialist outplacement agency brought in by Gateway, as well as the client management director at Clientlogic.

Intel

Intel opened its European HQ in Ireland in 1989.[18] PC and motherboard assembly began shortly thereafter, as did construction of a sophisticated microprocessor wafer manufacturing plant. The assembly operations reached their employment maximum of around 1,500 jobs in 1997.   It subsequently shifted its labour-intensive motherboard assembly activities from Ireland to the Far East, as did Apple; it ceased system assembly in Ireland and consolidated assembly activities in Malaysia, Puerto Rico and, to some extent, in the USA, and it consolidated cartridge assembly in its plants in the Philippines and Puerto Rico. It then refitted its Irish plant for much higher-level wafer production.

Intel recently opened a new IT innovation centre in Ireland, resumed work on its €2.5 billion FAB 24 fabrication facility, invested further in its research centre near Limerick and partnered three Irish universities in an academic Centre for Research on Adaptive Nanostructures and Nanodevices. In May 2004, it announced a further €1.6 billion investment to build a Fab 24.2 plant, which will reduce the size of microprocessors by a further 40 per cent. Ireland had been in competition with the company's Israeli and US plants for this investment. Highly skilled semiconductor design engineers will fill most of the new positions. Following construction in 2006, Intel will have invested €6 billion in Ireland since it first set up operations there in 1989.

What became of the displaced Intel workers?

The Irish Times, in June 1999, reported that some 750 Intel employees involved in assembly functions were informed that their jobs would be eliminated shortly as the

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[17] Gateway revealed that upon the announcement of closure it had received inquiries from six different Irish-based companies, one of which was electronics manufacturer Flextronics, which were interested in hiring some Gateway staff.

[18] An interview with a former director of Intel ESSM reveals that duties and "Fortress Europe" considerations were important in their decision to located in Europe, while the choice of Ireland was influenced by grant and tax levels as well as issues to do with the workforce quality, availability and stability.

company upgraded its Irish operations to produce the latest microchips. Each of the assembly staff were offered retraining and redeployment to allow them to transfer to the new production process, for which the company estimated that an additional 1,000 employees were required. Workers transferring from the assembly facilities were to have their existing pay grades preserved.

Dell

We see something similar to the processes analysed earlier in the case of Dell.[19] Manufacturing operations were located in Limerick in the south west of Ireland while a European logistics centre, a 140-strong European Product Group (involved mainly in localisation as well as product and process development) and a sales, technical support and marketing centre were located in Bray, just outside Dublin.

In 2001, the company announced a voluntary redundancy package for 200 of its 4,000+ employees at its Limerick operations, the first in its 10-year history in the city. The job shedding was largely confined to office staff. The firm's 1,200 employees in Bray and Cherrywood, Dublin, will be unaffected. The affected employees were offered "competitive severance packages", including more than six weeks pay per year of service, extended medical and life cover, career counseling and out-placement assistance. The following year, however, the firm announced the creation of between 100 and 200 full-time jobs at its call centre in Bray, Co Wicklow. Many of these were to be in highly skilled positions at Dell's new multilingual centre that offers technical support services for the firm's server and storage products.

AST (ARI Services Europe)

AST was set up in 1980 in Irvine California and started in Limerick in September 1994. It was taken over by Samsung (Korean) in September 1997, by which time it had 4,000 employees globally, located in Limerick (Ireland), Fort Worth (Texas), Irvine (California) and in China. At its high-water mark in Ireland it had 750 employees. By December 1997 this was down to 450, all of whom had permanent contracts.

In that month it announced that 150 of its Irish employees were to go as part of global restructuring operations. These 150 were expected to find employment at the nearby Dell (Raheen) and Cabletron facilities. It was thought that the firm might sell its Limerick facility and move to a smaller plant or shift production to the UK. The Irish facility was eventually sold to Dell, with a large part of the AST personnel in the facility simply transferred to the pay bill of Dell at that time.

In 1998 the company announced that it was withdrawing from the EU market for desktop computers and server machines (underlining the growing dominance of the PC market by the "big four" – Compaq, Dell, IBM and HP) to focus on portable notebooks. The smaller Limerick facility now operates as ARI Services, a purely services company owned by Samsung.

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[19] The material on job losses in Dell comes from the Irish Times of May 24, 2001, and August 17, 2002.

6.   Overall Labour Market Conditions in Ireland

Since the overall ICT sector shrank over the first few years of the new millennium, there are clearly some displaced workers who did not manage to retain or regain employment within ICT. The aggregate data suggest, nevertheless, that these workers would have been likely to be able to move into jobs outside the sector.

Figure 5 shows the dramatic decline in Ireland's rate of unemployment over the period, from over 10 percent in 1997 to around 4 percent today. The rate of long-term unemployment (i.e. unemployment of over 1 year's duration) fell even more precipitously, from 5.5 percent to 1.5 percent. Thus it is unlikely that workers whose jobs were displaced over this period would have encountered anything like the difficulties they might have encountered in other European countries in trying to find alternative employment.[20]

Figure 5: Unemployment and Long-Term Unemployment in Ireland
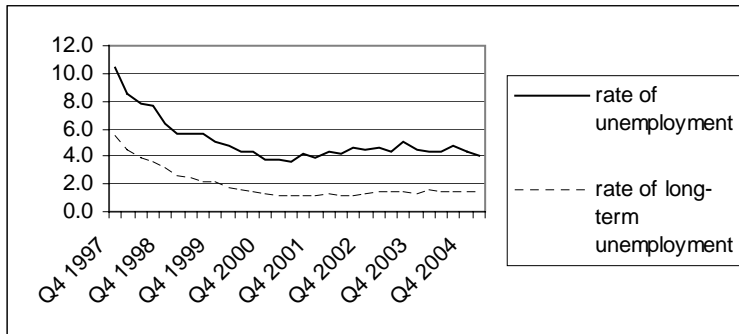
Source: Quarterly National Household Survey, Central Statistics Office.

This is not to suggest however that all displaced workers would have found it equally easy to move into alternative employment. Denny et al. (2000) show that the probability of being in employment rises with the level of educational attainment, while O'Connell (1999) shows that the share of long-term unemployment in total unemployment increases with age. In 1997 this share was just over 40 percent for those aged 15-24 years, rising to nearly 58 percent for those aged 25-44 and to 66 percent for those aged 45 and above. The long-term unemployed also have a particularly poor educational profile.

The Irish evidence suggests however that active labour-market programmes with strong linkages to the labour market – e.g. training in specific employable skills and subsidies for private-sector jobs – do enhance the subsequent employment prospects and earnings of participants (O'Connell and McGinnity, 1997), though there is the possibility that they may serve to redistribute employment opportunities towards participants in these programmes. O'Connell (1999) suggests that programmes

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[20] Some of the reasons advanced for the dramatic fall in Irish unemployment rate over this period include the boom in inward FDI flows, the extent of tax-rate reductions, the removal of poverty traps and the fairly light level of Irish labour-market regulation as evidenced by Koedijk and Kremers (1996). On the causes of the Irish boom see e.g. Barry (2004b).

targeted at marginalised groups suffer from a general weakness in not facilitating progression to further education and training. The requirement is for adequate training standards and certification arrangements to facilitate participants in gaining access to further education and training opportunities.

Concluding Comments

The opening up of Central and Eastern Europe offered new low-wage production locations with substantial supplies of relatively highly skilled labour at a short distance from (and now integrated into) the EU market. As a result, much system assembly activity has been shifting to CEE countries such as the Czech Republic and Hungary. The shift of computer assembly activity out of Ireland and Scotland resulted in knock-on job losses in the components sector, notably in plants which produced bulky enclosures in close proximity to the system assemblers.

This paper has analysed how Ireland adjusted in response to the general shift eastwards (to Asia and to Central and Eastern Europe) of the computer hardware sector over recent years. Having grown strongly over the course of the 1990s, employment in computer hardware in Ireland has fallen since the year 2000. We have seen both from the aggregate data and from firm-level analysis that there was general upgrading in the sector however, represented by a move from assembly into high-tech components and high-skill ICT services activities.[21]

The first type of adjustment is exemplified by the substantial expansion in Intel's Irish operations at the same time as assembly firms such as Gateway were withdrawing from the country. An example of the second type of adjustment was seen in the case of Apple where job numbers, having fallen from around 1,800 in 1998 (at which time the bulk of employees were involved in assembly operations) to about 600 in 2000, have now recovered to a level of around 1200, with most now employed in high-level European customer support services and logistics and finance functions.

The continuing boom in the Irish labour market served to ensure that even those who were displaced from the ICT sector were largely able to secure alternative employment in other sectors of the economy.

The progressive upgrading of the ICT sector might be interpreted as the outcome of comparative advantage, since the educational attainment level of the Irish labour force has continued to improve. Diligent governance is necessary however in ensuring that progress is made on the educational front; Barry (2005).

Diligent governance has also seen Irish (and Scottish) industrial strategy shift from the "local sourcing route" to cluster development – which seeks to build integrated vertical production clusters around subsidiaries of MNEs (Industrial Policy Review Group, 1992; Turok, 1997) – to the "technological innovation" route based on co-

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[21] The shift into services was aided of course by the sharp reduction in the corporation tax rate on services in the early years of the new millennium.

operative R&D projects involving companies, university research labs and government research institutions.[22]

The emergence of the new strategy in Ireland was heralded by the release in 1996 of the first-ever Irish Government White Paper on Science, Technology and Innovation. Investment in these areas increased five-fold under the National Development Plan 2000-2006. Further developments saw the launch in 1998 of the Programme for Research in Third-Level Institutions (which established 24 research centres as well as major programmes in human genomics and computational physics), by the funding by Science Foundation Ireland of five joint partnerships between third level research institutions and industry, and by the introduction of a 20 percent tax credit for incremental R&D in the Finance Act of 2004.

Within ICT alone, the last two years have registered a number of significant developments under the new strategy; Barry (2005). Bell Labs has announced its intention to set up a major R&D centre at Lucent Technologies' Dublin facility, linked with the establishment of a collaborative academic centre at one of the city's universities. Similarly, Hewlett-Packard announced the establishment of a world-class Technology Development Centre at its manufacturing facility outside Dublin, while its European Software Centre entered into collaboration with University College Galway in establishing the Digital Enterprise Research Institute. Intel has established an innovation centre at its main site outside Dublin, has increasing its investment in its research centre near Limerick and has partnered three Irish universities in an academic Centre for Research on Adaptive Nanostructures and Nanodevices. IBM, over this same period, announced further significant investments in its Irish R&D software facility in Dublin, influenced, according to one of the directors of the company, by the availability of the necessary skills, the strong support of the Industrial Development Agency and the growing emphasis on scientific research by Science Foundation Ireland.

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[22] McKendrick (1998) draws such a distinction between operational and technological clusters, pointing out that the latter are far "stickier" than the former. See also Young, Hood and Peters (1994, p. 669).

References

Barry, F.(2004a) "Prospects for Ireland in an Enlarged EU ", *World Economy*, 27, 6, 829-852.

Barry, F. (2004b) "Export Platform FDI: the Irish Experience", *EIB Papers*, 9, 2, 8-37. Luxembourg: European Investment Bank.

Barry, F. (2005) "Third-Level Education, Foreign Direct Investment and Economic Boom in Ireland", *International Journal of Technology Management*, (forthcoming).

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

Denny, K., C. Harmon and P. O'Connell (2000) *Investing in People: the Labour Market Impact of Human Resource Interventions funded under the 1994-1999 Community Support Framework in Ireland*, Policy Paper 38, Dublin: Economic and Social Research institute.

Giblin, M., P. Ryan and M. Moroney (2003) "Industrial Clusters: The Role of Organisations and Institutions", unpublished paper, National University of Ireland, Galway.

Green, R., J. Cunningham, I. Giblin, M. Moroney and L. Smyth (2001) "The Boundaryless Cluster: Information, Communications and Ireland", in OECD (ed.) *Innovative Clusters: Drivers of National Innovation Systems*, Paris.

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

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

McKendrick, D. (1998) *Dispersed Concentration: Industry Location and Globalization in Hard Disk Drives*; Report 98-03; The Information Storage Industry Center, University of California at San Diego.

O'Connell, P. (1999) "Astonishing Success: Economic Growth and the Labour Market in Ireland", Employment and Training Papers 44, Geneva: ILO.

O'Connell, P.J. and McGinnity, F. (1997) *Working Schemes? Active Labour Market Policy in Ireland.* Aldershot: Ashgate

Turok, I. (1997) "Linkages in the Scottish Electronics Industry: Further Evidence", *Regional Studies,* 31(7): 705-11.

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

Van Egeraat, C. and Jacobson, D. (2004) "The Rise and Demise of the Irish and Scottish Computer Hardware Industry", *European Planning Studies*, 12, 6, 809-834.

Van Egeraat, C. and Jacobson, D. (2005b) "The Geography of Production Linkages in the Irish and Scottish Microcomputer Industry: the Role of Logistics", *Economic Geography*, (forthcoming).

Young, S., N. Hood and E. Peters (1994) "Multinational Enterprises and Regional Economic Development", *Regional Studies,* 28(7): 657-77.