

Roper, Stephen; Grimes, Seamus

Conference Paper

Wireless Valley, Silicon Wadi and Digital Island - Helsinki, Tel Aviv and Dublin in the ICT Boom

43rd Congress of the European Regional Science Association: "Peripheries, Centres, and Spatial Development in the New Europe", 27th - 30th August 2003, Jyväskylä, Finland

Provided in Cooperation with:

European Regional Science Association (ERSA)

Suggested Citation: Roper, Stephen; Grimes, Seamus (2003) : Wireless Valley, Silicon Wadi and Digital Island - Helsinki, Tel Aviv and Dublin in the ICT Boom, 43rd Congress of the European Regional Science Association: "Peripheries, Centres, and Spatial Development in the New Europe", 27th - 30th August 2003, Jyväskylä, Finland, European Regional Science Association (ERSA), Louvain-la-Neuve

This Version is available at:

<https://hdl.handle.net/10419/115942>

Standard-Nutzungsbedingungen:

Die Dokumente auf EconStor dürfen zu eigenen wissenschaftlichen Zwecken und zum Privatgebrauch gespeichert und kopiert werden.

Sie dürfen die Dokumente nicht für öffentliche oder kommerzielle Zwecke vervielfältigen, öffentlich ausstellen, öffentlich zugänglich machen, vertreiben oder anderweitig nutzen.

Sofern die Verfasser die Dokumente unter Open-Content-Lizenzen (insbesondere CC-Lizenzen) zur Verfügung gestellt haben sollten, gelten abweichend von diesen Nutzungsbedingungen die in der dort genannten Lizenz gewährten Nutzungsrechte.

Terms of use:

Documents in EconStor may be saved and copied for your personal and scholarly purposes.

You are not to copy documents for public or commercial purposes, to exhibit the documents publicly, to make them publicly available on the internet, or to distribute or otherwise use the documents in public.

If the documents have been made available under an Open Content Licence (especially Creative Commons Licences), you may exercise further usage rights as specified in the indicated licence.

ERSA 2003 Congress

Wireless Valley, Silicon Wadi and Digital Island Helsinki, Tel Aviv and Dublin in the ICT Boom

Stephen Roper* and Seamus Grimes**

* Aston Business School, Aston Triangle, Birmingham, B4 7ET
E-mail: s.roper@aston.ac.uk

** Department of Geography and Centre for Innovation and Structural Change,
NUI Galway, University Road, Galway,
E-mail: seamus.grimes@nuigalway.ie

Abstract

Hyper-capitalism in global ICT markets during the late 1990s created a unique global production network shaped by multi-national corporations, global capital flows and a flourishing of high-tech entrepreneurial activity. Each of the cities considered here benefited substantially from global ICT growth in terms of employment and added value, but their position in the ICT global production network differed markedly as did their ability to appropriate value. In Dublin, value creation was based largely on inward technology and capital flows, although indigenous Dublin-based software companies demonstrated their ability to compete internationally. ICT clusters in Helsinki and Tel Aviv drew more strongly on the local knowledge base and benefited from changes in national regulatory and political conditions. In Helsinki, public and private R&D investments supported the highly effective globalisation strategy of Nokia to create a strongly localised, vertically-integrated and strongly specialised cluster. Value creation in the more diverse Israeli ICT cluster was also based primarily on locally developed technology, university R&D and the commercialisation of technology developed initially for military applications. By the end of the 1990s, the resulting ICT cluster in Tel Aviv was grounded in the local knowledge-base, technologically diverse, strongly entrepreneurial and globally oriented.

Wireless Valley, Silicon Wadi and Digital Island - Helsinki, Tel Aviv and Dublin in the ICT Boom

1. Introduction

During the 1990s, ICT markets grew at unprecedented rates stimulated by international inward investment, global capital flows and a flourishing of high-tech entrepreneurship. Nations' and regions' participation in the ICT boom varied, however, with three small European countries achieving dramatic growth rates. From 1995-2000, Finland achieved an average annual real GDP growth rate of 5.1 per cent pa, Ireland, grew at 4.4 per cent pa, and Israel achieved a notable 4.0 per cent pa. Over the same period, GDP growth in the EU as a whole averaged 2.6 per cent pa¹. The growth and development of these three 'tiger' economies has, of course, been extensively described elsewhere; on Finland see, for example, Steinbock (2001) and Paija (2000); on Israel see, for example, De Fontenay and Carmel (2001) and on Ireland see, for example, O'Riain (1997) and Grimes (2002). Some comparative analyses have also been undertaken, notably Roper and Frenkel (2000) on Israel and Ireland and Koski et al. (2001) who examine the geographical distribution of ICT activity throughout Europe. This paper extends previous comparative analyses and sets high-tech growth within each country firmly in the context of the global ICT sector. Key themes include the balance between global and local production advantages; inward investment; public policy and, crucially, local entrepreneurship. The analysis is based on the notion of a global production network (or GPN) as proposed in Henderson et al. (2001)².

Aside from the importance of high-tech growth in the development of the three economies, the comparative development of the three countries is all the more interesting because of a number of other shared characteristics. First, each economy is small, forcing firms to develop export markets if they are to maximise the potential for economies of scale in production and appropriate the full benefits of any innovative activity. Second, each of the three economies is very open with Finland and Ireland full members of the EU and Israel benefiting from a free-trade agreement with the EU concluded in the mid-1970s. Third, each country shares a somewhat peripheral location in terms of access to 'core' European markets. Fourth, each country has limited natural resources and future competitiveness and growth therefore depends on their ability to compete in knowledge-intensive markets. Fifth, each of the countries has a very different history of industrial and technology policy which has shaped their involvement in the global ICT sector. Some of the main contrasts here, are illustrated in Table 1, which highlights the dominant role of foreign direct investment (FDI) in Ireland, and the increasing importance of FDI in Finland over the 1997-99 period.

Sixth, central to the growth of the high-tech sector in each country has been the development of ITC clusters in Helsinki, Tel Aviv and Dublin. As Koski et al. (2001) notes: 'ICT-related businesses in Europe are concentrated around major urban centres' (p. 11). Cities – it has been argued - may offer particular advantages for

¹ Sources: OECD Economic Outlook 69, Annex Table 1; Bank of Israel, Table B1.

² In reality the paper falls into the category of meta-analysis or synthesis combining primary data analysis with a review of existing academic and official sources to develop an overview of ICT development in each city.

innovation and the development of high-tech industry (e.g. Simmie et al. 2000; Revilla Diez, 2000; Simmie, 2002; Strambach, 2002; Cooke et al., 2002; Audretsch, 2002; Fischer et al., 2001). For example, metropolitan areas offer the easy availability of highly skilled labour, high quality business services and the local availability of technological and financial partners (e.g. Shefer and Frenkel, 1998). They may also act as international 'gateways' through which human, financial and informational resources flow into and out of the country (Simmie, 2002), and act as attractors for inward investment. Less tangible local benefits may also result from an urban location in the form of externalities from academic research (e.g. Anselin et al. (1997), Anselin et al. (2000)), or more generalised knowledge spillovers (Feldman and Audretsch, 1999; Zucker et al., 1998) arising from specialisation (e.g. Griliches, 1992) or sectoral diversity (e.g. Jacobs, 1969). Finally, cities may provide a more supportive environment and institutional framework for high-tech entrepreneurship than other more rural or peripheral areas (e.g. Cooke et al., 2002).

The central focus in the remainder of this paper is how, and why, high-tech industry in Dublin, Helsinki and Tel Aviv developed in the way it did during the 1990s. In part the story reflects historical contrasts linked to language, and historical trading and political relationships, but other more contemporary influences are also important: for Tel Aviv, for example, military technology and mass immigration both impacted on development during the 1990s (e.g. Teubal, 1993; Roper, 2001); for Dublin, low profit tax rates encouraged large-scale inward investment, particularly by US technology firms (e.g. Ruane and Gorg, 2000); while for Helsinki, public strategies towards market liberalisation, education and highly entrepreneurial business strategies by indigenous telecommunications firms shaped high-tech growth (e.g. Steinbock, 2001).

These national factors cannot, however, be viewed in isolation from more global trends, in particular, the growth in global high-tech markets during the 1990s and increasing levels of international capital mobility. To reflect both the 'global' and 'local' dimensions of each cities' development we base our analysis around the notion of a global production network (or GPN) which is outlined in Section 2 (Henderson et al., 2001). Section 3 then provides a brief overview of the ICT GPN, and the process of value generation, enhancement and appropriation which characterised the boom of the 1990s. Sections 4, 5 and 6 then focus on each of the three study areas in turn focussing on the territorial embeddedness of the ICT GPN in each area and the particular role of inward investment, entrepreneurial activity and public policy. Section 7 briefly draws out some common themes.

2. Embeddedness and the GPN

The importance of the centripetal and centrifugal forces which lead to spatial agglomeration and the dispersion of commercial and industrial activity have long been recognised in both the geography and economics literatures. A desire to avoid local competition, the search for lower production costs, and costs of transportation may encourage dispersion, while positive Marshallian externalities, reduced transport costs and informational advantages may encourage spatial agglomeration and clustering (see, for example, the discussion in Koski et al., 2001, pp.1-3). Arguably, however, global moves towards knowledge-based competition, accompanied by the rapid development of connectivity and global logistics, have radically shifted the historical balance between these centrifugal and centripetal forces. On one hand, the

increasing importance of knowledge as the basis for competitiveness may have strengthened the centrifugal forces. It can be argued, for example, that while information can readily be transmitted over long distances, transmitting knowledge, which is often tacit and sticky, necessitates face-to-face interaction and frequent and repeated contacts. For Audretsch (1998), this means that: 'Knowledge spillovers tend to be spatially restricted.... The increased importance of innovative activity in the leading developed countries has triggered a resurgence in the importance of local regions as a key source of comparative advantage.' The locus of economic policy has hence increasingly shifted to the regional level, and 'a new policy approach is emerging, focusing on enabling the creation and commercialisation of knowledge...encouraging R&D, venture capital and new-firm start ups' (Audretsch, 1998, p. 26)³.

On the other hand, improved connectivity and global logistics might encourage the dispersal of commercial and industrial activity, and the geographical separation of elements of the development and production process. For example, the increasing globalisation of R&D activity may mean that the spatial distribution of the commercial benefits of R&D activity may be very different to that of the R&D activity itself. Reddy (1997, p.1821-22), for example, comments that: 'Today, new needs or trends can arise in any advanced market and the latest technologies may be located in another. TNCs attempt to gain a competitive advantage by sensing needs in one country, responding with capabilities located in a second, and diffusing the resulting innovation in markets world-wide'.

Attempts to understand the global distribution of high-tech activity – encompassing both these centripetal and centrifugal forces - have drawn both on notions of localised advantages and global corporate and trading networks. Studies have been constrained, however, by the lack of a single framework unifying globalising pressures within the world economy, particularly in high-tech sectors, and the increasing empirical evidence pointing to localised agglomeration advantages in knowledge production and knowledge based industries. One recent and persuasive attempt to fill this lacunae in the literature is Henderson et al. (2001) and the notion of the Global Production Network or GPN. Henderson et al. draw on the earlier work of Gereffi et al. (1994) on global commodity chains, viz 'sets of inter-organisational networks clustered around one commodity or product linking households, enterprise and states to one another within the world economy'. These networks are situationally specific, socially constructed and locally integrated, underscoring the social embeddedness of economic organisation (Gereffi et al., 1994, p. 2). However, Henderson et al. (2001) highlight a number of limitations of the global commodity chain concept; the commodity focus of the GCC schema has – they argue - led to a narrow focus on 'buyer-led' and 'producer driven' chains, with inadequate attention paid to network inter-relationships and the embeddedness of firms within their specific geographic context. Henderson et al. (2001) argue that a more fruitful approach takes into account the increasingly globalised nature of product and knowledge production, the importance of network

³ One reflection of this renewed interest in the region as a unit of analysis has been the growth of the literature on regional innovation systems (e.g. Braczyk et al., 1998), emphasising the capability of firms and other organisations and the degree of association within the regional economy. The focus of this type of literature has, however, been largely on the internal dynamic or composition of the region with much less attention paid to the position of the region in the wider global economy.

relationships between firms and their spatial location, viz. 'the global production network is proposed as a conceptual framework that is capable of grasping the global, regional and local economic and social dimensions of the processes involved in many forms of economic globalisation'. More specifically, the discussion of Henderson et al. (2001) suggests a definition of a GPN as '*the global network of firms, institutions and other economic agents which shapes, and is shaped by: the fundamental processes of knowledge and wealth creation, enhancement and exploitation; corporate, collective and institutional elements of organisational power; and, spatial and network embeddedness*'. The intention here is clear; on the one hand to recognise the importance of globalising forces, and in particular the influence of multi-national companies and international capital markets, while also encompassing the potential for significant local advantages and development trajectories.

Henderson et al. (2001) identify three 'conceptual categories' which they argue characterise any specific GPN: the process of value generation and distribution; the role (and power) of firms, organisations etc; and, the degree of territorial and network embeddedness. In terms of value generation and distribution, a key focus is on the way in which value added is actually generated within the GPN, a process which may be shaped by production and organisational techniques, inter-firm relationships or branding. Also important, might be legal or regulatory barriers to trade, or government policies aimed at protecting nascent sectors or companies. Equally important perhaps – particularly in the rapidly developing high-tech sectors - is the process by which value added can be increased through, for example, technology transfers within the network, the degree of developmental interaction between network participants, and the capability of local firms to generate positive localised factor or organisational advantages or brand rents. Finally, there is the question of how value is appropriated by different localities. As Henderson et al., 2001, p. 20 remark: 'It is one thing for value to be created and enhanced in given locations, but it may be quite another for it to be captured for the benefit of those locations. The pertinent issues here partly involve (a) matters of government policy, but they also involve (b) questions of firm ownership and (c) the nature of corporate governance in given national contexts'⁴.

The second factor which Henderson et al (2001) suggest characterises any GPN is the distribution of power between companies, institutions and collective organizations including supra-national bodies etc.

The third factor is the extent of territorial embeddedness of the GPN: 'GPNs do not only connect firms functionally and territorially but also they connect aspects of the social and spatial arrangements in which those firms are embedded and which influence their strategies and the values, priorities and expectations of managers,

⁴ For example, in both the UK and Israel it has been argued that despite high quality basic or scientific research, weaknesses in the capability or willingness of industry to exploit this research have led to a failure to appropriate subsequent value added. For example, Maital et al., 1993, p. 108: 'Israel has failed to fully convert its scientific achievements into export led growth. In proportion to its GDP, Israel outpaced European countries in patents publications and citations, yet lagged in R&D intensive exports'. And, in the UK DTI, 1998, pp. 10-11: 'We have a world class reputation in science and engineering ... Yet Britain suffers long-standing shortcomings which still hold us back. Too many British firms fail to match the performance of their overseas competitors, not just in terms of productivity but in innovation and quality'.

workers and communities alike' (Henderson et al., 2001, p. 22). Two issues are of particular interest here. First, the extent to which inward investment by multinational companies is embedded in the host economy, and thereby provides a conduit for inward (and also perhaps outward) knowledge transfers⁵. Second, the extent to which local entrepreneurial activity has given rise to locally-owned (or at least locally based) enterprises which have developed sufficiently to become part of the GPN.

In terms of inward investment, a number of authors have highlighted the potential for multinational inward investment to stimulate the development of dynamic clusters of firms through transfers of technology and knowledge (e.g. Morris, 1992; Wong, 1992; Young, Hood and Peters, 1994). Young, Hood and Hamill (1988) also summarise the main mechanisms through which inward investment can give technology benefits to a host economy: the new establishment of an MNE plant necessarily involves the physical relocation of technologies embodied in capital goods (e.g. machinery) and a number of forms of disembodied technology, including industrial property rights, unpatented know-how, and managerial and organisational expertise; undertaking local research and development; engaging in supplier development activities; has a 'demonstration effect' on local firms. Emphasising the particular importance of the latter two effects for regional development, Dicken (1992) suggests that the critical question is: "...the extent to which the technology (possessed by the multinational plant) is made available to potential users outside the firm either directly, through linkages with indigenous firms, or indirectly via the 'demonstration effect'" (Dicken, 1992, p. 392). Even where MNE plants do establish supply linkages with local firms it is by no means certain that knowledge transfers will take place (Dicken, 1992, p. 395). The balance of power in such relationships usually means that the terms of any knowledge transfers will be dictated primarily by the multinational, in light of its own overall interests (Dicken, 1992, p. 392). Hence, 'intentional' knowledge transfers (i.e. 'supplier development' efforts) are only likely to occur where MNE plants perceive there to be some benefit, such as improved quality, reduced costs, or improved service (Dunning, 1993, p. 456).

Perhaps equally important as inward investment is the entrepreneurial dynamic within a city, and the potential for the local development of specific competitive advantages in knowledge-based industries. Cooke et al., (2002), for example, consider the cases of Cardiff, Belfast and Tel Aviv and identify five systemic capabilities which they argue underpin the development of such a local entrepreneurial dynamic. First, they suggest, a pre-condition for the development of an entrepreneurial cluster is the existence of a unique local knowledge or research-base. In the case of Tel Aviv, Cooke et al. (2002) argue this derived predominantly from the Israeli military; in Belfast and Cardiff the main knowledge-base was within the universities. Secondly, Cooke et al. (2002) argue there needs to be an ethos and infrastructure seeking to promote start-ups and knowledge exploitation through business incubation. This is strongly developed in Israel (e.g. Roper, 1999) but was also represented by organisations seeking to promote university spin-outs in Belfast and Cardiff. Third, there needs to be early-stage investment funding available from either public or private sources. Fourth, product or service markets need to exist and be accessible to

⁵ For example, one often cited example of local embeddedness is the presence of an R&D function, and Kearns and Ruane (2000) found that R&D active inward investment plants in Ireland had greater longevity than plants not undertaking R&D.

start-up companies either through sub-contract mechanisms or sales to final users. Fifthly, there needs to be an established mechanism to allow the exit of early-stage investors through IPOs, stock exchange listings or merger/acquisition.

‘Crucially, though, each city in which these events occurred had appropriate research, training and technology-transfer organizations and an institutional set up that linked government, research and business in systemic ways that supported innovative small-firm growth. Each city possesses cultural, governance and intellectual assets that helps build up reputation and locational attractiveness for global and local firms. It is precisely because of variability in initial supply conditions (of knowledge, skills and infrastructure) that a large global demand is not met equivalently from everywhere ...’ (Cooke et al., 2002, p. 237).

3. A New Economy GPN?

Despite significant internal heterogeneity, a theme which we return to later, significant attention has focussed on the anatomy and implications of the growth of global ICT industries during the 1990s. On the supply-side, discussion has focussed on the spatial distribution of the industry (e.g. Koski et al., 2001), the role of international capital markets (e.g. Baygan and Freudenberg, 2000), and the longer-term consequences of ‘turbo-capitalism’ (Feng et al., 2002). On the demand-side, ICT growth and diffusion during the 1990s had a profound impact on US productivity growth although as Daveri (2002) notes: ‘as of 2001, the EU as a whole no longer appears seriously to lag behind the US in ICT adoption Despite the catching up in ICT diffusion experienced by most EU countries in recent years, ICT has so far delivered few, if any, productivity gains in Europe’. (p. 346).

There is general agreement about the nature of the ‘new economy’, of the late 1990s and the potentially profound impact of digital technologies on corporate behaviour, organisation and business models. Feng et al. (2001) for example, emphasise : (a) the emergence of a knowledge-based sector producing goods and services with much broader transformational potential than earlier demand-constrained, knowledge-intensive sectors such as pharmaceuticals; (b) falling costs of information and the potential for new distribution channels which may stimulate new competition, creating opportunities for first movers and threatening established corporate players; and (c) the reproducibility and non-rivalry of digital goods which creates a potentially new growth paradigm of increasing returns. These developments raised the possibility of new business models based on the Internet and emphasised the importance of human and knowledge capital rather than the historically-important range of physical corporate assets.

Despite its significance, however, developing a statistical portrait of the ICT boom of the 1990s is not straightforward; sectoral definitions differ between countries, for example, and arguments continue about what constitutes the ICT sector. OECD figures used below provide a detailed and standardised, if somewhat outdated, snapshot of the ICT sector for the OECD countries, while the Israeli Central Bureau of Statistics have produced comparable data for Israel (OECD, 2000; CBS, 2002). Figures on global industry growth, however, are usually taken from WITSA, the World Information Technology and Services Alliance, a private consortium of 48 ICT

industry associations (e.g. Daveri, 2002; Pohjola, 2002)⁶. Notably, however, both the OECD and WITSA figures include computer and telecommunications hardware and software manufacturing and IT services. On this basis, the WITSA figures suggest that global spending on ICT grew by an average of 8 per cent pa from U.S.\$1.3 trillion in 1993 to U.S.\$2.4 trillion in 2001 (WITSA, 2002). Dividing this growth by broad category (Figure 1) suggests some development in each part of the ICT sector with the overall composition of ITC spending remaining surprisingly stable throughout the 1995-2001 period. This suggests around 40 per cent of global ICT spend is linked to telecommunications; 10 per cent to software; 20 per cent to ICT services; 20 per cent to ICT hardware; and, 20 per cent to firms' internal ICT services (Figure 1B).

As indicated by both Koski et al. (2001) and Cooke et al. (2002), however, national and regional ICT growth rates have varied substantially. In terms of ITC spending during the 1990s, however, the US dominated global markets, accounting for more than 35 per cent of global ITC spend in 2001, a level equivalent to the *combined* spending of the next four countries (i.e. Japan, Germany, the UK and France) (Figure 2). Per capita spending, however, suggests a different pattern with high levels of per capita investment among the Northern European economies, the US and Japan (Figure 3). OECD figures also suggest that in 1998 the US also accounted for around a third of total ICT employment in the OECD (Table 2). However, the ICT sector was notably more important to some other (smaller) countries as a source of employment, value added and exports. For example, in Israel (2000) and Sweden (1998) ICT accounted for more than 6.0 per cent of business employment, compared to only 3.6 per cent in the OECD as a whole as well as above average shares of value added. The ICT sector was also notably more important in business R&D in the countries considered here than the OECD norm as well as in their exports (Table 2).

The scale of US ITC spending, and the dominant importance of US product and capital markets over this period is hard to exaggerate. From the demand-side, the US market represented the key international market for technology companies with Irish and Israeli technology companies often setting up their first international sales office in the US, sometimes as prelude to an IPO (e.g. de Fontenay and Carmel, 2001). Similarly, in 1996, OECD (1998) suggested that the US market accounted for \$212.7bn of the total \$460.3bn OECD market for IT, and \$118.1bn (55.5 per cent) of the \$249.0bn OECD market for packaged software and services (OECD, 1998, Table 19). In terms of capital markets and outward-investment, the US was also dominant over this period. Baygan and Freudenberg (2000), for example, in their analysis of the internationalization of venture capital, note that new private equity funding in the US in 1999 totalled \$108.1bn compared to \$27.1bn in Europe; while venture capital funding totalled \$46.6bn in the US compared to \$12.9bn in Europe. The US was also the largest single source of outward merger and acquisition activity in 1998 with 23.8 per cent of global flows (Kang and Johansson, 2000).

4. Tel Aviv's High-Tech Cluster

⁶ The WITSA data itself is based on firm level surveys in each country conducted by International Data Corporation a private consulting company. As Daveri notes, while the countries covered by the WITSA data probably include around 98 per cent of the global IT industry (WITSA, 2000), the precise derivation of the data remains unclear. Definitional issues and the treatment of price changes here are profound and are discussed in Daveri, 2002, pp 348-349.

(a) Context

The development of Tel Aviv's high-tech cluster in the 1990s has its roots in longer term measures to promote high-tech growth in Israel. As early as the 1960s, the Israeli government was supporting the development of Science Parks at the universities (e.g. the Kiryat Weizmann Science Park in 1967 at Rehovot; Felsenstein, 1994) and giving R&D grants to individual firms (Teubal, 1993). During the 1970s, the Israeli economy became more open to trade; bi-national R&D funds were established and, albeit relatively unsuccessful, attempts were made to attract inward investment, particularly to more peripheral areas (Shefer and Bar-El, 1993). Despite this, rapid structural change took place in the indigenously-owned sector as the military build-up continued and the related civil electronics and aircraft industries expanded. From 1968-83, for example, high-tech industry in Israel increased its share of output from 6 to 24 per cent and its share of exports from 5 to 28 per cent (Teubal, 1993). Macro-economic crisis in Israel in the early-1980s threatened the growth of indigenous high-tech industry, and perhaps more importantly, reshaped the political complexion of Israel and related social and industrial policy. Previous 'state regulated capitalism' had an implicit 'bias associated with deep antagonism, or even hostility towards small business-owners' and entrepreneurship. With changes in the political scene and a shift towards more free-market economic policies, a gradual change in attitude in favour of the small business sector occurred' (Fetelstein, 2001). Geopolitical changes in the 1980s and early-1990s reinforced this effect and released the human capital on which much Israeli entrepreneurship of more recent years was based⁷.

The development of the Israeli ICT cluster during the 1990s has been ably described in De Fontenay and Carmel (2001) who note, first that over the 1990-2000 period, Israeli exports of manufactured ICT products grew five-fold, while service exports grew by a factor of ten (Table 3). Second, they also note that after the mid-1990s employment in ICT services in Israel exceeded that in ICT manufacturing, and that by 2000, the ICT sector accounted for a third of all Israeli exports but only 6 per cent of national employment. A third facet of the Israeli ICT boom is the concentration of Israeli firms in the 'development' stage of the global electronics value chain, i.e. in niche sectors where competition is knowledge rather than cost-based and production volumes are relatively small⁸. Fourth, Israeli electronics exports are also diverse with no concentration in any particular product group although telecommunications equipment (44.5 per cent), computer equipment (16.4 per cent) and medical

⁷ Two factors were particularly important. First, the cancellation in 1987 of the Lavi fighter project, the end of the Cold War and the easing of the geo-political situation in the Middle East reduced both export and domestic demand for military hardware and released substantial amounts of highly skilled labour into the Israeli labour market. Secondly, post-1989, mass immigration to Israel from the FSU has added nearly a million to the Israeli population and vastly increased the nation's endowment of human capital. Simmons (1995), for example, notes that 40 per cent of early immigrants from the FSU were university graduates compared to 10 per cent of the existing Israeli workforce.

⁸ This is a marked contrast to Ireland where the electronics sector is much more concentrated in a specific product group (i.e. computers and computer components) and is more strongly geared to mass rather than niche market areas (Roper and Frenkel, 2000). An essentially similar contrast could be made between the Irish and Israeli software sectors: the Israeli sector concentrates on developing leading edge applications in imaging, voice response and recognition, artificial intelligence, data communications and network and software security; while the Irish sector - at least the externally-owned element - is focussed on the reproduction, distribution and marketing of software initially developed elsewhere (Crone, 2002; Teubal, 2001).

diagnostic equipment (8.1 per cent) were all important export products (Table 4)⁹. Fifth, Israel's success in establishing a market position in knowledge intensive sectors is also evident in its role as a major global development centre for international ICT businesses like Intel, Motorola, IBM, Microsoft, Alcatel and 3Com which all have significant R&D facilities in Israel¹⁰. Again, One possible characterisation of the global market position of the Israeli ICT clusters is given in Figure 4 which also represents the Irish and Finnish clusters described below.

The Tel Aviv metropolitan area is the central hub of commercial and high-tech activity in Israel as well as the dominant international 'gateway' to Israel for people, capital and trade. The current population of the city is around 350,000 but, perhaps more important is that Tel Aviv-Yafo is the core of Israel's largest metropolitan area, which covers around 2.65m million people. On the Eastern side, the metropolitan area of Tel Aviv is bounded by the Mediterranean; on the West, urban expansion is limited by the frontier between Israel and the occupied territories. Urban development has therefore largely followed the coastal strip to the North towards Netanya and to the South towards Rehovot. Over the past decade suburbanisation and ex-urbanisation have accelerated and limited gentrification of central areas has also taken place (Feitelson, 2001).

Employment in the Tel Aviv metropolitan area has grown steadily in recent years and is now around 1.0m, with around 330,000 people employed in Tel Aviv-Yafo proper. As Table 5 indicates the majority of this employment is in financial and business services (28.6 per cent), education and health (20.9 per cent), wholesale and retailing (13.6 per cent) and the other production industries which includes manufacturing (12.4 per cent). Per capita incomes and growth rates in the Tel Aviv-Yafo metropolitan area are on average higher than those for Israel as a whole and are projected to remain so. Planning scenarios for Israel 2020, for example, envisage that in terms of per capital incomes Tel Aviv-Yafo will maintain a lead of 20-45 per cent over other parts of Israel (Kipnis, 1998). Despite this steady growth in employment and incomes, unemployment in the Tel Aviv area has fluctuated between 7 and 9%, and there is an increasingly wide split in earnings between those employed in the globalised high-tech and commercial sectors and those in activities serving largely local markets.

Tel Aviv metropolitan area has a dominant role in every element of the Israeli ICT sector. Compiled using company listings publicised by the Israeli government, Table 6 suggests that the Tel Aviv conurbation plays host to around 72 per cent of all high-tech (i.e. electronics, software and telecommunications) businesses in Israel. Tel Aviv's dominance is most marked in software (70.9 per cent) and telecommunications

⁹ This diversity – at least within manufactured exports – stands in marked contrast to both Finland and Ireland where more than 60 per cent of electronics exports were telecoms equipment and computer equipment respectively. This difference in the sectoral structure of ICT manufacturing in the three countries suggests the potential for different types of agglomeration economies: in Ireland and Finland, as envisaged by Griliches (1992), for example, such economies might arise from specialisation; whereas in Israel agglomeration economies may instead reflect sectoral diversity as envisaged by Jacobs (1969).

¹⁰ Felsenstein (1997) considers this in terms of 'reverse technology transfer' with multi-national companies setting up R&D labs in Israel to benefit from strengths of the Israeli National System of Innovation but then manufacturing the products developed elsewhere.

(89.8 per cent) and slightly less clear in electronics (60.9 per cent) where Haifa also has a significant cluster of businesses.

(b) Value Creation and Upgrading

As indicated earlier, creating value added in high-tech industry has also long been a concern of the Israeli state, a policy supported nationally with investment and technology grants. Unlike investment grants, however, R&D support has been available to firms in Israel regardless of location, although a locational premium has been paid for firms in less developed areas (Roper and Frenkel, 2000). This has probably favoured high-tech development in Tel Aviv and, together with the other advantages of a metropolitan location, encouraged a concentration of R&D-related activity.

A number of other factors have contributed to the concentration of ICT activity in the Tel Aviv area. First, Israel invests 0.62 per cent of GDP in R&D, compared to 0.54 per cent in Finland and 0.26 per cent in Ireland, and the Tel Aviv-Yafo region is host to two of Israel's major universities (Tel Aviv University, Weizmann Institute) and other significant research and educational institutions (e.g. the Soreq Nuclear Research Centre and the agricultural school of Hebrew University of Jerusalem). This contributes to a knowledge-rich environment for high-tech development and ensures a supply of research trained staff. Second, Tel Aviv is the centre of the Israeli banking, finance and venture capital industries, and has strongly developed links to external financial centres and resources, particularly in the US. Third, Tel Aviv- Yafo has a concentration of science parks and incubator units supported by the universities, local authorities, private companies and central government¹¹. Other industrial areas in Tel Aviv-Yafo have no direct link to the universities but have attracted significant high-tech activity. In particular, the Herzliya Industrial Zone to the North of the city (e.g. Digital Equipment, 3Com, Motorola) has been attractive because of the availability of greenfield sites and in more recent years other areas (particularly to the north-east of Tel Aviv-Yafo) have also attracted high-tech facilities.

Fourth, firms in Tel Aviv-Yafo probably enjoy 'cluster' based advantages due to a high concentration of other high-tech firms which might act as customers, suppliers, partners or sources of information or skilled manpower. Fifth, Felsenstein (1997), indicates that in Israel foreign-owned firms - particularly North American-owned businesses - have a tendency to adopt metropolitan locations (Tel Aviv or Haifa). Notably he concludes that the advantage of such a metropolitan location must be outweighing the incentive benefits of more peripheral locations.' Government financial aid has not been clearly directed in the past and still does not aid enough in offsetting peripheral disadvantages, explaining why grant incentives for development towns have not significantly influenced locational decisions of firms' (Shefer and Bar El, 1993, p. 251). Sixth, Kipnis (1998) suggests there may also have been push factors which have encouraged Israeli firms to relocate to Tel Aviv, viz. 'Haifa City, once considered a competitive centre to Tel Aviv, has suffered for the past 30 years from a 'poor business climate' syndrome, and has gradually lost most of its assets. Catalysing

¹¹ In particular, the Atidim science and industrial park to the north east of the city is owned jointly by Tel Aviv University and Municipality of Tel Aviv. Kiryat Weizmann Industrial Park to the south (25km) in Rehovot is adjacent to the Weizmann Institute. The park currently houses over 40 science-based enterprises employing over 3,000 people.

this process was a transfer from Haifa to Tel Aviv of almost all of the established national companies' headquarters' (p. 655).

Entrepreneurship has also played an important part in the Israeli ICT boom. Some notable companies were established by those leaving the IDF (see Cooke et al., 2002; De Fontenay and Carmel, 2001), while others were established as university spin-outs or entrepreneurial start-ups. Checkpoint, Memco and Aladdin, for example, all became world-leaders in their respective markets and numerous other Israeli companies achieved notable success in both capital and product markets. By the peak of the high-tech boom in 2000, De Fontenay and Carmel (2001) suggest Israel had about 4000 high-tech firms and new ones were forming at the rate of 500 start-ups per year. Commercial application of systems originally developed for defence purposes is only part of the story, however. Israel's academic and wider research community - bolstered by immigration from the FSU - also played an important part in the growth of 'Silicon Wadi'. De Fontenay and Carmel (2001) emphasise algorithmic innovations made at the Weizmann Institute and elsewhere in the development of the Israeli data security industry, while others have focussed on policy initiatives such as the small business advice centres or technology incubator network (e.g. Goldberg and Lavi-Steiner, 1996; Modena and Shefer, 1998; Roper, 1999)¹³ and R&D support (e.g. Trajtenberg, 2001).

Another key aspect of the development of high-tech business in Tel Aviv has been ready access to financial and venture capital support for small firms. The dominant position of Tel Aviv in the financial and business services sector in Israel is reflected the larger proportion of employment in this sector (28.6 per cent) than in either Helsinki (19.5 per cent) or Dublin (21.4 per cent) and in the fact that Tel Aviv-Yafo holds around half of all banking jobs in Israel (16,000 out of 32,000). Tel Aviv and the surrounding areas also play a dominant role in the rapidly expanding Israeli venture capital industry. For example, of the 57 venture capital funds listed on the Israeli government's resource site for science in mid-2001, 85 per cent were located in the Tel Aviv-Yafo metropolitan area 13 per cent in Jerusalem and only one in Haifa¹⁴.

¹³ The Technological Incubators Programme was established in 1991 and throughout the 1990s provided grant support of up to 85 per cent of project cost over two years (OCS, 1997a). Four technology incubators are situated in the Tel Aviv-Yafo metropolitan area: the Biomedical Incubator, Rad-Ramot Ltd which was established in 1997 and supports start-ups in all aspects of the biomedical field; The Incubator For Technological Entrepreneurship (ITEK), Kiryat Weizmann Ltd which was established in 1991 and is situated on Kiryat Weizmann Science Park adjacent to the Weizmann Institute of Science; The Nitzanim Initiative Centre Ltd, Nachal Soreq, which was established in 1992, and is part owned by Isorad, the commercial arm of Soreq Nuclear Research Centre; and, Target Technology Centre, Poleg Industrial Park, Netanya.

¹⁴ In fact, a single location is identified only for 52 of the funds. Of these 44 were located within the Tel Aviv-Yafo metropolitan area, 7 were in Jerusalem and one was located in Haifa. Source: <http://www.science.co.il>.

A similar concentration is evident in the geographical distribution of venture capital investments in Israel. In 1999, 78 per cent of all investments were made in Tel Aviv area, 14 per cent in Haifa and the North and 8 per cent in Jerusalem¹⁵.

2. Dublin's High-Tech Cluster

(a) Context

Historically, Ireland does not have a strong industrial tradition like that found in the UK or Germany (e.g. Yearly, 1995). Neither has Ireland traditionally had the emphasis on applied scientific research which has so strongly characterised the development of, for example, the Israeli economy. Instead, since the late 1950s, industrial policy in Ireland has been based on the principle of 'industrialisation by invitation'. Prior to the mid-1980s, this was largely concentrated in computer and computer components. As a result, electronics exports from Ireland are dominated by computers and computer components which together accounted for 63.5 per cent of all electronics exports (Table 4) and by 1998, meant that 61 per cent of electronics plants in Ireland were US-owned and that these plants accounted for 82 per cent of electronics employment.

As Ireland's dominant population and commercial centre the attraction of Dublin as an industrial location is to some extent self-evident. Early inward investment certainly tended to locate in or near Dublin to take advantage of labour market and logistic advantages. Since the early-1970s, however, attempts to attract high-tech inward investment to Ireland have been accompanied by a policy of dispersal. Higher government subsidies and the development of industrial estates, infrastructure and educational provision have all been undertaken in an attempt to persuade inward investors to locate away from Dublin to less developed regions (O'Farrell, 1980). From 1969-76, for example, this led to a fall in the proportion of new high-tech plants being established in Dublin from 55 to 20 per cent, with a converse increase in establishments in less developed areas. More recent studies (e.g. Meyer and Strobl, 1997) argue that this trend has been sustained with the extent of external-ownership of manufacturing firms now similar in Dublin and more peripheral areas¹⁶. Despite the success of the policy of dispersal of high-tech activity a distinct concentration of electronics manufacturing plants in and around Dublin is still evident. In 1998, for example, 27.8 per cent of all manufacturing plants in Ireland were located in the Dublin region which accounted for 43.6 per cent of plants manufacturing Office machinery and computers (Nace 30) and 34.3 per cent of plants manufacturing electrical machinery and apparatus (Nace 31).¹⁷

Since the mid-1980s, inward investment by high-tech manufacturing firms to Ireland has been accompanied by massive FDI by US software companies. Microsoft, Oracle, Lotus and others all have major operations in Ireland producing and selling packaged software or products primarily to EU markets¹⁸. The key activities these firms

¹⁵ Source: Israeli High-Tech and Investment Report, Feb 2000 (www.isitech.co.il).

¹⁶ Moreover, a more sectoral focus adopted since the 1980s has contributed to the development of clusters outside the Dublin metropolitan area, notably pharmaceuticals in the South West (i.e. Cork) and electronics in the Irish Mid-West and East (i.e. Galway and Limerick) (Meyler and Strobl, 1997).

¹⁷ Source: Census of Industrial Production, 1998, Table 20.

¹⁸ The scale of this inward investment has been such that Ireland has become the major European centre for software production and the country is now the world's largest exporter of software products.

undertake in Ireland include localisation, production and distribution with a relatively low level of employment of software developers¹⁹. However, it is important to note that:

‘... growth is largely a result of FDI by worlds largest software companies but the character of the [software] sector differs markedly from that of other high-tech businesses in that the indigenous Irish-owned branch of the sector has also growth very rapidly and become a substantial industry itself. Indigenous software firms employed over 9,000 people by 1997, which was 50 per cent of total employment in the sector. This compares to just 4,900 in the computers, pharmaceuticals and instrument engineering sectors combined despite their longer history of growth’ (O’Malley and O’Gorman, 2001, p. 304).

More recent figures, published by the National Software Directorate in Dublin, suggest that in 1998 the software sector in Ireland employed 21,630 of which 9,250 were working in indigenously-owned companies and 10,650 in externally-owned businesses. A further 1,730 were working in software firms that were originally indigenously-owned but had since been acquired by externally-owned firms. By contrast to externally-owned software firms, Irish-owned software firms are typically smaller, strongly ‘product’ and export focussed, and selling applications into specialised markets for process industries, financial services and distribution. This difference in activities and market positioning is reflected in figures for the software industry. In 1998, indigenously-owned firms, for example, accounted for 42.8 per cent of employment but only 13.7 per cent of sales and 9.7 per cent of software exports from Ireland.

The growth of the Irish software sector has been particularly important in Dublin where the industry is very strongly concentrated. O’Malley and O’Gorman (2001), suggest that 76 per cent of overseas software companies were located in the Dublin area as early as 1991, and that 67 per cent of indigenous software companies were located in the Dublin region in 1995. O’Malley and O’Gorman (2001), highlight four factors which they regard as having been particularly important in underpinning the growth of the indigenous software sector in Dublin:

- The availability of suitably skilled graduates. Steps were taken to expand the number of IT graduates from the mid-1980s in order to take advantage of the opportunity to attract software inward investment. This has had the unanticipated benefit of providing a workforce and stimulus to the development of the indigenous software sector in Ireland.
- State support. Four-fifths of companies interviewed by O’Malley and O’Gorman had received some state support which had accelerated their development. Low profit tax rates also leave a high proportion of any profits available for re-investment.

OECD figures, for example, suggest that in 1998 software exports from Ireland were \$3.29bn, larger than the \$2.96bn from the US.

¹⁹ Microsoft’s European Product Development Centre in Dublin, for example, employs nearly 1,000 people and is responsible for the localisation and support of more than 100 products in 27 languages.

- Domestic demand from TNCs – has both shaped the products which Irish indigenous software companies have developed with specific TNCs operating in Ireland acting as important initial ‘lead customers’.
- Work experience in TNCs operating in Ireland either in software or a client company is common among the founders of indigenous Irish software companies.

Urban regeneration measures have also played a facilitating role in the development of the software sector and other business service activities in central Dublin. Early initiatives in this area - beginning in the late-1980s - led to the re-development of Custom House Docks as an International Financial Services Centre (IFSC) and residential redevelopment of some inner-city areas providing over 6,800 new apartments by end-1996²⁰. The programme of urban renewal was continued in the 1990s with the designation of two further Enterprise Zones situated adjacent to the docklands with fiscal incentives to promote industrial operations. Development in these areas was promoted by the IDA and has attracted wide range of companies including software, teleservices and research. By end-1999, over 78,000 sq. m of office space had been developed on the two sites. The availability of this office accommodation and development sites in the Designated Areas - along with fiscal incentives and reduced planning constraints for property development – have facilitated, at least, the boom in Dublin’s financial and software sectors since the mid-1990s.

To summarise, high-tech industry in the Dublin region – and more generally in Ireland - may be said to comprise three main elements. First, the Dublin region has a more than proportionate share (around 44 per cent) of high-tech manufacturing plants located predominantly in the urban periphery. These plants, like much of the Irish electronics sector, are strongly oriented towards the production of computers and computer components. Second, Dublin also hosts a large proportion (perhaps 80 per cent) of software inward investments to Ireland. Primarily these are investments by US companies designed to localise, produce and market existing software products for the European and other markets. Third, Dublin also hosts perhaps the same proportion of a rapidly growing indigenous software sector which by 1999 was almost equivalent in terms of employment to the externally-owned software companies.

(b) Value Creation and Upgrading

Two quite distinct value creation processes are at work within the Dublin element of the global ICT GPN. First, and dominant in value terms at least, is that firms located in Dublin - and in Ireland more generally - play a key role in process by which technology developed outside Ireland is embodied in physical hardware and software in large scale production and support operations. US high-tech firms, in particular, have over the last three decades made substantial greenfield investments in Ireland to serve European ICT markets. Local capacities and advantages play relatively little role in either value creation or value upgrading in these plants, which typically depend on inward technology transfer for new product developments etc. Indeed, beyond

²⁰ As McGuirk (2001, p.657) notes however: ‘Despite hugely successful physical regeneration State led gentrification which contrasted vividly with economic deprivation and social marginalisation among established inner-city communities?’.

their labour input the links of many such plants to the indigenous economy are weak, and local value appropriation is limited due to the repatriation of profits.

The second value creation process at work in Ireland is that associated with the indigenously-owned software sector. Although demand for this sector is related to the growth of externally-owned ICT capacity in Ireland as O'Malley and Gorman (2001) note, value generation here is locally driven and value upgrading is also largely the result of local innovation and enterprise (Crone, 2002).

The development of these two distinct value creation processes is linked both to the history of inward investment to Ireland and to local social and industrial policy. For example, until the late 1990s - in contrast to both Finland and Israel - levels of public investment in Ireland in R&D were low, suggesting a relatively low level of public commitment to the development of indigenous technological capacity. Even as late as 1997, total R&D investment in Ireland at 1.4 per cent of GDP was only around half of that in Finland and Israel. Business R&D (1.03 per cent) was also low by international standards and was highly concentrated in externally-owned enterprises²¹.

More positive - and some would argue crucial to the development of the entire ICT cluster in Ireland - has been the expansion in further and higher education in Ireland since the 1970s. The development of the Regional Technology Colleges throughout Ireland, and developments in the university network, have benefited other urban centres (e.g. Galway, Limerick), but both further and higher education places remain disproportionately concentrated in Dublin (e.g. Roper et al., 2002). The four main higher education institutions in Dublin each of which is involved in ICT related training and research are: Trinity College, University College Dublin, Dublin City University, and Dublin Institute of Technology. Partly because of their origins and development Dublin City University and Dublin Institute of Technology have historically been more business oriented than either Trinity or UCD. In more recent years, however, each university has developed its industrial liaison activities and expanded its links with business.

Other aspects of the Irish operating environment for high-tech business have also proved positive in sustaining the process of value creation, particularly through inward investment; grants/subsidies for investment, reduced corporate tax rates, an English language base, free access to EU markets and wage levels which are moderate by Northern European standards. Investment incentives available comprise both fiscal and discretionary grant based elements, with the latter depending on the attractiveness, location and employment potential of individual projects (Ruane and Gorg, 1997). In addition a 12 per cent corporation tax rate is applied to both manufacturing and tradable services activities. Another factor worth highlighting perhaps particularly in terms of recent developments in Dublin, have been positive partnership arrangements between government agencies and private sector developers. The evident success of developments in the Designated Areas is one example. Another, more recent, example is the partnership between IDA and a private sector property company to establish a National Digital Park for e-commerce

²¹ Since 1997, however, significant steps have been taken in Ireland to develop indigenous technological capacity. Research funding available to the universities has been increased substantially and other major increases in support for business R&D have also been announced.

development at the Citiwest Business Campus. IDA will market the centre as a world class location for e-commerce activities and the developer will handle property related aspects of site²².

The cumulative impact of these investment incentives is obvious both in terms of the composition of Irish high-tech industry and in the scale of FDI flows. From 1997-99 FDI into Ireland was equivalent to 47.5 per cent of GDCF, compared to 26.3 per cent in Finland and only 9.1 per cent in Israel (Table 1).

Until the late 1990s, support for high-tech start-ups in Ireland was limited, with few significant incubator facilities, and relatively low levels of venture capital availability. Unlike Israel, the general support framework (i.e. grant and subsidy availability) for high-tech start-ups was also similar to that for larger and established businesses. In recent years, however, business incubation facilities have developed, and venture capital availability in Ireland has increased significantly²³. Through the Seed and Venture Capital Measure of the Operational Programme 1994-99, Enterprise Ireland with ERDF support have co-funded a number of VC funds and made available (€90 million) targeted at growth oriented SMEs. The National Software Directorate provide a 'comprehensive' listing of 18 venture capital funds currently operating in Ireland of which 17 are based in Dublin. The exception, Shannon Ventures Ltd, is based on the National Technology Park, Limerick. Irish based VC funds totalled around \$120m in 1999, of which \$102m was invested in domestic companies and \$10m was invested outside Ireland. In addition \$380m was invested in Irish companies by VC funds located elsewhere. In other words, of a total venture capital investment of \$482m in Ireland in 1999, 79 per cent came from outside the country (Baygan and Freudenberg, 2000, Table 5). This level of external dependence is high by European standards with only Denmark having a broadly similar profile²⁴.

6. Helsinki

(a) Context

Helsinki is the political capital, financial and trade centre, and largest city in Finland, with a population of 555,000. The Greater Helsinki Region (GHR) has 1.8 million

²² In Ireland, the relative importance of the fiscal and discretionary elements of these incentive packages has attracted considerable debate. Ruane and Gorg (1997) summarise the by stressing the importance of Double Tax agreements and noting that: 'Comparing tax incentives with other incentives, various surveys have concluded that the tax incentives are the most important incentive encouraging manufacturing investors to locate in Ireland. For example, a recent Deloitte Touche Tohmatsu survey indicated that almost 60 per cent of foreign companies interviewed found the ten per cent rate to have been very influential in their location choice. Furthermore, IDA Ireland personnel would suggest that tax incentives are particularly popular with US firms'.

²³ Local equity markets in Ireland are relatively limited in capacity. Although the Irish Stock Exchange has been operating since 1793, and has recently launched a specialist technology market (ITEQ) to provide a sectoral and geographical focus for Irish and European investors in Irish technology, the exchange remains relatively small. Total equity market capitalisation of the ISE was Euro84bn at end August 2001 and sixty-nine companies were quoted on the ISE's various markets. At the same point, the ITEQ market currently had eight listed companies and a market capitalisation of Euro2.1bn.

²⁴ The percentages of VC investments coming from other European countries in 1999 were: UK, 4.3; Germany, 18.0; France, 18.0; Italy, 11.2; Netherlands, 27.3; Sweden, 32.1; Spain, 24.7; Belgium, 28.9; Denmark, 77.8; Switzerland, 42.2; Finland, 43.1; Norway, 26.1; Portugal, 25.5; Austria, 24.5 (Source: Baygan and Freudenberg, 2000, Table 5).

²⁶ Other centres Espoo, estimated 24,000 ICT jobs in 2000; Tampere, 13,500 in 2000; and Oulu, 10,500. Along with Salo, Helsinki, Espoo, Tampere, and Oulu house Nokia's central operations.

inhabitants out of a national population of 5.2m, and the city region has grown faster than the rest of Finland since 1990 both in terms of population and employment (Tukiainen, 2003, p. 11). By 2000 the GHR accounted for 48% of all ICT jobs in Finland (59,000) and 37 per cent of all employment²⁶.

The dominant position of Helsinki, and more generally the GHR, is largely historical and developed as part of Finland's close historical links its Eastern neighbours. From the mid-1940s to the late 1980s, in particular, the development of Finland was closely intertwined with that of the FSU and Moscow's command economy and planning cycles (Tainio 1996). From the mid-1950s, Finland adopted a strategy of *investment-driven* growth which, with the economy dominated by traditional forest, and metal and engineering industries with very limited inward investment. In the mid-1980s, industry and government began to pay increasing attention to the development of high technology, and R&D investment rose from less than 1.5 per cent of GDP in 1985 to more than 2 per cent in 1991.

Following the collapse of the FSU, Finland experienced a significant recession - GDP declined by 10% between 1991 and 1993, unemployment reached 16.6% in 1994, and the government experienced a substantial budget deficit. This precipitated a significant change in policy with a move towards promoting an *innovation-driven* economy through the development of industrial clusters. This involved first, substantial investments in domestic R&D reaching 3.1 per cent of GDP by 1999²⁷. Second, Finland pursued a policy of active participation in EU R&D programmes: by 2000, the volume of European cooperative R&D in Finland was nearly FIM 1 billion (EUR 170 million) annually. Third, strong public institutions have been maintained and developed to support technological development. A key actor has been Tekes, Finland's National Technology Agency, which provides funding and expert services for R&D projects and promotes national and international networking. Fourth, part of the policy transition involved the internationalization of the Finnish capital markets with the abolition of laws restricting foreign ownership. As the restrictions were removed, foreign investment rose rapidly and by 2000, foreign holdings accounted for 74% of total market capitalization of shares (Steinbock 1998, Chapter 10). Fifth, public authorities adopted a progressive attitude toward all forms of mobile communications (see, for example, Pajja, 2000; Steinbock, 2001).

In 1999, the gross value of cluster production amounted to an estimated EUR 21.4 billion. The ICT cluster was dominated by equipment manufacturing and electronic components, which represented in excess of 70% of the value. The value added generated in the cluster represented 40% of the gross value of production. In 1992, the cluster reached a turning point in its trend rate of growth and grew at an average annual rate of 20% (manufacturing 32%, services 12%) until the end of the decade. By 1999, the cluster's share of GDP was 6.9%. Concurrently, the composition of ICT value added in GDP has shifted. In the early 1980s, ICT services comprised more than 1.5% in GDP; in the early 1990s, the figure exceeded 2%, and increased to over 3% by the end of the decade. The expansion of ICT manufacturing, however, has been even more impressive. In the early 1980s, it made up less than 0.5% of ICT value added in GDP and in the early 1990s, after steady growth, it declined to less than

²⁷ In 1999 the R&D expenditure of Helsinki region was FIM 10,300 million and accounted for 44.6 % of the entire Finnish R&D expenditure.

0.5%. However, it soared to close to 4% by the end of the decade. With 83,000 employees, the ICT cluster accounted for 3.6% of total employment in 1999. Despite the relative significance of the ICT cluster in the Finnish economy, the share of ICT firms is only 1.4% (4,000) of the total (Exhibit 2-3a).

A key, if not the crucial, driver of the Finnish ICT boom of the 1990s was the emergence of Nokia as the leading global supplier of mobile phones (market share in 2001 was 37 per cent). By 2001, Nokia also had 18 production facilities in 10 countries, was conducting R&D in 15 countries and had significant sales presence in 130 countries worldwide. The growth of Nokia was fuelled by rapidly expanding markets but was facilitated by external capital which meant that by 2000, 90 per cent of Nokia stock was held outside Finland. Nokia's operations remained strongly concentrated in Finland, however. Approximately 60 per cent of the firm's R&D remains in Finland along with some 55 per cent of the entire production volume (for Ericsson, the corresponding figure was only 3 per cent; Steinbock, 2001). Other studies have suggested that in 1999, when Nokia employed 21,000 in Finland, there were an estimated 15,000 jobs in Finnish subcontractors²⁸. The symbolic importance of Nokia in the growth of the Finnish ICT cluster is hard to over-estimate; the firm's quantitative importance is also significant, however accounting for around 20 per cent of all Finnish R&D spending, around 70 per cent of the total capitalisation of the Helsinki stock exchange, and around half of all cluster employment²⁹.

A number of strengths of the Finnish ICT cluster are worth highlighting. First, the cluster is strongly embedded in the wider Finnish economy through technological, corporate, organizational and governmental links. Within the corporate sector this is epitomised by strong local supply-chains and a strong dependence on locally-conducted R&D. The strong position of Nokia in the downstream elements of the ICT value chain also means that a high proportion of the value added resulting from Finnish R&D is captured by Finnish companies³⁰. A number of weaknesses of Finland's ICT have also been highlighted, however. First and most obviously the growth of the cluster has depended significantly on the international success of Nokia. Second, and partly as a result of the dominance of Nokia and mobile telephony, there is something of a lack of diversity within the Finnish cluster, evident in the strong concentration of exports in telecommunications equipment (Table 4). In more human terms too Finland remains the most ethnically homogeneous country in the EU due to its strict, longstanding application of immigration policies and, to a lesser extent, its geographic location, harsh climate, and difficult language.³¹ Lack of cultural diversity arguably makes it more difficult to address international markets, restrict personal international networks, and limit creative diversity within Finnish companies. Other potential difficulties relate to the more general business environment in Finland,

²⁸Source: "Nokia jakaa kasvun ja kivun", Helsingin Sanomat, August 1, 1999.

²⁹ In 1999, ICT cluster employment was estimated at around 83,000. Nokia itself employed 21,000 in Finland and a further 15,000 were employed in sub-contractors.

³⁰ This is in marked contrast to both Ireland and Israel both of whose global market position is more concentrated in a specific stage of the ICT value chain than that of Finland where cluster operations are more vertically integrated.

³¹ In 2000, the total number of foreign citizens living in Finland was estimated at 93,000 (only 1.7%). The ratio – 0.06 immigrants per 100 inhabitants – is the lowest after France and well below the EU average of 0.22. Source: Eurostat.

focusing particularly on high tax rates and the maintenance of Finland's high cost social welfare provisions.

(b) Value Creation and Upgrading

Finland's ICT boom of the 1990s was largely an urban phenomena with strong population growth and job increases taking place in only a handful of urban regions, first and foremost in the Helsinki region (Susiluoto and Loikkanen 2001). Here, knowledge intensive industries, telecommunication and business-to-business services have been the engines of growth. (City office of Helsinki 2002.). The Helsinki region has also always been the centre of ICT production in Finland and during the 1990s the industry became increasingly concentrated in Helsinki. Although the ICT sector's share of total production rose between 1988 and 1999 from around 10 % to 16 % in Helsinki it rose from 17 per cent to 23 per cent (Figure 4; Tukiainen, 2003, p. 23). One consequence is that unemployment rates have tended to be lower in the GHR than in other parts of Finland and average levels of productivity have been estimated to be up to 50 per cent higher than those in Finland's weakest regions (Susiluoto-Loikkanen 2000).

Within the Helsinki region, ICT activity is strongly concentrated to the South and West of the metropolitan area, and is almost non-existent in eastern Helsinki, northern Espoo and Vantaa. The concentrations of ICT activity, however, reflect different origins: in Espoo the sector has evolved around Helsinki University of Technology; in Ruoholahti the concentration is a result of city planning policies; while the traditional concentration remains in Helsinki city centre.

High levels of business, higher education and public R&D investment supported by effective technology transfer institutions (e.g. Tekes, SITRA) have provided the primary basis for value creation in the Helsinki ICT cluster. In Helsinki in particular the university sector is important, dominated by Helsinki University of Technology (HUT) and the University of Art and Design Helsinki, Arabianranta. Also important is the polytechnic system developed in Finland in the mid-1990s. There are eight polytechnics in Helsinki region, of which two are significant in ICT; Helsinki polytechnic Stadia and the EVTEK institute of technology. The development of the polytechnic system and the expansion of ICT training in the university sector led to an overall increase in the number of ICT students in Helsinki in the late 1990s. From 1995 to 2000, the ICT share of all students has increased in Helsinki region from 10,9 % to 12,6 %, and in Finland from 8,8 % to 11,8 %. The impact of Finland's universities on industry is more significant because of well established interaction with industry, with the ICT-oriented universities (in Helsinki, Lappeenranta, Oulu and Tampere) having an active and long tradition in product and process development. An important element in the relationship between the universities and industry has been played by the *Technical Research Centre (VTT)*; founded in 1941). The largest public research unit in Finland. VTT carries out technical and techno-economic R&D in its

³⁵ The Finnish supplier sector has focused on highly customised inputs while in standard components - requiring large scale and effective distribution channels - Finnish OEMs rely on imports. In excess of 90% of the electronic component market value is composed of imports.

own right and in partnership with universities and industry. The organisation has more than 3000 employees of which 2159 work in Helsinki region (Espoo).

Accompanying heavy investment in R&D have been attempts to turn Helsinki metropolitan region into a “learning city.” Local initiatives focussing on education, IT skills, promotion of competitiveness, improving entrepreneurship, and opportunities for interaction and cooperation have been supported by national policy intended to develop Finland into an information society through the cultivation of the ICT cluster, as well as investments in education, research, and product development (e.g., SITRA, 1998).

Appropriation of value from Finland's ICT R&D has been shaped largely by Nokia's strategic decisions during the 1990s, and in particular Nokia's decision not to vertically integrate into semiconductors (unlike its direct rivals Motorola, Ericsson). Instead, in addition to developing its R&D networks, Nokia has focused on the downstream side of the value chain (brand, segmentation, design), and developed extensive and long-term supplier relationships with other companies within the Finnish ICT cluster. This strategic decision, accompanied with Nokia's dominance has had important implications for the development of the Finnish ICT cluster and local enterprise. On the positive side, outsourcing by Nokia has created great growth opportunities and challenges for Finnish firms. Among Nokia's suppliers (components, contract manufacturers, electronic manufacturing services), Elcoteq was perhaps the most significant although its revenues are less than 15 per cent of those of Nokia; other component and contract manufacturers were quite small in comparison, including Perlos, NK Cables, Flextronics International Finland, and Aspocomp.³⁵ Nokia's sourcing strategy also contributed strongly to development of the ICT cluster in the GHR cluster as almost all Nokia's suppliers – and certainly the most important ones – have their headquarters in the GHR.

On the more negative side, the importance of Nokia as a lead customer has meant that many Finnish firms have developed as subcontractors, possessing little strategic flexibility. Business models have had to be customized to Nokia's requirements, with suppliers forced to focus on cost reduction strategies rather than developing independent market positions (Steinbock, 2001). Second, the increasing requirement during the 1990s for Nokia's suppliers to be able to supply globally has dominated firms' investment decisions, forcing a dependence on a single major customer relationship. Third, and of broader consequence for the ICT cluster, has been that the domestic *supporting* sector has specialised in meeting the needs of Nokia rather than developing any very broad diversity.

High-tech entrepreneurship and start-ups have yet to achieve prominence in Finnish high-tech industry despite substantial development of venture capital and other supports for entrepreneurial activity in Finland during the 1990s³⁷. Venture capital support, in particular expanded rapidly during the late-1990s stimulated by the Finnish government's policy of pump-priming venture capital investment since the

³⁷ Tukeynen (2003, p.18) notes, however, that ICT start-ups are around 50 per cent more common in the ICT sector in Finland than other industries.

launch of Start Fund of Kera Oy in 1990. By the end of 2000, Finland's Venture Capital Association had 35 member organizations of which half a dozen were public VC organizations, such as Sitra, and the rest were private VC firms, such as Eqvitec Partners, CapMan Capital Management, and Merita Capital.³⁸ Private VC accounted for 91 per cent of funding although the dominant source of funds remained Finnish in origin.

In addition to the wider availability of VC funding a number of other positive influences on entrepreneurship in Finland are worth highlighting. First, as indicated above, Finland has a well developed and commercially focused higher education system and an institutional and financial commitment to supporting commercially oriented research. Second, through TEKES, SITRA and the Employment and Economic Development Centres (TE-centres), Finland provides substantial public support for start-up companies. Third, schemes designed to allow start-ups to draw on the managerial resources of Finland's larger companies through mentoring/guidance programmes have been developed to increase the probability that high-tech start-ups succeed.

The liberalisation of Finland's capital markets and the relaxation of regulations on external ownership of Finnish companies in the early-1990s opened the door to greater external involvement in the Finnish economy. The nature of the involvement has been very different, however, to that in Israel and Ireland. In particular, external investment has been primarily attracted by established companies such as Nokia, by other ICT businesses and - to a more limited extent - by the potential rewards of VC investments in Finnish ICT start-ups. Very little investment has flowed into Finland with the intention of developing the large-scale production facilities which have characterised inward investment to Ireland. In other words, inward investment to Finland during the 1990s was primarily attracted by Finnish technology and enterprise rather than other factor endowments. Inward technology transfer accompanying the investment was therefore limited, with external investment facilitating the development of the Finnish cluster rather than having any very profound impact on its technological trajectory.

7. Discussion

Hyper-capitalism in global ICT markets during the late 1990s created a unique global production network shaped by multi-national corporations, global capital flows and a flourishing of high-tech entrepreneurial activity. The speed of these commercial developments, allied with changing technologies and the associated business models, presented new challenges and opportunities for companies, cities and regions. Areas' ability to respond and take advantage of these opportunities was inevitably shaped by their historical involvement in the global economy and their local capability to generate value and take advantage of positive externalities in knowledge creation. Importantly, public policy and the institutional and regulatory environment for business also played an important role.

Each of the cities considered here benefited substantially from global ICT growth in terms of employment and added value but their positioning in the ICT GPN differed

³⁸ In the following VC sections, the data originate from the annual industry reports of the Finnish Venture Capital Association (FVCA).

markedly. For example, at the start of the 1990s Dublin's primary role in the ICT GPN was as the European base for US IT hardware manufacturers. By 2000, further inward investment by US manufacturing and software businesses had established Dublin as a significant ICT centre in Europe and made Ireland Europe's largest software exporter. Throughout the 1990s, however, the capability of inward investors to Ireland to generate value in international markets depended primarily on inward technology transfer. Indigenous Irish software companies did, however, demonstrate their ability to compete internationally, with the software cluster strongly Dublin centred.

Unlike Dublin, the ICT clusters in both Helsinki and Tel Aviv drew more strongly on the local knowledge base and benefited from changes in regulatory and political conditions. In Helsinki, public and private R&D investments supported the highly effective globalisation strategy of Nokia to create a strongly localised, vertically-integrated and strongly specialised cluster around mobile telephony. Crucial to this development, however, was the long-term support of the Finnish government for the telecomms sector and the liberalisation of Finnish capital markets in the early 1990s. Value creation in the more diverse Israeli ICT cluster was also based primarily on locally developed technology, university R&D and the commercialisation of technology developed initially for military applications. Here too, however, changes in the political climate were important. Internationally, easing tensions allowed the transfer of human and financial resources from defence to civilian applications in Israel. Nationally, a more liberal political environment also created opportunities for entrepreneurship, an openness to inward venture capital investment and engagement with the international economy. By the end of the 1990s, the resulting ICT cluster in Tel Aviv was grounded in the local knowledge-base, technologically diverse, strongly entrepreneurial and globally oriented (Cooke et al., 2002)

For none of the cities considered here was the ICT boom costless, with each facing labour shortages, congestion, rising housing costs and increasing income disparities. For example, Felsenstein (1996) notes that even by 1996 large high-tech firms in Tel Aviv were drawing employees from the Haifa, Jerusalem and Beersheva areas up to a 100km away. 'High technology firms are therefore transforming metropolitan labour markets into national labour markets'. Essentially similar issues, have meant that road congestion and rapidly rising house prices have also become a barrier to development in Dublin. Three factors have contributed to this problem. First, population growth has tended to be accommodated by urban extension rather than increases in density which has meant that people are travelling further to work. Secondly, an inadequate public transport system has led to increased car use and travel distance which has reinforced congestion. Thirdly, McGuirk and MacLaren (2001) highlight the impact of micro rather than level metro-planning which has generated inconsistencies between local and metropolitan planning objectives and constraints. Congestion has been less of an issue in Helsinki, but here too housing prices rose rapidly during the 1990s (City office of Helsinki, 2002).

The comparative experiences of Dublin, Helsinki and Tel Aviv during the 1990s suggest at least three lessons for regional policy and analysis. First, they suggest there are 'many ways to skin a cat' - in other words each city found a different strategy (industrialisation by invitation, flagship firm, diversity) but achieved the same goal (a significant ICT cluster). Second, the comparison suggests the importance of path dependence in that the foundations of each cities' success during the 1990s was laid in

previous periods. For Dublin, it was previous inward investment that was important along with investments in higher education; for Finland the positive development of mobile telephony dates back to the 1960s (Steinbock, 2001); while for Israel military investment and university research strength provided the basis for cluster growth (e.g. Cooke et al., 2002). Third, the case studies also suggest the importance of policy both in terms of industrial development but also in terms of governments' willingness to intervene (e.g. in stimulating venture capital markets) and in the regulation of capital markets.

Table 1: FDI and Transnationality Indicators

	Finland	Ireland	Israel
FDI inflows as % of GDGF 1997-1999	26.3	47.5	9.1
FDI inward stock as % of GDP	14.3	45.4	17.9
Value added of foreign affiliates as % of GDP	9.5	40.2	8.7
Employment of foreign affiliates as % of total employment	10.1	9.8	10.2
Transnationality index	15.0	35.7	11.5

Source: The World Investment Report 2002, United Nations, New York. Annex table A.1.6. p. 275.

Table 2: Scale and Importance of the ICT Sector: 1998

	Employment in ICT (000s)	Share of Empl. In Business Sector (%)	Share of Value Added in Business Sector (%)	Share of ICT R&D in total business sector (%)	Share of ICT in Exports (%)	Share of ICT in Imports (%)
Australia	196	2.6	4.1	26.8	13.1	4.4
Austria	165	4.9	6.8		8.2	5
Belgium	130	4.3	5.8	20.1	7.4	6.7
Canada	430	4.6	6.5	43.7	12.4	7.2
Czech Republic	152	3.3	4.7	4.6	10.5	5.5
Denmark	96	5.1		21.1	12.7	8.3
Finland	88	5.6	8.3	51	16.1	19.6
France	681	4	5.3	26.4	11.1	9.4
Germany	974	3.1	6.1	20.1	11	8.6
Hungary	157	5.7	9.2	11.3	19.7	21.5
Iceland	4	4.2		21.8	8.1	1.3
Ireland	56	4.6		47.7	33.9	32.6
Israel	148	6	12.7	85	14.1	30.1
Italy	671	3.5	5.8	26.5	8.5	4.4
Japan	2060	3.4	5.8	40.4	13.5	24
Korea	462	2.5	10.7	40.9	18	21.8
Netherlands	199	3.8	5.1	19.6	16.7	14.6
New Zealand	31	2.1		17.7	11.3	3.5
Norway	74	5.3	6.4	29.2	7.8	3.5
Portugal	94	2.7	5.6	23.5	8.4	6.3
Sweden	174	6.3	9.3	27.9	14.2	14.9
Switzerland	172	6			9.4	5.3
Turkey	100	0.5		21.7	8.6	4.7
UK	1112	4.8	8.4	21.8	14.9	15
US	4521	3.9	8.7	38	16.4	15.2
G7	10449	3.8	7.4	35.3	13.5	12.8
EU 15	4441	3.9	6.4	23.6	11.8	10.1
OECD	12800	3.6	7.4	34.6	13.2	12.5

Sources: OECD (2000), Central Bureau of Statistics, 2002.

Table 3: High Tech Growth in Israel: Exports and Employment

	1990	1992	1996	1998	2000
1. Exports (\$95m)					
ICT Manufacturing	79.0	81.0	70.7	68.2	67.2
ICT Services (incl. telecomms and software)	21.0	19.0	29.3	31.8	32.8
Total ICT	2424	3168	5459	8122	14993
2. Employment					
ICT Manufacturing	64.3	62.9	48.4	45.0	37.8
ICT Services (incl. telecomms and software)	35.7	37.1	51.6	55.0	62.2
Total ICT	56	62	95	111	148

Source: De Fontenay and Carmel (2001), Tables 1 and 2.

Table 4: Composition of Exports of Electronic Products: Finland, Ireland and Israel

SITC.3	Product Group	Finland %	Ireland %	Israel %
751	Office Machines	0.3	0.4	0.0
752	Computer Equipment	8.9	38.4	16.4
759	Office Equip Parts/Accs.	1.5	25.1	6.0
761	Television Receivers	1.8	0.0	0.0
762	Radio Broadcast Receiver	0.1	0.0	2.3
763	Sound/TV Recorders Etc	0.3	0.1	0.4
764	Telecomms Equipment Nes	62.5	14.1	44.5
771	Elect Power Transm Equip	6.8	1.8	1.2
772	Electric Circuit Equipmt	3.8	3.9	7.5
773	Electrical Distrib Equip	3.0	1.5	0.9
774	Medical Etc El Diag Equip	3.0	0.2	8.1
775	Domestic Equipment	2.2	0.9	0.2
776	Valves/Transistors/Etc	3.0	11.1	7.3
778	Electrical Equipment Nes	2.9	2.4	5.1
	Total	100.0	100.0	100.0

Note: Finland and Israel, 1998; Ireland, 1999.

Source: UN Statistics Division, COMTRADE database.

Table 5: Demographic and Labour Market Comparisons: Tel Aviv, Helsinki and Dublin

	Tel Aviv	Helsinki	Dublin
City Population	348.3	555.5	481.9
City Population Density	6659.3	2995	409.8
Metropolitan Area Population	2652.7	1200	1058.3
Metropolitan Area Density	1754.7	1615	
Unemployment Rate	8.0	7.4	2.9
Composition of Employment:			
Agriculture, Forestry, Fishing	0.2	0.4	0.7
Other Production Industries	12.4	14.4	13.6
Construction	4.3	5.3	7.9
Wholesale, Retailing	13.6	16.2	14.7
Hotels, Restaurants etc	5.1	3.5	6.2
Transport, telecommunications	7.2	9.1	9.2
Financial and Business Services	28.6	19.5	21.4
Public Administration	5.6	6.3	5.7
Education and Health	20.9	17.1	14.5
Other Services	2.1	6.5	6.1
	100.0	100.0	100.0

Note and Sources: Population 1998/99: Statistics Finland, Statistical Abstract of Israel, 2000; CSO, Dublin. Unemployment and Employment figures for Tel Aviv relate to the Tel Aviv and Jaffe area for 1999 (Source: Statistical Abstract of Israel, 2000). Dublin figures relate to the Dublin region in 2001 (Source: CSO). Helsinki employment figures relate to the Helsinki metropolitan area for 1999 (industry was unknown for 2 per cent of all employees) (Source: Statistics Finland); Unemployment figures relate to 2001.

Table 6: Location of High-Tech Businesses in Israel

	Electronics	Software	Telecommunicat ions	Total
Tel Aviv	60.9	70.9	89.8	71.9
Jerusalem	8.3	9.7	2.0	7.9
Haifa	27.1	11.8	6.1	14.6
Other or na	3.8	7.6	2.0	5.6
Total (%)	100	100	100	100
Total (no.)	133	289	98	520

Source: Author's analysis based on data from www.science.co.il.

Figure 1: Global Positioning of Irish, Finnish and Israeli High-Tech Sectors

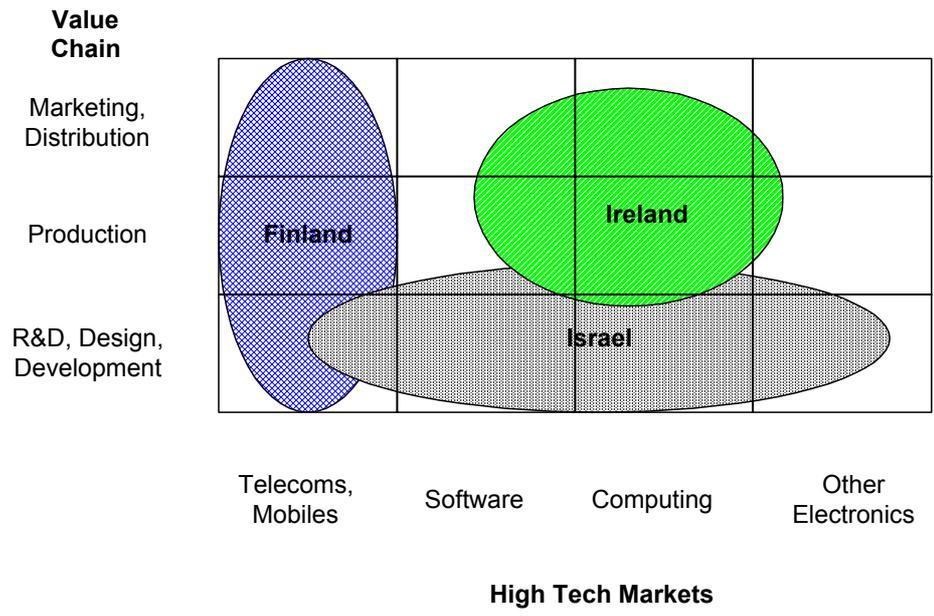
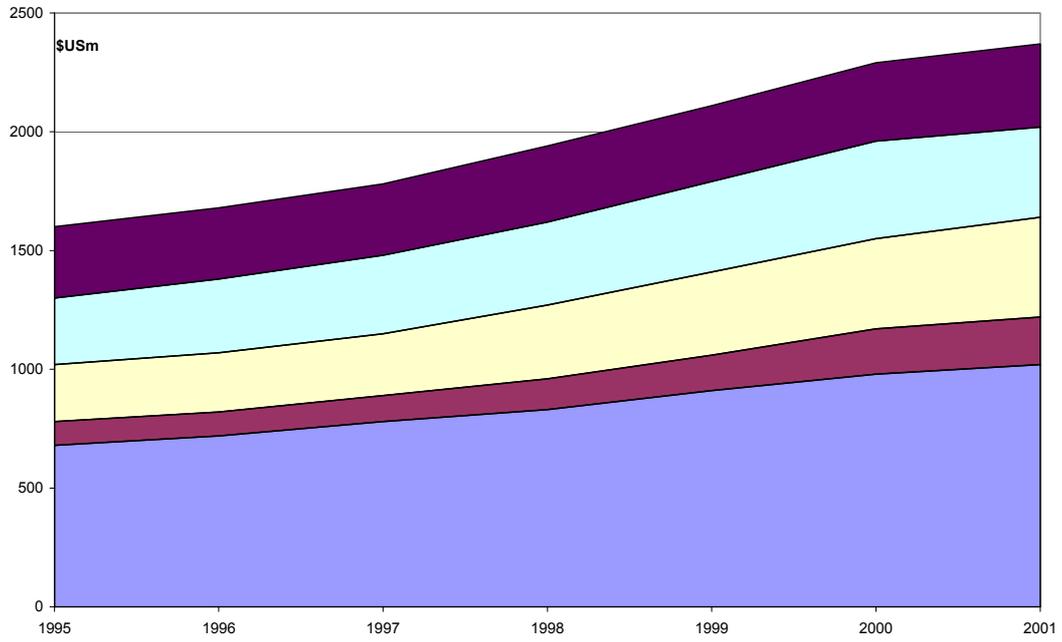
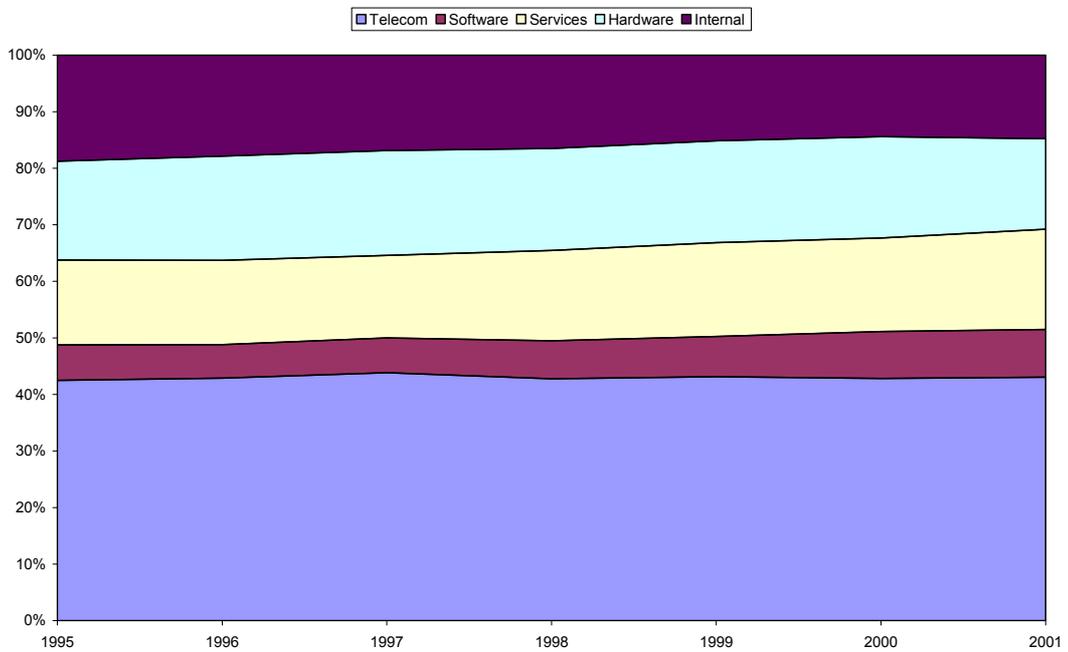


Figure 2: ITC Spending Growth: 1995-2001

A. Growth

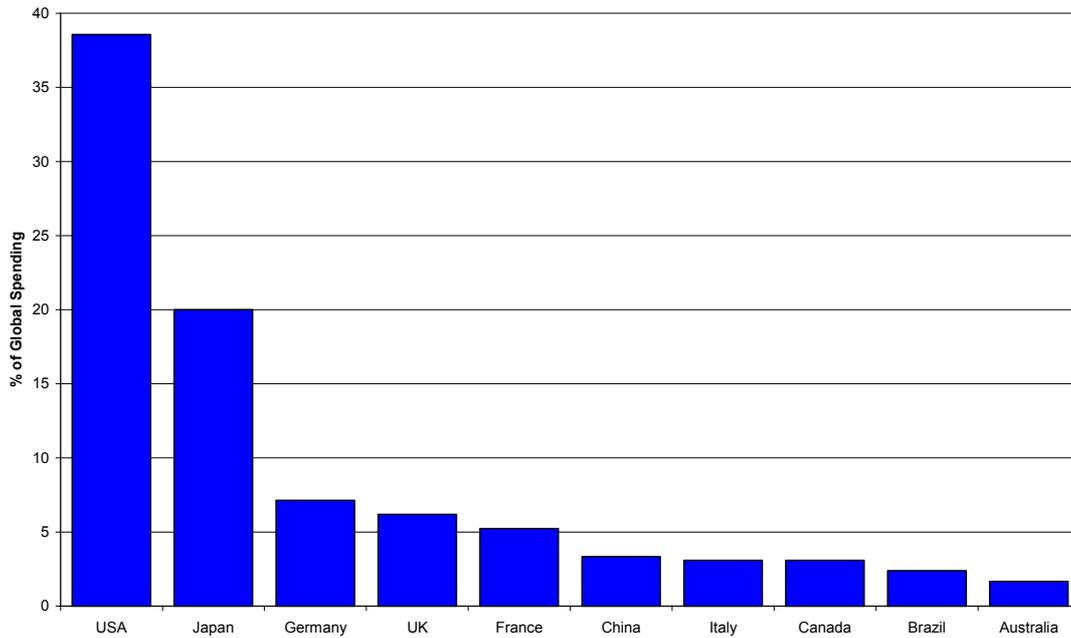


B. Composition



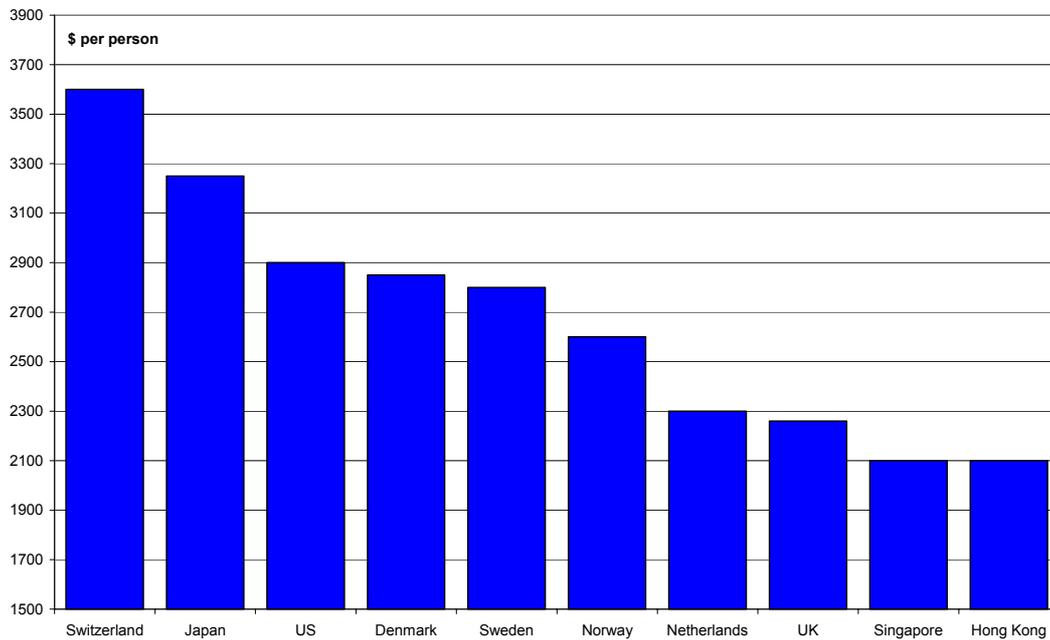
Source: WITSA 2002

Figure 3: National Shares of Global ITC Spending - 2001



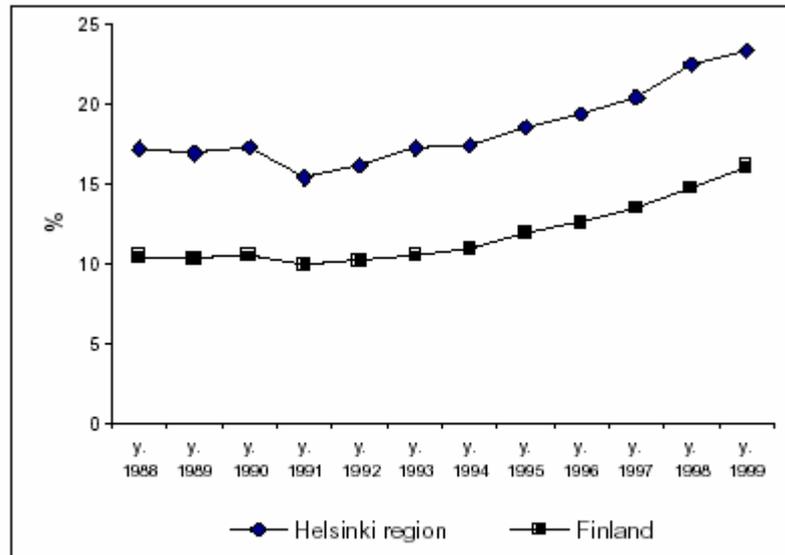
Source: WITSA 2002

Figure 4: Per Capita ITC Spending in the Top Ten Countries - 2001



Source: WITSA 2002

Figure 5: ICT Share of Total Production in Finland and Helsinki



Source: Statistics Finland

References

- Ainamo, A (1997) 'The Evolution of the Finnish System of Innovation: The Contribution of Nokia', in Fynes, B and Ennis, S (eds.) *Competing from the Periphery*, Oaktree Press, Dublin.
- Anselin, L Varga, A and Acs, Z (1997) 'Local Geographic Spillovers Between University Research and High Technology Innovations', *Journal of Urban Economics*, 42, 422-448.
- Anselin, L Varga, A and Acs, Z J (2000) 'Geographical and Sectoral Characteristics of Academic Knowledge Externalities', *Papers in Regional Science*, 19, 435-443.
- Audretsch D B (1998) 'Agglomeration and the location of innovative activity', *Oxford Review of Economic Policy*, 14(2), 18-29.
- Audretsch, D (2002) 'The Innovative Advantage of US Cities', *European Planning Studies*, 10, 2, 165-176.
- Baygan, G and Freudenberg, M (2000) 'The Internationalisation of Venture Capital Activity in OECD Countries: Implications for Measurement and Policy', STI Working Papers 2000/7, OECD, Paris. WITSA, 2000),
- Braczyk, H-J, Cooke, P and Heidenreich, M (1998) *Regional Innovation Systems*, UCL Press, London.
- Central Bureau of Statistics (2002) 'Information and Communication Technologies in Israel – 1990-2000', Statistilie No. 25.
- Cooke, P Davies, C and Wilson, R (2001) 'Innovation Advantages of Cities: From Knowledge to Equity in Five Basic Steps', *European Planning Studies*, 10, 2, 234-250.
- Crone, M (2002) 'Regional Competitiveness - Regional Co-operation and Cluster Development – The Irish Software Industry', paper presented at the European Regional Science Association Conference, Dortmund, August.
- Daveri, F (2002) 'The New Economy in Europe', *Oxford Review of Economic Policy*, 18, 3, 345-362.

- De Fontenay, C and Carmel, E (2001) 'Israel's Silicon Wadi: The Forces behind cluster formation', In Bresnahan, T, Gambardell, A and Saxenian, A (eds.) *Silicon Valley and its Imitators*, forthcoming.
- Dicken P. (1992) *Global Shift: The Internationalisation of Economic Activity*, 2nd Edition. Paul Chapman, London.
- Dunning J. H. (1993) *Multinational Enterprises and the Global Economy*. Addison-Wesley, Wokingham.
- Feitelson, E (2001) Malicious siting or unrecognised processes? A spatio-temporal analysis of environmental conflicts in Tel-Aviv, *Urban studies*, 38, 7, 1143-1160.
- Felsenstein, D (1997) The making of a high technology node: foreign-owned companies in Israeli high technology, *Regional studies*, 31, 4, 367-380.
- Feng, H Fround, J Haslam, C Johal, S and Williams, K (2001) 'A New Business Model? The Capital Market and the New Economy', *Economy and Society*, 30, 4, 467-503.
- Gereffi, G. and M. Korzeniewicz (eds.) (1994), *Commodity Chains and Global Capitalism*. Westport, Praeger.
- Goldberg, A I and Lavi-Steiner, O (1996) 'Developing an Effective Technological Incubator – The Experience of Israel', *Industry and Higher Education*, December, 371-376.
- Griliches Z (1992) 'The search for R&D spillovers', *Scandinavian Journal of Economics*, 94 (supplement), 29-47.
- Grimes, S (2002) 'Ireland's Emerging Information Economy: Recent Trends and Future Prospects', *Regional Studies*, 37, 1, 1-12.
- Henderson J, Dicken P, Hess M, Coe Nand Wai-Chung Yeung H (2001) 'Global Production networks and the analysis of economic development, University of Manchester
- Jacobs, J. (1969) *The Economy of Cities*. New York: Random House.
- Kang, N-H and Johansson, S (2000) 'Cross-Border mergers and acquisitions: Their role in industrial globalisation', OECD, Paris.
- Kipnis, B A (1998) Technology and industrial policy for a metropolis at the threshold of the global economy: the case of Haifa, Israel, *Urban Studies*, 35, 4, 649-662.
- Koski, H Rouvinen, P and Ylä-Antilla, P (2001) 'ICT Clusters in Europe – The Great Central Banana and the Small Nordic Potato', UNU/WIDER Discussion Paper 2001/6, May.
- Lavy, V (1994) 'The Effect of Investment Subsidies on the Survival of Firms in Israel', The Maurice Falk Institute for Economic Research in Israel, Discussion Paper 94.04, Jerusalem.
- McGuirk, P M (2000) Power and policy networks in urban governance: local government and property-led regeneration in Dublin, *Urban studies*, 37, 4, 651-672.
- Meyler, A and Strobl, E (1997) 'Regional Employment Performance of Irish Industry, 1972-96: Job Flow Analysis', Trinity Economic Papers, Technical Paper No 9, June, Dublin.
- Modena, V and Shefer, D (1998) 'Technological Incubators as Creators of New High Technology Firms in Israel', paper presented at the 38th European Regional Science Association Congress, Vienna.
- Morris J. (1992) Flexible internationalisation in the electronics industry: implications for regional economies, *Environment & Planning C* 10, 407-421.
- O'Farrell, P (1980) 'Multinational Companies and Regional Development: The Irish Experience', *Regional Studies*, 14, 2.

- O'Riain, S (1997) 'The Birth of a Celtic Tiger', *Communications of the Association for Computing Machinery (ACM)*, 40, 3, 11-16.
- OCS (1998) 'Technological Incubators in Israel', Office of the Chief Scientist, Ministry of Industry and Trade, Tel Aviv.
- OECD (1998) 'The Software Sector: A Statistical Profile for Selected OECD Countries', Directorate for Science, Technology and Industry, Paris.
- OECD (2000) '*Economic Survey: Finland*', July, OECD Paris and New York.
- OECD (2001) '*Measuring the ICT Sector*', Paris.
- O'Malley, E and O'Gorman, C (2001) 'Competitive Advantage in the Irish Indigenous Software Industry and the Role of Inward Foreign Direct Investment', *European Planning Studies*, 9, 3, 2001.
- Paija, L (2000) 'ICT Cluster – The Engine of Knowledge Driven Growth in Finland', ETLA Discussion Paper No 733, Helsinki.
- Reddy, P (1997) 'New trends in globalisation of corporate R&D and implications for innovation capability in host countries: A survey from India', *World Development*, 25, 11, 1821-1838.
- Roper and Frenkel (2000) Roper, S and Frenkel, A (2000) 'Different paths to Success – The growth of the Electronics Sector in Ireland and Israel', *Environment and Planning C*, 18, 6, 651-666.
- Roper, S Hewitt-Dundas, N and Savage, (2002) M 'Benchmarking Innovation Performance in Ireland's Three NUTS 2 Regions', Working Paper, NIERC, Belfast.
- Roper, S (1999) 'Israel's Technology Incubators – Repeatable Success or Costly Failure?', *Regional Studies*, 33, 2, 175-180.
- Ruane, F and Gorg, H (1997) 'Reflections on Irish Industrial Policy Towards Foreign Direct Investment', Trinity Economic Papers Series, 97/3, Dublin.
- Schienstock, G Koski, P and Rasanen, P (1998) 'The Regionalisation of the Finnish Innovation System – The Case of Pirkanmaa', in Braczyk, H-J et al. (eds), '*Regional Innovation Systems*', UCL Press, London.
- Shefer, D and Bar-El, E (1993) 'High Technology Industries a Vehicle for Growth in Israel's Peripheral Regions', *Environment and Planning C*, 11, 245-261.
- Shefer, D and Frenkel, A (1998) 'Local Milieu and Innovations: Some Empirical Results', *Annals of Regional Science*, 32, 185-200.
- Simmie, J (2002) 'Trading Places: Competitive Cities in the Global Economy', *European Planning Studies*, 10, 2, 201-214.
- Simmie, J., Hart, D., Sennett, J. and Wood, P. (2000) *Innovation in Europe: a Tale of Five Cities*, Working
- Simmons, D K (1993) 'An Evaluation Of Current Efforts To Promote Entrepreneurship In Israel', Unpublished Masters Thesis, Faculty Of Architecture And Town Planning, Technion, Haifa.
- Steinbock, D (1998) 'The Competitive Advantage of Finland: From Cartels to Competition?', ETLA/SITRA, Helsinki.
- Steinbock, D (2001) 'Assessing Finland's Wireless Valley; Can the Pioneering Continue?', *Telecommunications Policy*, 25, 71-100.
- Strambach, S (2002) 'Change in the Innovation Process: New knowledge Production and Competitive Cities – The Case of Stuttgart', *European Planning Studies*, 10, 2, 215-231.
- Susiluoto I, Loikkanen H (2001) : Seutukuntien taloudellinen tehokkuus 1988-1999. Helsingin kaupungin tietokeskuksen tutkimuksia 2001:9 (Efficiency of Regional Economies in Finland 1988-1999 - cited in Tukiainen, 2003)

- Teubal, M (1993) 'The Innovation System of Israel: Description Performance and Outstanding Issues' in Nelson, R R (ed) '*National Innovation Systems: A Comparative Analysis*', Oxford University Press, 1993.
- Trajtenberg, M (2000) 'R&D Policy in Israel: An Overview and Reassessment' NBER Working Paper No. 7930, October 2000
- Tukiainen, J (2003), 'ICT Cluster Study Helsinki Region', Helsinki Urban Facts Office, 2000.2.
- WITSA (2000) 'Digital Planet 2000: The Global Information Economy', World Information Technology and Services Alliance, Vienna.
- WITSA (2002) 'Digital Planet 2002: The Global Information Economy', World Information Technology and Services Alliance, Vienna.
- Yearly, S (1995) 'From One Dependency to Another: The Political Economy of Science Policy in the Irish Republic in the Second Half of the Twentieth Century', *Science, Technology and Human Values*, 20, 2, 171-196.
- Young S., Hood N. and Hamill J. (1988) Impact of inward direct investment on the United Kingdom, in *Foreign Multinationals and the British Economy*, pp. 63-101. Croom Helm, London.
- Young S., Hood N. and Peters E. (1994) Multinational enterprises and regional economic development, *Regional Studies* 28, 657-677.
- Zucker L G, Darby M R and Bewer M B (1998b) 'Intellectual human capital and the birth of US biotechnology enterprises', *American Economic Review*, 88, 290-306.