POLICIES FOR NEW PROSPERITY

Promoting Agglomerations of Knowledge Intensive Industries

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Policies for New Prosperity

How Agglomerations of Knowledge Intensive Industries Emerge

ABSTRACT

This paper explores how new agglomerations of high technology firms emerge. Policy makers in many regions have sought to create the local conditions and knowledge base that will allow a dynamic and innovative cohort of new high technology entrepreneurial firms develop. We outline local policy interventions that may be effective in seeding new agglomerations. We analyze the policy interventions adopted by two city-regions that have sought to develop new knowledge-based high technology industries. We conclude by arguing that policy makers can play an important role in creating new agglomerations, but that the development process is contingent on local conditions and, therefore efforts to directly transpose a development model from a successful district will be ineffective.

EXECUTIVE SUMMARY

The purpose of this paper is to explore if policy makers can encourage endogenous growth in city-regions that have experienced decline by transposing a model from a successful industrial district populated with high technology businesses. During the 1970s and 1980s many previously successful agglomerations of industries failed to respond to increased competition from low cost-cost regions or to the increased globalization of economic activity. However, many local regions, such as Silicon Valley and central Italy, and cities, such as Los Angeles and London, have continued to prosper.

The paper starts by examining how new industries emerge and the different explanations for agglomeration of new knowledge-based high tech industries. A second section outlines possible public policy measures that either individually or collectively could "seed" the development of an agglomeration of internationally competitive high tech firms. Potential policy interventions include the upgrading of factor conditions, stimulating entrepreneurial activity, building a knowledge base, stimulating information and knowledge flows, and attracting inward foreign direct investments from MNEs.

The paper then turns to two empirical cases of city-regions, namely Dublin, Ireland and Tampere, Finland, where policy makers have specifically sought to encourage the development of new high tech agglomerations. The Dublin case outlines how since the early 1990s a cohort of high growth, export orientated high tech firms has emerged. This new agglomeration has emerged as a result of the interaction of a number of policy interventions, including the industrial development strategy of attracting inward direct investment; substantial state financial aid for new indigenous software firms; the development of a technically educated workforce; and investment in the telecommunications system. Tampere Central Region, Finland, has experienced, within a relatively short period of time the emergence of a new information technology (IT) industrial sector. The emergence of the IT sector in Tampere was driven
by the global mobile phone supplier, Nokia Group, and by the high levels of both state and private R&D activities in IT. Tampere is characterized by a strong endogenous science and technology base. Additionally, policy makers in Tampere have employed a strategy of building institutions and social capital.

This paper explores a number of important issues in relation to the seeding of a new industrial district. First, we explore what is the role of public policy makers in stimulating new industrial activity and what constitutes appropriate policy? This research suggests that a broadening and deepening of what constitutes industrial policy is essential to the development of policy interventions that might seed new agglomerations. Specifically policy makers need to shift from sector and industry-specific subsidies and arrangements towards cluster policies. However, policy makers still face the dilemma of whether a market driven model based on informal co-ordination, collaboration and innovation transfer, or a model of supporting the local industrial milieu through local governance structures, is more effective at seeding a new industrial district?

Second, we explore the role of inward foreign direct investment in the development of indigenous competitive advantage? This research suggests that inward FDI can play an important role in seeding the development of a new agglomeration, but that the impact of inward FDI is highly contingent on the specific nature of the MNE operation, the characteristics of the host economy and the nature of the interaction between them. Third, we explore if city-regions should seek to specialize when promoting new industrial districts? Policy makers in city-regions in small open economies are faced with the dilemma that the cost of limiting the risk of specialization, that is greater diversity, is the loss of the present benefits of specialization.

In conclusion, this paper suggests that timely public policy interventions at innovation system, “industry” and firm level can play an important role in seeding new knowledge-based high technology industries, but that the process of industrial district formation is contingent on local processes and conditions and, therefore, efforts to directly transpose a development model will be ineffective. A more fruitful approach to the development of effective industrial policy interventions might be to seek a deeper understanding of local development processes. This might involve the use of studies of other regions as benchmarks for performance and as a source of ideas, rather than as a source of a model for development.
INTRODUCTION

The transformation of the global economy during the 1970's and 1980's resulted in the decline of many traditional industrial agglomerations in Western European cities. Job losses in industries such as textiles, brewing, steel, and mechanical manufacturing resulted in high unemployment, inner-city decay, and urban social problems. Previously successful agglomerations of industries failed to respond to increased competition from low cost-cost regions or to the increased globalization of economic activity, factors that had been facilitated by political, social, technological, and economic forces.

However, many local regions, such as Silicon Valley and central Italy, and cities, such as Los Angeles and London, have continued to prosper in this new global environment. Paradoxically it would appear that the sources of global competitiveness are increasingly dependent on local economic, political and social institutions and processes. The relative permanency of spatial heterogeneity among cities and regions is dependent on the balance between localized increasing returns to scale and the transaction costs of overcoming distances (Krugman, 1995); on the dynamic process of competition and co-operation between firms that facilitates the development and exploitation of assets and resources (Porter, 1990); on the presence of socially and institutionally mediated forms of selective co-operation between actors (Best, 1990; Cooke and Morgan, 1998) and on the presence of what is loosely refereed to as the innovation milieux (Aydalot, 1986).

Urbanization economics and localization economics suggest possibilities for a renewed role for public-policy makers in local economic development. In particular, policy makers in many regions have sought to counter the decline in traditional industries by developing new knowledge-based high technology industries. Policy makers have sought to emulate and replicate successful city-regions and industrial districts by developing a "technopolis" (Preer, 1992), by supporting clusters of industries (Porter, 1990), and by facilitating the development of an innovation milieu (Aydalot, 1986). While these policy responses have been based on attempts to draw general lessons from successful new industrial districts, few authors have explained how agglomerations of new knowledge-based high technology industries develop and what policy interventions can best "seed" the development of these new industries in city-regions which have experienced urban decline.

The purpose of this paper is to explore if policy makers can encourage endogenous growth in city-regions by transposing a model from a successful industrial district populated with high technology businesses. The paper starts by examining how new industries emerge and the different explanations for agglomeration of new knowledge-based high technology industries. A second section outlines possible public policy measures that either individually or collectively could "seed" the development of an agglomeration of internationally competitive high technology firms. The paper then turns to two empirical cases of city-regions, namely Dublin, Ireland and Tampere, Finland, where policy makers have specifically sought to encourage the development of new knowledge-based high technology industries. The paper concludes by exploring how the role of public policy in developing new industries has changed in many European regions in response to these new explanations for agglomeration of new knowledge-
based high technology industries. In conclusion, this paper suggests that timely public policy interventions at innovation system, “industry” and firm level can play an important role in seeding new knowledge-based high technology industries, but that the process of industrial district formation is contingent on local processes and conditions and, therefore, efforts to directly transpose a development model will be ineffective.

LITERATURE REVIEW

The emergence of new industries

This paper focuses on the local aspects of industrial agglomeration and especially on the question of how new knowledge-intensive agglomerations can be promoted within a city-region. The development of new firms and entire industries is based on major new product and service innovations which open up new markets or on new ways to produce or distribute these products and services. These innovations may take place in existing firms, but they may also often start as new business ventures originated, for example, from a large firm or a research institute. The potential of a region to establish new industries depends on the capability to produce new knowledge in the relevant scientific and technological fields or on the capability to quickly absorb and exploit knowledge created elsewhere.

While firm size and demand conditions are important determinants of innovation activity, technological opportunities and appropriability conditions may have a more significant influence on innovative activity. These latter factors have a crucial effects on innovation intensity, on industrial agglomeration tendencies, and on new, small firms’ market entry choices (Breschi and Malerba, 1997). High opportunity conditions, lot of possibilities to apply new technologies, combined with high possibilities to appropriate the profits from an innovation create the potential for a company to reap high returns from its innovative efforts and pioneering position. However lower appropriability conditions with positive spillover effects may be more favorable to faster innovation and the emergence of a new industry.

New technology intensive firms and industries often start as spin-offs from research laboratories and large companies. The following conditions in the local milieu and in the home market are conducive to increased new firm creation: close and trusting co-operation between producers and customers which supports the collective learning processes; a market which is easy to survey and which allows reliable anticipation of future demand; and the absence of intensive competition and the presence of specific advantages for ‘insiders’ (Lovio 1985). Furthermore, due to growing complexities of industries and technologies, firms very seldom innovate in isolation. In pursuit of innovation, firms interact and build networks with other organizations to create, develop and exchange various kinds of knowledge, information and other resources.

However as a technology intensive industry emerges, access to export markets becomes critical. This is particularly the case for small countries with small domestic markets. Therefore it is crucial to
have both a local market, with advanced users capable of absorbing technological innovations, as well as firms integrated into the global market for the successful development of a new industry or industrial cluster. Also it may be necessary to have some strong “growth engines” which have succeed in international markets and thereby open channels for small firms to follow.

Models of industrial agglomeration

Given the importance of the local environment to innovative activity and the emergence of new industries, we now briefly introduce three variations of how new agglomerations of knowledge-based industries emerge. The first, the so-called technopolis model, is close to the traditional technology-push model focused on development and commercialization of high-technology. The concept of technopolis refers to a geographical agglomeration of high-technology activities (‘science city’) whose objective is to successfully commercialize technology to create wealth and high-value jobs (Gibson & Stiles 2000). Traditionally, a major challenge faced by technopoleis has been to create and foster regionally-based cooperation across academic, business, and government sectors. Another challenge has been to encourage the births of spin-off and start-up firms in the Technopolis.

The second, the (regional) cluster model, focuses on the (geographical) propinquity of firms developing and using similar and related products and technologies in order to produce positive-sum gains for innovation. Porter (1990) popularized the view that the development of internationally competitive firms depends on the presence of clusters of industries that exploit the attributes of their home city-region or country. Porter's model suggested that the critical competitive factors no longer involved factors such as labor costs, resource availability and the general macro-economic environment but rather qualitative factors of the local environment that are intensified through clustering (Gordon, 1999).

The third, the (regional) innovation system model, widens the focus towards an analysis of different institutional settings stimulating or restricting interactive communication, learning, and innovation. The innovation systems approach assumes that the most fundamental resource in contemporary economies is knowledge, that the most important process is learning, and that learning is predominantly an interactive and, thus, a socially embedded process, which cannot be understood without taking into account its institutional and cultural context (Lundvall 1992). These institutions include the financial, educational, and science and technology institutions as well as a vast array of other institutions affecting the creation, diffusion, and adoption of innovation and technology.

Policy interventions aimed at supporting the development of new industries

Policy makers in many regions have sought to facilitate the development of high technology agglomerations through direct policy interventions. We now explore the policy interventions that might be important in facilitating the development of new high tech agglomerations. However, there is evidence
that the development of existing successful agglomerations are partially explained in terms of many path dependent and chance events.

In general, there has been a broadening and deepening of what constitutes industrial policy in many European regions. A number of key changes can be identified (Lundvall 1999). First, there has emerged a major shift from sector and industry-specific subsidies and arrangements towards cluster policies. These cluster approaches have sought synergies between industries, firms and other actors within wide resource areas. These cluster policies have also often increasingly included relevant services in their sphere of influence as these often represent the most rapidly growing sectors of the economy, and as the boundaries between manufacturing and services have become increasingly blurred. Second, the distinction between several policy approaches has become less salient and, related to this, innovation policy has become more central to industrial policy. Third, the innovation systems approach has been widely adopted as a model to analyze structures and processes crucial to industrial performance at the country level. This directs policy-makers’ attention towards linkages and interactions within and between different subsystems and towards actions that will improve the innovation capacity of the whole economy.

**Upgrading factor conditions**

The international competitiveness of firms is dependent on the presence of local resources, such as labor market pooling, specialized inputs and services, and knowledge and information. An important part of developing an agglomeration is therefore the investment in resources and the institutions that create and develop resources. The role of government is to facilitate the development of resources from "basic" to "advanced" factors; to invest in developing technologies and capabilities that are common to all the industries in a cluster; and to develop the labor force through an open and competitive labor market. Investment in resources and infrastructure will usually involve investments in the education system, in industrial training, and in research activities within firms and within research institutions such as universities.

**Stimulating entrepreneurial activity**

Entrepreneurs are essential agents of change in a well functioning market economy and a competitive small-firm structure can foster innovation and facilitate the exploitation of technological and organizational innovations. City growth has been linked to the localized spread of ideas and knowledge, with industries exhibiting faster growth in cities where firms are smaller than average industry size (Glaeser et al., 1992). A small firm structure is seen as essential to the stimulation, development and exploitation of knowledge. Consequently policy makers have sought to stimulate entrepreneurial activity and the growth and development of SMEs by providing venture capital and preferential loan finance; by offering favorable tax incentives; by removing impediments to business start-up; by providing management training; and by providing business advice through mentoring schemes. However, there is
evidence that many small business supports are ineffective; that larger firms with a degree of local monopoly are better at encouraging innovation because they can internalize and capture the benefits; and that the faster growth observed in small firms is the due to the arithmetic relationship between size and growth.

**Building a knowledge base**

There are three different knowledge bases important for stimulating innovative activity (Oerlemans et al. 1999). First there is the general scientific knowledge base, which is essentially public and codified, and is often published in scientific journals or transmitted by channels such as conferences. The scientific knowledge base is highly differentiated internally and its relevance for industrial production and innovation varies significantly. Also firms’ ability to make use of this knowledge varies significantly, and is often dependent on interfaces such as R&D units within a firm or external institutions to mediate information flows. Governments can seek to encourage the development and exploitation of this knowledge through mediating institutions such as research institutions, actors like technology licensing offices, innovation centers, and measurement, testing and certification laboratories (Autio, 1998). In sectors characterized by rapid technological development, scientific infrastructure plays a substantial role whereas intermediating institutions typically are of less importance (Carlsson, 1997). However, the role intermediating institutions play may increases as an industry matures.

The second category of knowledge base exists at the level of the industry or product field. This knowledge base consists of shared understandings of, for example, technical functions, performance characteristics, and use of materials for products and processes. Policy makers can seek to increase the development and exploitation of this knowledge through institutions like professional and vocational education and training organizations, trade organizations, and consultants together with the most fundamental actors within production chains – suppliers, customers, and other firms like partners and competitors. The third level of knowledge base occurs at the level of the firm. As such it is highly localized and specific and forms the basis of a firm’s competitive position. This knowledge base is not only technical, but also includes competencies related to functions such as financing and marketing.

**Stimulating information and knowledge flows**

To enhance knowledge flows, it is essential to recognize that industrial sectors differ considerably it terms of their use of knowledge, in their innovation processes, search procedures, and sources of knowledge and information (Nelson and Winter, 1982; Pavitt, 1990). Policy-makers can enhance flows of knowledge by subsidizing investments in capital embodied technology (new equipment, materials, software etc.); by easing access to codified, disembodied knowledge (scientific publications, seminars, patent information, electronic databases etc.); and by encouraging human embodied information and knowledge flows by, for example, education and training schemes, professional mobility and rotation programs, the creation of science parks and new business incubators, research and development co-operation programs and
networks within industry and between industry and science and technology institutions, and schemes to
develop supplier-user co-operation within production chains.

Another dimension of encouraging knowledge flows between actors within a given system relates
to the so-called absorptive or dynamic capability of the firm. Firms vary considerably in their abilities to
access and exploit external resources in their environment, as well as in their abilities to define and
develop their own internal competences to create competitive advantage (Dodgson & Bessant, 1996;
Arnold & Thuriaux, 1997). Firms must develop strategic capabilities in searching for new market
opportunities, and in understanding and managing the fit between the firm’s capabilities and market
needs. In addition, a firm needs internal capabilities to manage its tangible and intangible knowledge
base. Further, a firm also needs external capabilities to access external knowledge bases, to manage its
producer-user relations, and to access partners if complementary assets are needed.

Education and training both increases the general stock of human capital and enhances learning
capability thus inducing innovation activities. Flows of human capital can be mediated through
institutions such as regional labor offices, career planning offices, recruitment centers, and various
initiatives that couples the labor needs of the companies with the supply of labor. A circulation of skilled
workforce, together with inter-firm imitation processes, contributes to the overall collective learning
processes among firms at a regional or local level. In stimulating information and knowledge flows, there
is an important task for regional policy-makers to launch initiatives that build bridges between
“hothouses” of successful and emergent industrial districts, and which connect their own region with
other matching regions in the world (Sölvell & Zander 1998). These relationships reduce the barriers to
entry between these markets and provide easier access to external sources of technology, thereby
facilitating the growth and internationalization of newly established ventures.

Attracting inward foreign direct investments by MNEs

City-regions compete for FDI (Gordon, 1999). The policy of attracting inward FDI is an important
economic development strategy of many city-regions that have experienced high levels of unemployment.
For policy-makers inward FDI provides a number of potential benefits to the host economy, principal
amongst these is employment growth. However inward investments featuring relatively autonomous
decision-making, high skilled and high value-added functions, and long-term collaborative local linkages can
also become deeply embedded in the local economy, support the development of local firms and encourage
self-sustaining growth of inter-linked industry clusters. Inward FDI can sometimes serve to “seed” a cluster,
by acting as sophisticated customers or as related industries. Foreign MNEs can encourage the development
of associated local industry clusters by two principal routes, the development of local sourcing of inputs or the
development of R&D and technological innovation capabilities.
RESEARCH METHODS

The cases described below seek to explain how Dublin and Tampere developed agglomerations of firms in new knowledge based industries. In analyzing these two cases we use an innovation systems approach. This approach involves an analysis of the key actors, the nature of interactions between these actors, and the innovation processes that these actors and constellations perform. Within the innovation systems approach, research and analysis has been practiced through several ‘lenses’, including the national, regional, technological and sector ‘lenses’. Our focus is primarily on the regional aspects of development. Our analysis is based on the assumption that there are several reasons why in a contemporary economy characterized by increasing global forces, a local/regional dimension is still an important determinant of firms’ innovative activities (Lundvall & Borras 1998, Porter & Sölvell 1998, Howells 1999). First, formal and informal contacts between network members are made possible through casual and/or planned information exchanges and meetings, and customer-supplier relationships. Second, synergies can emerge from the shared cultural, psychological or political perspectives of actors engaged in the same specialization in the same economic region. Third, the localized pool of specialized expertise and knowledge in a region contains a considerable amount of tacit knowledge embedded in the system and its networks, and is therefore difficult to transfer to another locality.

The Dublin case describes and explains how in the short time of a decade a dynamic, internationally competitive sector emerged in Dublin. The case is based on interviews with leading actors, firms, and policy makers. The owner-managers of 36 software firms were interviewed. The purpose of these interviews was to explore how and why these companies had developed. The number of companies interviewed represented just over 9 per cent of the 390 indigenous companies in the industry, but they accounted for about one-third of indigenous employment since most of the largest firms were included. We interviewed policy makers and other key informants (e.g. National Software Directorate, University Industry Liaison Officers, Industrial Development Executives). We used published data to support propositions suggested by the interviews, e.g. comparative data on education, etc.

The Tampere case describes and explains how a dynamic, fast growing IT sector emerged and expanded during the 1990s. The case draws from a number of projects which have sought to describe and explain the emergence and nature of the IT sector in Tampere. The case is based on interviews with key experts representing firms, consultants, research and education institutes and public authorities. In these interviews the focus has been to discuss whether, and to what extent, the IT sector has the characteristics of an emerging innovation milieu, and to identify the policy options that might support this development. Data from research reports, statistics, and annual reports is used to support propositions suggested by the interviews, e.g. data on employment, bottlenecks of business development, etc.
CASE ANALYSIS

Case 1: the software industry in Dublin

Ireland was a relative latecomer to industrialization. The industrial development policy response to the slow development of indigenous industry has been to pursue a very aggressive policy of attracting inward invest from overseas multinational enterprises. This policy has proved successful in a number of sectors including Chemicals and Pharmaceuticals, Financial Services, Electronics and Computer Manufacturing. In fact, by the 1980s Ireland was the fifth largest manufacturer of computers in the world. However the cyclical nature of some of these industries, the mobility of international investment and the recession in the 1980s lead to a series of high publicity plant closures. An industrial policy review in the 1980s suggested that Ireland needed to develop its own indigenous industrial base and to be more selective in attracting inward FDI projects (National Economic and Social Council, 1982).

During the 1980s the industrial development agency became more aggressive in targeting FDI projects that required a skilled workforce, that had potential for sub-supply activities to indigenous firms, and those that would locate an important strategic function in Ireland. One industry that met these criteria was the emerging software industry. The industrial development agency targeted producers of large packaged software products and attracted these to Ireland. Overseas software MNEs were attracted to Ireland because Ireland provided access to the European market, low corporate tax rates, generous employment grants, and a readily available highly skilled relatively low cost workforce. The major overseas firms in Ireland include subsidiaries of many of the world’s largest software companies, such as Microsoft, Oracle and Lotus. When these companies first located in Ireland these overseas MNEs engaged in manufacturing operations. Subsequently, the Irish subsidiaries began to localize the software for overseas markets. In response to the demand from these MNEs a strong supplier base of both indigenous and overseas companies developed. Subsequently customer support activities and some software development activity were located in Ireland.

Ireland is now the fifth largest producer of software in the world, and the world’s second largest software exporter with more than half of all sales in Europe of software packages for personal computers originating in Ireland. The majority of this high volume of output and exports is attributable to the large amount of inward foreign direct investment by MNEs. However, the indigenous software sector has over 550 firms, employs over 9,000 people and exports nearly 70% of all output. Between 1991 and 1997 the overall growth performance of the indigenous software industry has been strong, with output growing at 23% p.a. and exports growing at the higher rate of 35% p.a. (Table 1). By the late 1990s the indigenous sector provided as many jobs as overseas MNEs.

This case seeks to explain how in the short time of a decade this dynamic, internationally competitive sector emerged in Dublin. The development of the indigenous component of this new high technology sector in Dublin occurred in the context of rapid growth in demand in world markets for software products in the 1980s and 1990s. However this does not explain why a small region such as Dublin became such a significant beneficiary of this growth. The development of the indigenous software sector in Dublin can be attributed to the following factors.
Domestic demand

Compared to most other countries MNEs are relatively more important in the Irish economy. These MNEs acted as important customers to indigenous software firms and played an important role in strengthening the capabilities of many indigenous software firms. For example, of the indigenous software firms interviewed for this research, about one-third of the firms had half or more of their sales in Ireland going to subsidiaries of overseas MNEs; about a quarter of those interviewed explicitly stated that overseas MNEs in Ireland were important initial customers; and for about two-fifths of those interviewed, selling to overseas MNEs in Ireland had helped directly to provide access to export markets. Additionally, overseas software MNEs subcontract or outsource a variety of functions to indigenous firms. Most of the indigenous companies, which perform these outsourced functions developed mainly because of the demand from the MNEs concerned.

Educated workforce

Ireland had a high skilled workforce, many of whom had skills suitable to the software sector. Dublin had a comparative advantage in education during the 1980s and 1990s. The third-level education system in Ireland is relatively highly focused on courses relevant to the software industry, and during the late 1980s and early 1990s the supply of technical graduates expanded rapidly. The availability of an educated skilled workforce was a direct consequence of the state responding to the needs of overseas MNEs in the electronics, computer hardware manufacturing and engineering sectors. The third-level education system in Ireland is, in fact, relatively highly focused on courses that are relevant to the software industry. Degrees in “mathematics and computing” amounted to 5 per cent of all degrees awarded in 1992, which was the fifth highest percentage among all OECD countries (OECD, 1995, Table R15). Viewed in relation to the size of population, the number of mathematics and computing graduates again looks high in Ireland compared with most other countries. The number of math and computing degrees awarded in Ireland in 1992 amounted to 1.05 per cent of the population at the typical age for graduation; this was the fifth highest figure among OECD countries and it was 40 per cent higher than the OECD average figure of 0.75 per cent (derived from OECD, 1995, Tables R12 and R15).

State aids for new venture creation and development

The development agency responsible for supporting indigenous industry has provided extensive support and encouragement for SMEs involved in manufacturing software products. These supports include low taxes on profits made from exports, generous employment grants, research and development grants, feasibility study grants, management development grants and advice and support for exporting and strategic planning. Most indigenous software companies availed of state financial aid in some form (Clarke,
1995). The main impact of such financial aid was that it provided cash flow during the product development process, allowing firms to hire employees earlier and reduce the product development cycle. Additionally, this financial aid enabled firms to build sales faster and to take risks they might otherwise not have taken (Clarke, 1995).

About one third of the companies in our survey reported that the state development agencies had influenced their strategy or goals, most commonly by encouraging and assisting them to develop exports. State supports were limited to start-ups and SMEs engaged in manufacturing software products for export markets. This meant that in Dublin, unlike in most other regions, new technology firms become focused on export markets from a very early stage of development.

The development agency also sought to increase the flow of private capital into the industry. This was achieved by the co-founding of a number of venture capital funds targeted at software companies. Furthermore, a number of high profile IPOs by indigenous Irish companies on the NASDAQ exchange in the 1990s resulted in a dramatic increase in the availability of finance for new software start-ups. By the mid 1990s US venture capitalists from the Boston and Silicon Valleys regions recognized the potential of Irish software firms and started actively soliciting business in Dublin.

**Telecommunications Infrastructure**

The state made a substantial investment in upgrading the telecommunications network in the 1980s. The existence of a good quality telecommunications system is an important condition for most software companies, but it seems that having it does not necessarily give them a great competitive advantage since other countries have it too. However, the telecommunications infrastructure was a relative competitive advantage for Ireland earlier on, when Ireland had a relatively sophisticated system.

**Incubators**

The principal sector, which is the immediate source of “spin-offs” of indigenous software firms, is the indigenous software industry itself. Most of the founding entrepreneurs of the firms in our survey had been working in Irish indigenous firms immediately prior to starting their companies. About one-third of the founding entrepreneurs had been working in foreign-owned MNEs immediately prior to start-up. It is notable that Irish software entrepreneurs have very commonly gained some experience in foreign MNEs in Ireland, as was the case for about two-thirds of those in our survey. About half of them had also worked abroad in software or a related sector at some time before starting their company, and about half had at some time worked in a sector, which now constitutes a major customer for their company.

**Does Dublin represent an emerging high tech agglomeration?**

There are a number of reasons why the Irish software sector can be described as an emerging industrial district. First, the development of the software sector is highly concentrated within Dublin city and the surrounding areas. Two-thirds of indigenous software firms are in the Dublin area alone. For comparison, the
Dublin area has just 28 per cent of industrial establishments and 26 per cent of industrial employment. Second, the strong growth, with a particular emphasis on export growth, suggests that this emerging sector may be regarded as internationally competitive. The growth rate of the Irish indigenous software industry has been far outstripping growth in international demand in the 1990s, indicating that it has been gaining a rapidly increasing market share and can therefore be regarded as internationally competitive. Third, indigenous firms currently have sufficient scale to compete on international markets. While most firms in this sector remain small (average employment of 16 employees) there are quite a number of far larger companies in the software industry internationally. However, a survey of the US software industry found that 51 per cent of responding companies had sales revenues of less than $1 million and average employment of 8; a further 34 per cent had sales revenues of 1 to 10 million dollars and average employment of 35; and 8 per cent had sales revenues of 10 to 50 million dollars and average employment of 158 (Price Waterhouse LLP, 1996, p.28). This looks very similar to the size structure of the Irish indigenous industry, and it is only the remaining few percent of US companies that are of a much larger scale than Irish companies. Fourth, an important characteristic of many successful industrial districts is that firms in the sector benefit from the presence of other firms through informal networking. There is some evidence that this is the case in the indigenous software sector. About half of the firms in our survey do co-operate with other software firms in Ireland. Nearly all of these co-operate with other indigenous software firms, while about half of those that co-operate also co-operate with foreign-owned software MNEs in Ireland. In terms of whether social interaction with other software companies in Ireland is important for their business, e.g., for informally exchanging technical or market information, a majority of the firms we interviewed said that social interaction with other companies is not significant for the success of their business. Fifth, an important measure of the sustainability of this success is the amount of research & development (R&D) activity in firms. Firms in the indigenous software industry undertake an exceptionally high level of R&D. R&D expenditure amounted to over 10 per cent of the value of sales in the indigenous software sector in 1995. Among those indigenous software companies who do actually perform R&D, R&D expenditure was 18.4 per cent of sales in 1993, compared with an average figure of 1.5 per cent for R&D performing companies in all sectors of the Irish economy.

However, there are several factors that may prevent the further development of this sector in Dublin. There is significant competition for skilled employees and software firms are experiencing particular difficulty in sourcing skilled employees. This problem is a direct result of the success of the industry. A second significant concern is the development and availability of infrastructure, in particular telecommunications infrastructure. Many firms report the lack of availability of competitively priced fast broadband infrastructure is constraining development. Third, there is concern among policy makers that the low level of spin-off from universities and the relatively low levels of commercialization of research developed within universities may hamper the development of the sector.
Case 2: the IT industry in Tampere

The industrial structure of Finland has changed exceptionally fast and profoundly during the post-Second World War period: changing from an agricultural to industrial society during the period from the 1950s to the 1970s, and then from an industrial society towards a knowledge-based economy during the past few decades. For example, in 1970, the electronics sector accounted for just two percent of total Finnish exports, by 1990 this was 11 per cent and by 1999 this had increased to 29 per cent. Similarly, during the period 1990 to 2000 the production and exports of electronics and information and communication technology-based products increased fivefold (Valtion tiete- ja teknologianeuvosto, 2000).

Tampere central region, the second largest urban region in Finland, has always had a central position in Finland as an industrial region. Tampere was industrialized as early as in the 1840’s as cotton mills were established in the banks of Tammerkoski rapid. Later in the 19th century paper mills and metal manufacturing emerged. Food and chemical industries grew in importance in the beginning of 20th century. During and following the Second World War, metal and machine building industry’s emerged as important sectors. However, by the mid 1970’s, due to the oil crises, industrial restructuring began and manufacturing employment began to decrease. During the early years of the 1990’s, the collapse of trade with the Soviet Union, a bank crisis in Finland, and the structural economic problems of the Finnish economy resulted in a deep economic crisis that impacted on Finland and Tampere in a profound way. Employment, investment, industrial production, and exports declined dramatically, resulting in high unemployment.

In the beginning of the 1990’s it became evident in Finland that traditional industries alone would not form a sound basis for future employment growth. The deep recession made possible substantial shifts in the strategies of the national and regional public authorities. A wide consensus was established among firms and public authorities that the IT sector offered the best possibilities for maintaining and renewing the industrial base. The policy response, referred to as a ‘national project’, to the industrial crises of the 1990s was intensive public and joint private-public initiatives and activities to support the development of the IT cluster, both at the national level and specifically within several regions, including the Tampere region (Valtion tiete- ja teknologianeuvosto, 2000). Approximately a half of the research expenditure in Finland, including both the private and public finance, is currently spent on maintaining and increasing the competitiveness of the IT and related industries. In education, approximately 35 per cent of the students from the universities and polytechnics graduate in subjects related to IT. In addition, public and private actors have agreed on and carried out large programs to train graduates of other subjects in response to the increasing needs of the IT sector (Tiede- ja teknologianeuvosto, 2000). However, in addition to this strong public initiative, Nokia, the world’s leading mobile phone supplier, played a critical role in the transformation of the Finnish economy, for example, Nokia now spends approximately the same annually on R&D as the Finnish state, and files by far the largest number of patents in Finland.

Tampere has been able to maintain its position as an important industrial region by successfully introducing new industries, most recently in the fields of information and telecommunication technologies. In less than five years, the IT sector more than doubled its size in Tampere. In 1996 there
were a total of 170 firms, employing 5,200, with a total output of 4,590 million FIM (772 million euros). Employment increased in private firms from 3,000 in 1994 to 6,750 in 1997, an increase of 125.2 per cent (Tampere Center of Expertise 1998). By 2000, the IT sector employed approximately 10,000 people, and if the Media and New Media sub-sector and the related Services and Commerce sub-sector are included, employment is 15,500 people. (Statistics Finland 2000). The IT sector in Tampere is very diversified, consisting of six main areas, which are increasingly converging into a digital media cluster.

Why, then, did the IT sector develop in Tampere, a region that experienced significant industrial decline during the 1970s and again in the beginning of the 1990s? The birth and rapid growth of the IT sector in Tampere has been based on several factors, which are discussed below (Kautonen & Kolehmainen 2000; Schienstock et al. 1999; Kautonen & Tiainen 1999).

Public policies

Despite traditionally pursuing a relatively non-interventionist industrial policy, there have been intensive public initiatives and activities to support the development of the IT cluster, both at the national level and in several regions in Finland, including Tampere. While research and development expenditures remained low until the 1980s, amounting to only slightly more than 1 percent of GNP in 1980, they rapidly grew during the 1980s and 1990s, exceeding 2 percent of GNP by the late 1980s and 3 per cent by 1999. The Finnish government initiated large programs of research in target technologies, especially those related to information and communication technologies. The national and regional governments also sponsored technology parks that provide facilities for co-operative R&D projects involving industry and local universities.

In Tampere, the Tampere Center of Expertise Program acts as a catalyst in promoting new developments and bringing different actors together. It also acts as a mediator between national level financiers and service suppliers and local firms. The development projects coordinated by the program cover all the factors that are relevant to business success: technology, sales and marketing, production, education and training, finance and administration. In addition to development projects carried out with firms and firm-service organization networks, the program has also sought to identify gaps in the regional system of innovation. It has then initiated and facilitated the establishment of new solutions and institutions to overcome these gaps.

Nokia Group – the growth engine

The growth and internationalization of the Nokia Group has had a large impact in Tampere. Nokia was founded in Tampere central region in 1865 as a wood-pulp mill, grew into a conglomerate encompassing industries ranging from paper to chemicals and rubber, and by the 1990s it had streamlined into a telecommunications company. In the beginning of the 1990’s, Nokia employed only about 200 people in Tampere; today it employs 3,600 white-collar workers, almost all in R&D functions. Nokia has
concentrated much of its new generation mobile Internet R&D functions to its Research Center, located in Hermia Science Park, in Tampere.

**Educated workforce**

The Tampere region has a large supply of university graduates in the field of IT. The two local universities and several other educational institutes played an important role in providing suitably skilled workers for the emerging IT industry. Overall, 28 per cent of inhabitants (older than 15 years) in the region have a university degree (Tampereen kaupunginkanslia 2000). Tampere University of Technology (TUT) and the University of Tampere produce more than 200 graduates annually in the fields of electronics, information and communication technologies, and new media. This is accompanied by a high number of graduates from other educational institutes, strongly specialized in IT applications.

The local labor in Tampere is characterized by relatively low labor mobility. This has the negative effect of reducing the rate of technological spillovers from R&D intensive firms, though on the positive side it has been argued that lower rates of labor mobility have encouraged firms to invest in the development and training of the workforce. Salary levels in Tampere are lower than those in Helsinki, resulting in a relatively higher growth in employment in Tampere. Another factor favoring Tampere is that surveys have consistently shown that Tampere is the most popular city in Finland to live in.

**Local industrial base**

One of the roots of the IT sector in Tampere was the machine building industry, as process equipment became increasingly dependent on electronics and amalgamated software. In addition, the co-location of several large, internationalized paper and metal industry companies, together with public authorities, offered an important client-base for new small IT firms. More recently, the media conglomerate Alma Media and the television-broadcasting corporation TV 2 have been important components of the regional IT cluster in Tampere.

**Close university-industry co-operation**

The region has a strong indigenous science and technology base, which matches the needs of industry, due to a long tradition of university-industry co-operation and high-level research conducted in the two local universities (Jones-Evans 2000). The University of Tampere and Tampere University of Technology (TUT) played a crucial role in the emergence of the IT sector in Tampere as their key personnel established some of the first companies in the field. University-industry co-operation here been achieved through high labor mobility especially between TUT’s and companies’ staff; university initiatives such as part-time professorships for experts from industry; and the importance of external funding of research activities (about 60 per cent of TUT’s research expenditure is funded from external sources). TUT played a central role in fields such as digital signal processing for the Nokia Group in the beginning of the
1990’s, and the university continues to be an important partner for Nokia and several large U.S. companies.

“Laboratory of information society”

The information and communication infrastructure in Tampere is highly developed because the region has acted as an important test laboratory for the new “information society”. Finnish consumer markets have been receptive to new IT applications (e.g. internet banking, WAP protocol, etc.). In addition, many of the services of public sector service providers such as schools, libraries, and municipalities are accessible through the Internet.

Does Tampere represent an emerging high tech agglomeration?

There are a number of reasons why the IT sector in Tampere represent an emerging and sustainable industrial district. First, there is an agglomeration of diversified IT activities and related strong R&D functions in Tampere central region. The company base in IT consists of several large, internationally successful companies and a large group of small firms, many of which are experiencing high growth. There are some large, international IT companies in Tampere, the largest of these being the Nokia Group. Approximately 250 small and medium-sized IT firms and business units are located in the region. Second, there is also a strong indigenous science and technology base, based on two local universities and other public and private R&D facilities in the region. Tampere central region is the second most important center for research and development in Finland. It has a 14 per cent share of national expenditure on R&D. Approximately 70 per cent of the R&D expenditure in Tampere Central Region is private investment. The region accounts for 12 per cent of patent applications in Finland, approximately 300 applications p.a. Third, heavy investments in R&D from the mid-1990’s in a wide population of firms in Tampere seems to have paid off well. The statistics suggest that the fairly static development in rates of productivity growth and exports that characterized Tampere in the early 1990s were replaced by higher growth rates from 1997 onwards. For example, for 1997-1998, productivity growth for Tampere was 22.8% compared to a national rate of 6.2%; and growth in exports for Tampere was 65.5% compared to a national rate of 10.9% (Statistics Finland, 2000). Fourth, there are a proportionately large number of different private-public partnerships in the region, indicating a high accumulated social capital. The Center of Expertise Program connects many different stake-holders therefore facilitating the planning of new initiatives and collective actions.

On the other hand, there are also some problems, which may hinder the future growth of the IT sector in Tampere. First, as in the case of Dublin, there is a problem resulting from the success of the sector, IT firms are experiencing particular difficulty in sourcing skilled employees. Second, the number of new business establishments has been rather low, if related to the overall company base of the region and to high possibilities offered by a vast amount of research conducted in the local universities and R&D intensive firms. Despite lots of efforts to facilitate and encourage university spin-offs, researchers in
universities have either chosen to continue their career in the university or they have chosen to work for one of the large companies in the region. Third, inter-firm networks seem not to occur at the same rate as private-public partnerships, with the exception of dyads between producer and user firms (see Kautonen & Tiainen 2000). This lack of inter-firm networking is partly due to ongoing technological convergence and industry consolidation, which has led to mergers between firms. However, project-based partnerships are often established, but these seldom seem to be of strategic importance.

DISCUSSION AND CONCLUSIONS

This paper explored the role of policy makers in the development of new clusters of knowledge-based industries. In both Dublin and Tampere there has been an explicit attempt by policy-makers to encourage the development of new knowledge based industries. The literature suggested that policy makers pursue a number of strategies to encourage the development of new agglomerations of high technology industries. These include the upgrading of factor conditions, stimulating entrepreneurial activity, building a knowledge base, stimulating information and knowledge flows, and attracting inward foreign direct investments from MNEs.

In the case of the software sector in Dublin the industrial strategy of attracting inward direct investment produced many unanticipated benefits. The success of this policy was dependent on the presence of sophisticated factor inputs, most importantly in terms of a technically educated workforce and a sophisticated telecommunications system. Consequently, the Irish government invested heavily in developing these factor inputs. However, this investment had to be combined with significant “on the job” learning in MNEs in a broad range of sectors, before a sufficient knowledge base emerged that facilitated the development of new software ventures. This policy also resulted in a domestic market of sophisticated customers, many of whom were internationally competitive firms. Furthermore, these unanticipated timely benefits were combined with substantial interventionist public policy measures to produce a cohort of export orientated indigenous software firms. These policies supported export orientated software producers by grant aiding the software development process. However, it is only in the past few years that industrial policy makers have explicitly sought to create a knowledge base by encouraging both the development and exploitation of research at third level educational establishments. In addition, policy makers did not seek to encourage the flow of information through the development of networks among indigenous firms.

In the case of the IT sector in Finland, substantial state investment in R&D in selected industries that were newly emerging resulted in the development of a work force that was both educated in appropriate skills and that had research experience in many of these new sectors. Strong initial leadership in some new technologies, and in particular the international success of one company, Nokia, served to increase both material and immaterial investments in the IT sector. There has been significant public investment in R&D, both in individual firms and to a greater extent in technology programs consisting of universities, large, internationalized leading firms, and SMEs. This has provided the IT sector both with a
strong endogenous science and technology base, and with close university-industry relations, which in Tampere has been based on a tradition of university industry co-operation. Tampere has employed a strategy of building institutions and social capital, which have enabled it to become a crucial node as one of the three main centers of R&D in Finland. Many traditional industries have regained their competitive positions by exploiting the strong IT base of the region. Due to the rapid growth of the IT sector, there is a problem with a scarcity of skilled work force. In Tampere, this has also been a relatively low rate of new venture creation, although measures to stimulate entrepreneurial activity have been a part of the local policy-makers’ toolbox. Foreign direct investments were very modest in Tampere during the development of the IT sector. However, as Finland has become known as an emerging information society, the level of inward foreign direct investment has increased. Overall, the development of the broad based IT sector, both by sub sectors and by technologies, has been based on organic, endogenous growth in Tampere.

Case Comparison

The process of development of new agglomerations of high technology firms differs significantly between these two cases. The experiences of these two cases raise a number of important issues concerning the development of new industrial agglomerations. These issues are important to policy makers who seek to develop new agglomerations of high technology firms by transposing a model from a successful industrial district populated with high technology businesses. In the following table, some of the key features of the two cases are highlighted (Table 2).

Insert Table 2 about here

What is the role of public policy makers in stimulating new industrial activity?

Traditionally, governments have justified industrial and related policies at national and regional levels in terms of perceived market failures. Government responses to perceived market failures have included subsidies; directed public procurement; initiatives to protect intellectual property rights; joint technology programs between research organizations and industry; investment in "strategic" industries; and environmental and labor regulation. However, paradoxically, much traditional technology policy is characterized by conflicting forces (Badham 1994, Schienstock 1994). On the one hand, it has sought to enhance innovation activities by using subsidies while simultaneously other policy interventions have sought to minimize the negative consequences of technological change through protective legislation. Furthermore traditional government measures to influence firms’ (innovation) activities have tended to be reactive in nature, have assumed a rather limited role for regional level responses and have, in practice, been little more than attempts to redistribute wealth in favor of some producer groups at the expense of other groups (Krugman, 1996; Logan and Molotch, 1987). Public policies have tended to be effective only in a case of supporting existing industries and exploiting established technological trajectories,
whereas they have been rather ineffective to support the emergence of and shifts to new industries and technological fields (Lundvall 1999).

The cases presented above suggest that a broad based industrial policy, and specifically one that includes measures aimed at improving human capital both as supply of graduates in IT-related fields of science, and as enhancement of existing human resources within firms, is crucial to the development of knowledge-based industries. Significant investments in these should ensure that the return for investments in public support for firms’ R&D activities and technological spillover effects will be maximized, therefore enabling an emergence of a new industrial district. Furthermore, the presence of internationally competitive customers acted as an important stimulus to the development of sectors, supporting the concept for a cluster based industrial policy rather than an industry specific policy.

What is the appropriate model for encouraging knowledge flows?

Is a market driven model based on informal co-ordination, collaboration and innovation transfer, or a model of supporting the local industrial milieu through local governance structures, more effective at seeding a new industrial district? The recently established rationale governing policy intervention is that the role of government is to create the general framework conditions conducive to industrial development and innovation in a form that is, in principle, common to all firms in the national economy. Some recent approaches have stressed that public sector may have a new kind of role as animateurs and interlocutors for innovation activities in industry, organizing dialogue between actors, setting up discussion on prospective and future growth areas and potential problems and development gaps (Cooke & Morgan 1998).

Compared to Dublin, the Tampere model appeared to be based more on specific and focused state development initiatives aimed at encouraging innovation and collaboration, although many of these initiatives are strongly influenced by private sector needs through the private sector demand and provision of finance. In the Finnish case, the existence of several types of programs and steering mechanisms has facilitated the emergence of an intense dialogue and partnership approach between public and private actors in the IT sector, encompassing national, regional and local levels. In Tampere, this continuous interaction has resulted in the development of significant social capital, which has further contributed to a creation of numerous joint ventures and other possibilities to exploit local synergies.

However, it can be argued that the role of many public sector governance structures has been over emphasized in many successful cases. The Irish case demonstrated how the development of a new industrial district might be the result of firm level supports, with market forces determining the extent and nature of innovation activities. It seems that the importance of time, firms’ own "grassroots" collaboration, co-operation and innovation transfer, historical events and trends that have a direct impact on the specific forms of development, have often been under-emphasized in explaining industrial districts. This may be because of the static nature of much of the analysis of industrial districts. We conclude that the two cases presented show that public policy makers’ role in facilitating the emergence of new knowledge intensive industries may vary to a great extent.
What is the role of inward foreign direct investment in the endogenous development of competitive advantage?

The attraction of inward FDI has many potential benefits for an economy. However, the impact of inward FDI is highly contingent on the specific nature of the MNE operation, the characteristics of the host economy and the nature of the interaction between them (Dicken et al., 1994). Turok (1993) argues that the use of inward FDI to encourage economic growth can be characterized as either “developmental” or “dependent”. In the “developmental” model FDI is characterized by high skill, high value-added functions that are part of long-term investments. In this model the MNE becomes embedded in the host economy and plays an important role in the development of indigenous industry. Young, Hood and Peters (1994) argue that MNE subsidiaries, which have characteristics such as high-level skills and functions and a degree of autonomy, can encourage the development of associated local industry clusters by developing local sourcing of inputs and by developing R&D and technological innovation capabilities. Porter (1990) argued that MNEs can play an important role in seeding the development of a cluster, though he excluded them from a central position in his “diamond” model, choosing instead to emphasize the importance of indigenous firms. In contrast, in the “dependent” model, FDI is characterized by low skilled weakly embedded MNEs. These MNEs are therefore vulnerable to external shocks and they are essentially much more internationally mobile. In the later case MNEs do little to promote sustained development in the host economy.

The Irish case suggests that the exogenous (FDI) development can play a significant role in seeding a new industrial district; but that this will only be the case if a significant number of related events occur. As regards foreign MNEs in the software sector in Ireland, Coe (1997) argues that they fall short of the full “developmental” model. However, he does conclude that they appear to be part of a higher quality round of FDI than those that occurred previously in Ireland. This can be seen in “the strategic role of Irish plants within the networks of multinationals, in the high-skill elements of the workforce, the high level of economic embeddedness in terms of local supply linkages, and the attraction of new functions to plants once they have become established” (Coe, 1997:227). In the Finnish case, a new industrial sector was based on endogenous development where FDI did not play a role in the beginning, and only after the country became internationally known for its fast growing IT sector foreign investors began to invest in Finland, including Tampere central region.

Should city-regions seek to specialize when promoting new industrial districts?

Models of agglomeration suggest that smaller cities that specialize benefit from stronger localization economies arising from the proximity of closely related producers. However, as cities specialize they increase their exposure to the risk of specific sectors and technologies. Furthermore, there is evidence that suggests that most innovations and most new plant creations occur in particularly diversified cities and that, consequently, narrow specialization may in fact hinder innovation (Duranton and Puga, 2000). Indeed, diversity across industries with a common science base has a positive and highly significant effect.
on innovative output (Feldman and Audrescht, 1999). Therefore, policy makers in city-regions in small
open economies are faced with the dilemma that the cost of limiting the risk of specialization, that is
greater diversity, is the loss of the present benefits of specialization. The case of Dublin is one of very
specialized development in the software sector. In contrast, the IT sector in Tampere is broad based
covering a range of sub-sectors. As the theory suggests, this diversity can be seen in Tampere as the
region is innovative if measured by patenting and R&D investments, as well as output indicators like
growth of productivity or exports from 1997 on.

Can policy makers transpose a development model from another successful region?

Policy makers in many regions are actively seeking development models from successful industrial
districts. However, there are several reasons why attempts to transpose a development model from a
successful industrial district might not work. First, most agglomerations of industries have not been the
result of direct policy interventions; second, there may be no one desirable pattern of firm and inter-firm
organization; third, even if such patterns exist it may not be possible to derive them from the study of
successful regions; fourth, localization may be the result of accidents and history that start a cumulative
process; fifth, there is a strong link between innovation and diversity, suggesting that highly innovative
clusters cannot be bred in previously highly specialized environments; sixth, there may be a life cycle
effect in emergent industries, where initial localization is followed by dispersion as the industry matures;
seventh, governments and their industrial policies are more efficient in supporting the exploitation of
existing opportunities rather than trying to open up new trajectories of development; and finally, there
may be no general principles which govern the design and implementation of industrial policy.

In conclusion, this paper suggests that timely public policy interventions at innovation system,
“industry” and firm level can play an important role in seeding new knowledge-based high technology
industries, but that the process of industrial district formation is contingent on local processes and
conditions and, therefore, efforts to directly transpose a development model will be ineffective. A more
fruitful approach to the development of effective industrial policy interventions might be to seek a deeper
understanding of local development processes. This might involve the use of studies of other regions as
benchmarks for performance and as a source of ideas, rather than as a source of a model for development.
REFERENCES

Arnold, E. & Thuriaux, B. 1997. Developing Firms’ Technological Capabilities. Technopolis Ltd.


Table 1 Employment, Number of Companies, Sales Revenue and Exports in the Software Industry, 1991-97

<table>
<thead>
<tr>
<th></th>
<th>1991</th>
<th>1993</th>
<th>1995</th>
<th>1997</th>
<th>% Change p.a.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Employment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigenous</td>
<td>3,801</td>
<td>4,495</td>
<td>5,773</td>
<td>9,200</td>
<td>+ 16%</td>
</tr>
<tr>
<td>Overseas</td>
<td>3,992</td>
<td>4,448</td>
<td>6,011</td>
<td>9,100</td>
<td>+ 15%</td>
</tr>
<tr>
<td>Total</td>
<td>7,793</td>
<td>8,943</td>
<td>11,784</td>
<td>18,300</td>
<td>+ 15%</td>
</tr>
<tr>
<td>Output (IR£ m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigenous</td>
<td>150</td>
<td>236</td>
<td>386</td>
<td>528</td>
<td>+ 23%</td>
</tr>
<tr>
<td>Overseas</td>
<td>1,580</td>
<td>1,756</td>
<td>2,611</td>
<td>3,933</td>
<td>+ 16%</td>
</tr>
<tr>
<td>Total</td>
<td>1,730</td>
<td>1,992</td>
<td>2,997</td>
<td>4,461</td>
<td>+ 17%</td>
</tr>
<tr>
<td>Exports (IR£ m)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigenous</td>
<td>61</td>
<td>116</td>
<td>226</td>
<td>365</td>
<td>+ 35%</td>
</tr>
<tr>
<td>Overseas</td>
<td>1,548</td>
<td>1,726</td>
<td>2,585</td>
<td>3,854</td>
<td>+ 16%</td>
</tr>
<tr>
<td>Total</td>
<td>1,609</td>
<td>1,842</td>
<td>2,811</td>
<td>4,219</td>
<td>+ 17%</td>
</tr>
<tr>
<td>Number of Firms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Indigenous</td>
<td>291</td>
<td>336</td>
<td>390</td>
<td>561</td>
<td>+ 12%</td>
</tr>
<tr>
<td>Overseas</td>
<td>74</td>
<td>81</td>
<td>93</td>
<td>108</td>
<td>+ 6.5%</td>
</tr>
<tr>
<td>Total</td>
<td>365</td>
<td>417</td>
<td>483</td>
<td>679</td>
<td>+ 11%</td>
</tr>
</tbody>
</table>

Source: The National Software Directorate, 1998
IR£1 = US$1.06
Table 2 Emergence of the software sector in Dublin and the IT sector in Tampere

<table>
<thead>
<tr>
<th>Key Features</th>
<th>Dublin</th>
<th>Tampere</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Key Variables</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Industry structure</strong></td>
<td>Software industry</td>
<td>Diversified IT sector</td>
</tr>
<tr>
<td></td>
<td>MNEs; and internationally competitive indigenous SMEs</td>
<td>One key enterprise (Nokia); several large internationally competitive firms; and small local firms</td>
</tr>
<tr>
<td><strong>Size &amp; employment growth rate</strong></td>
<td>680 firms</td>
<td>200 firms</td>
</tr>
<tr>
<td></td>
<td>18,300 employees (1997), 23% p.a.</td>
<td>6,800 employees (1997), 30% p.a.</td>
</tr>
<tr>
<td><strong>Local Demand for indigenous SMEs</strong></td>
<td>Broad base of MNEs</td>
<td>Large internationalized domestic and local firms in IT sector</td>
</tr>
<tr>
<td></td>
<td>MNEs in software/IT sector</td>
<td>Traditional industries</td>
</tr>
<tr>
<td><strong>Building enhanced factor conditions &amp; knowledge base</strong></td>
<td>Educated labor supply</td>
<td>White-collar labor supply</td>
</tr>
<tr>
<td></td>
<td>“On-the-job training” and R&amp;D</td>
<td>Training and R&amp;D</td>
</tr>
<tr>
<td></td>
<td>Telecommunication infrastructure</td>
<td>Indigenous S&amp;T base</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Local universities</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Telecommunication infrastructure</td>
</tr>
<tr>
<td><strong>Stimulating information &amp; knowledge flows</strong></td>
<td>Weak ties between firms</td>
<td>University-industry co-operation in technology programs</td>
</tr>
<tr>
<td></td>
<td>High labor mobility</td>
<td>Producer-user dyads</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Intermediaries (public sector initiatives)</td>
</tr>
<tr>
<td><strong>Stimulating entrepreneurial activities</strong></td>
<td>Direct financial aid from the state</td>
<td>State aids</td>
</tr>
<tr>
<td></td>
<td>Spin-offs from software industry</td>
<td>Spin-offs from universities &amp; firms</td>
</tr>
<tr>
<td></td>
<td>MNEs acted as incubators for entrepreneurs</td>
<td>Science parks as incubators</td>
</tr>
<tr>
<td><strong>Attracting foreign direct investments</strong></td>
<td>High importance</td>
<td>Low initial importance, but becoming important</td>
</tr>
</tbody>
</table>