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Links between multinational firms and domestic firms: a comparison of the software industry in India, Ireland and Israel

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Links between multinational firms and domestic firms: a comparison of the software industry in India, Ireland and Israel

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Abstract

India, Ireland and Israel have experienced a high growth in the software industry especially during the 1990s. This paper aims to analyze the role of multinational corporations (MNCs) in the development of the software industry in these countries. The study is centred on software production and IT-related services - software development, chip design and electronic devices design, computer and Internet services such as web design and maintenance, and call centres. The empirical analysis leads to two final conclusions. First, it shows that the evolution of software activities and the role of MNCs vary considerably across these three countries. The main differences concern the time of entry of MNCs relative to domestic firms and the type of activities conducted by MNCs, which appear to reflect different regional comparative advantages. The second final conclusion is that the overall impact of MNCs on the development of the domestic software industry in the three examples analysed is quite controversial. Ireland is the only case where many MNCs entered before the domestic industry started and contributed on various grounds to its emergence, mainly as customers and sources of competencies. In Israel and India, the positive effects of MNCs on domestic firms, such as reputation, access to capital and managerial capabilities, have become apparent only in recent years. This suggests that analysts of MNCs' linkages and policy makers in emerging regions should devote attention to MNCs' entry timing in new industries.

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1. Introduction

This paper analyzes the role of multinational corporations (MNCs) in the development of the software industry in India, Ireland and Israel. Our study is centred on software production and IT-related services - software development, chip design and electronic devices design, computer and Internet services such as web design and maintenance, and call centres.

Ireland, Israel and India have experienced a high growth in the software industry especially during the 1990s. Software revenues reached $9.3bn in Ireland and $8.3bn in India in 2000. In Israel the software industry has reached a similar size (about $4.2bn in 2001) (NASSCOM, 2002; NSD, 2002; IASH, 2002). Much of software growth in these countries is accounted for by exports, which represent about 75% of Indian's total sales and about 84% of Irish sales (NASSCOM; 2002, and NSD, 2002). Similarly, exports represented about 73% of Israeli software sales (IASH, 2002).

These countries have benefited from historical linkages with the US and the UK which have been reinforced by the communities of expatriates working for lead ICT producers or big users such as financial institutions. These linkages have promoted the inflows of capital, ideas, business models, and technologies.

In particular, compared to other regions, these countries have been particularly successful in attracting foreign firms, which account for a significant share of national software activities, especially in India and Ireland.

In the case of Israel and Ireland the local governments have introduced various incentives to attract the location of MNCs. One reason for such policies is that MNCs are viewed as a channel through which technologies and business practices from abroad can be transferred to the economies of emerging countries.

The economic theory has highlighted several potential effects of MNCs for the host economies. Building upon Hirschman's seminal contribution (1958), recent works have pointed out both positive externalities associated with people mobility, demonstration effects or knowledge spillovers and negative competition effects – MNCs may attract demand away from domestic firms and compete with them in the local labour market (*e.g.*, Rodriguez-Clare, 1996; Markusen and Venables, 1999). But the empirical evidence has not reached any clear-cut conclusions as to which are the benefits of MNCs, the conditions that promote the absorption of knowledge spillovers produced by MNCs and the implications for public policies.[1]

This paper examines the evolution of MNCs activities over time and their linkages with domestic software firms. Our main question is about the contribution of MNCs to the evolution of the local software industry and precisely we ask whether MNCs represent the engine of software growth in

these countries or whether they have entered attracted by the formation of new software clusters. To answer this question we analyse the role of MNCs by taking into account two different visions of industry evolution. According to the first vision, the formation of high tech clusters like Silicon Valley is explained by Marshallian geographical externalities and the formation of social networks (Saxenian, 1994; Porter, 1998). In line with this view, which can be defined as the *distributed model of industry growth*, industrial clusters are "organized around the region and (their) professional and technical networks rather than around an individual firm." (Saxenian, 1994:30). The localized accumulation of technical knowledge represents the critical source of entrepreneurship and growth: "this localized accumulation of technical knowledge enhanced the viability of Silicon Valley start-ups and reinforced a shared technical culture" (*ibid.*: 37)[2]. Looking at the formation of our software clusters with this model in mind, MNCs do not represent the engine of growth since they enter to take advantage of the geographic proximity with firms and institutions that are already there. However, MNCs may generate externalities through various types of linkages with domestic firms – *e.g.*, people mobility, knowledge exchange between employees and subcontracting.

A different hypothesis about new industrial clusters formation is centred on the role of large organizations (like MNCs), which represent the key source of knowledge and industry agglomeration. In this pattern of industry evolution, which we refer to as *corporate competence & inheritance model*, the engine of industry agglomeration is the knowledge stock of early successful entrants which is transferred to other firms primarily through spin-offs, rather than the knowledge embedded in the regional network ("successful incumbent firms can be powerful incubators of significant later entrants", Klepper, 2001: 34). In the case of Silicon Valley, for example, this model highlights the role played by Fairchild Semiconductors and its very large number of spinoffs as the engine of entrepreneurship and industry growth rather than the local professional network. In this view, MNCs represent the natural engine of growth for new clusters.

With these hypotheses in mind, our analysis addresses the following issues in a comparative perspective:

- what is the role played by MNCs in the development of the software industry in these countries? Did MNCs enter at the early stages of formation of the local software industry and

[1] See, for instance, Caves (1974); Lall (1978); Young, Hood and Peters (1994); Coe (1997); Fellstein (1997); Barry and Bradley (1997); Aitken and Harrison (1999); Gorg and Strobl (2002).

[2] It is worth to note that Saxenian (1994) recognizes the importance of large firms like Fairchild Semiconductor Corporation "as an important managerial training ground" for the Silicon Valley. However, in her view the engine of entrepreneurship and industry growth is the regional network rather than the single firm.

placed the building blocks of this industry or did they enter at later stages, when a domestic industry had been already established?

- what kind of activities MNCs conduct locally? Do they conduct high value added activities like R&D or lower value added activities like assembling and customer support? What is the division of labour with local firms? Do their activities complement or substitute those of domestic firms?
- which are the linkages established with domestic firms and what is their impact on domestic firms? Are MNCs a source of technology spillovers, new business models, skilled people or spinoffs? Do they represent a significant source of revenues and a bridge to foreign markets for domestic firms?

This paper analyses such issues by drawing on different sources of data, including D&B's Who Owns Whom, corporate websites and national industrial association datasets. An important source of information for the purposes here is represented by the collection of events concerning both domestic and MNCs reported by the InfotrackWeb database. The latter provides press information on several categories of corporate events – from the establishment of a new subsidiary to restructuring operations and strategic alliances. Another critical source of information is represented by interviews conducted with Irish and Indian software firms in an earlier project (see Arora, Gambardella and Torrisi, 2001). Finally, our analysis rely on 14 additional interviews with managers of MNCs operating in India, Ireland and Israel, founders of MNCs' spin-offs, managers of local firms involved in linkages with MNCs and officers of industry associations conducted in 2003 (see the Appendix for details).

The paper is organized as follows. Section 2 illustrates different patterns of entry strategies and compares software activities conducted by MNCs in the three countries in historical perspective. Section 3 analyses different types of linkages between MNCs and indigenous software companies. Section 4 summarizes the main benefits of MNCs involvement in the local economies for domestic software firms while Section 5 concludes the paper.

2. MNCs and the evolution of the software industry

The main issue explored in this Section is whether MNCs entered before or in parallel with the growth of a domestic software industry. We also examine the activities that they conduct in the sample countries and the division of labour with local firms.

The analysis starts addressing the entry of MNCs and the evolution of their local activities over time. The differences in historical background and market size across the three countries analysed suggests to look first at the role of MNCs in each country.

The analysis is centred on MNCs operating in the ICT sectors, including software. However, the role of some non-ICT MNCs (e.g. banks and general consulting companies) is also illustrated especially in the case of India.

India

In India the domestic software industry begun to develop in parallel with the entry of few MNCs. Some MNC which entered the first stages of development of this industry in the 1980s have influenced the strategy and business models of early domestic entrants.

The relationship between MNCs and the Indian software industry is marked by two major events. First, the exit of IBM in 1977, which was induced by restrictive policies on international trade and foreign direct investments. Second, the establishment of Citibank Overseas Software Limited in Bombay in 1984 and the location of a Texas Instrument R&D laboratory in Bangalore in 1985.

The exit of IBM opened a window of opportunity to other MNCs like Honeywell, Digital Equipment Corp., Burroughs and Fujitsu; these firms filled the gap created by the departure of IBM by establishing alliances with domestic firms - *e.g*. Burroughs with Tata Consulting Services (TCS) and Digital with Hinditron. Until the mid of the 1980s, domestic software firms were primarily involved in developing porting programs from IBM to other proprietary platforms, development and maintenance of custom applications for a variety of computer platforms. This probably represented an important learning ground for domestic firms. Over time several domestic firms adopted a business model based on the supply of software professionals who worked on the customer premises on a temporary basis (on-site servicing). The pricing system centred on time and material billing was part of this business model (Arora *et al*., 2001).

The entry of Citibank and Texas Instruments (TI) by mid-1980s marked another important change in the evolution of the domestic software industry. Citibank Overseas Software Ltd. (COSL) probably represents the first example of offshore business processing outsourcing (BPO) in India. COSL aimed at the digitisation of Citibank's worldwide back office operations starting from those located in India (Athreye, 2002).

TI also pioneered the offshore model in India with important differences compared with Citicorp. TI operations in Bangalore focused on high end R&D activities in the areas of chip design and chip-related software. The TI's digital signal processing (DSP) chip was developed by this R&D laboratory and then commercialised on a global scale. Over time the TI subsidiary developed strong linkages with the Indian School of Science in Bangalore and has funded the startup of about 20 university research laboratories. Moreover, at the time of entry in India, TI brought in its satellite communication facilities which represented the frontier in communication technology. TI also

allowed domestic firms to use the excess capacity of its satellite connection.

TI's business model, centred on the use of a powerful communication facility and high end offshore R&D activities carried out on a global scale for the rest of the corporation, provided an important demonstration effect to domestic firms like TCS, Infosys and Wipro. These firms, located in the same metropolitan area, have imitated this model and today most of their services are offered on an offshore basis rather than on-site (Patibandla and Petersen, 2002).

The successful experiences of TI and COSL in India gave also a demonstration effect to other foreign ICT firms which during the 1980s and, especially, the 1990s established offshore development centres in Bangalore and other Indian locations.

Table 1 lists some representative examples of MNCs located in India in different times.

Table 1. Representative MNCs in India

Name of Firm	*Employees (1)*	*Year of establishment*	*Specialization*
Citibank Overseas Software Ltd (COSL)	508	1985	Banking software
Texas Instruments	500	1985	Chip design, chip related software development
Microsoft	Na	1987	Na
Baan InfoSystems	1,600	1989	ERP systems
General Electric	11,000	1989	Business process outsourcing (BPO)
Hewlett Packard	1,100	1989	Software development, high end R&D, sales
Hughes Software Systems	542	1991	Telecom software
Motorola	1,300	1991	High-end R&D, software development and coding, communication software
Oracle	450	1994	Databases, tools, education, platform techn.
SAP	Na	1996	E-business solutions
Adobe	200	1998	Application software for handheld devices
Cisco	2,100	1998	Communication software
IBM	2,000	1998	Supply chain management, media mining, web services
Nortel	Na	2000	Telecom software

(1) Latest available data.

The first generation of MNCs that entered during the 1980s have not enjoyed significant government incentives. The Indian government has introduced measures addressing specifically software exports and inward foreign investments (relief from import duties on hardware and software, tax exemption for income arising from export, and tax vacancies for firms operating in technology parks and software export zones) only during the 1990s.[3] The main factors that attracted MNCs in this country then have been the large pool of skilled (and English-speaking) labour force and, to a lesser extent, the domestic market. More recently, the proximity to other Far East markets

[3] Even though some export processing zones in areas like Bombay existed before 1991, the opening of the Indian economy to international trade and FDIs started in the 1990s (see the Indian Ministry of Commerce and the Indian Ministry of Information Technology, http://commin.nic.in and http//www.mit.gov.in respectively). The number of software technology parks in particular has increased very rapidly, from 164 in 1991-92 to about 1,400 in 1999-2000.

have also contributed to attract some MNCs.

Today in India the domestic and multinational software firms employ over 500,000 people. Although the majority of exporters are Indian-owned firms, foreign affiliates in 1998-99 accounted for about 27 per cent of India's software revenues ($10-bn) and 16 per cent of software exports[4]. Almost all leading US and European ICT firms have established software facilities in India during the 1990s and 2000s and the bulk of foreign affiliates' exports is directed to their parent companies. In general, MNCs carry out four types of activities in India. First, some MNCs are engaged in IT-enabled services like call centres, analysis of credit risks, loans underwriting, insurance claims evaluations, tax returns processing, financial analysis and stock sales. These are typical BPO services. The development centres of GE Capital, Price Whaterhouse and Citibanks fall in this category of outsourcing facilities. Second, some MNCs have units active in sales and customer support services, which sometimes co-exist with manufacturing and R&D operations. These centres focus on domestic customers or foreign customers. An example of export-oriented customers support centres is the global implementation, development and support centre established by PeopleSoft of the US in Bangalore in 2003[5] . Third, a few MNCs conduct high-end R&D activities which support the parent company's R&D operations. The autonomy of local researchers from the company's R&D is quite limited. A typical example is represented by BMC Software, a US enterprise management software company with over 6,000 employees worldwide. BMC opened an offshore development centre in Pune in 2001. Its mission is to provide "R&D and IT project support to its parent company. From this location, employees become integral part of the various business unit teams that work on our industry leading product solutions"[6]. Finally, other MNCs have established high-end R&D laboratories with a high level of autonomy from parent company's R&D. Besides TI, an interesting case of high-end R&D is represented by the Adobe's R&D centre in Noida which developed a new version of Acrobat Reader for handheld devices, by carrying out autonomously all development stages, from the conception of the idea to final production. Its engineers have filed 15 worldwide patent applications related to several Adobe' products like PocketPC, Pagemaker and Photo Deluxe[7] (Patibandla and Petersen, 2002). Other MNCs are also upgrading their R&D locations in India. A case in point is Cisco, which has announced the launch of a new network management software product. Cisco Vice-President and head of the Cisco Global Development Centre in Bangalore has claimed that this is the first time that a product has

[4] *The Hindu*, 18 September 2002. According to more recent NASSCOM estimates, MNCs account for 22 per cent of IT services exports and 45% of IT enabled services exports in 2001-02 (electronic correspondence with NASSCOM, August 25 2003)

[5] www.peoplesoft.com

[6] www.bmc.com

[7] www.adobeindia.com

been conceived, designed, developed and released from Cisco's Development facilities in India[8].

Until recently MNCs have not competed directly with domestic firms since they have outsourced in India back-office operations. More recently, Indian activities of global BPO service providers have become competitors of large Indian firms like TCS and Wipro. For instance, according to company reports, ABB India has recently assigned IBM India the task of managing the IT network of its local units. This example shows clearly that global IT solutions providers such as IBM Global Services are trying to become first-tier suppliers in global projects by shifting most of their facilities to India (Forrester, 2001). If they succeed many domestic firms would be relegated to a second-tier position. Even if the majority of MNCs have been late in committing resources to India, in the near future the relationship between MNCs and large firms such as Wipro, Infosys and TCS could be mixed: on the one hand, MNCs are likely to continue to cooperate with these firms to have access their large scale resources. On the other hand, domestic companies are establishing their own international brands and therefore tend to become strong competitors of MNCs like IBM Global Service, Deloitte Consulting, EDS and Accenture. In this respect, the comparative advantage of the largest Indian software firms is represented by development costs and an effective management of BPO service, while the comparative advantage of MNCs lays in their reputation and visibility in the international markets.

Ireland

Several MNCs operating in the ICT industries have entered Ireland before a domestic industry started to grow. The main factors that have attracted MNCs in Ireland are represented by the high fiscal incentives, a considerable pool of skilled people with low opportunity costs and the proximity with the EU market (Arora, Gambardella and Torrisi, 2001).

In the period between the 1970s and early 1980s there was a first wave of foreign computer and telecommunication equipment manufacturers which started to establish their operations in Ireland such as Digital, Amdhal, Ericsson, Apple and Wang. The operations of these firms were primarily focused on sub-assembly and packaging of mass market products, such as minicomputers and peripherals. Key components were imported from abroad while end products and intermediate goods were exported to foreign distributors. In this period software activities in Ireland were still very limited and MNCs outsourced low value added activities - *e.g.* software manual printing, packaging and language translation services – to local suppliers (Tallon and Kraemer, 1999; O'Riain, 1999; see Table 2 for a list of representative MNCs).

[8] *Express Computer*, January 30 2003.

A second wave of MNCs entered the Irish market during the 1980s. Among these new entrants, the most important operations are those of IBM, Lotus, Siemens-Nixdorf, Motorola, Lucent Technologies, Microsoft, Oracle, and EDS. These firms focused on personal computers manufacturing and software packages. By the end of the 1990s Ireland became the 8th largest world exporter of computers and accounted for about one-third of all personal computers sold in Europe. Over 40% of US FDI in European electronics since the 1980 was directed to Ireland (NSD, 1998).

Most of these activities were then conducted by subsidiaries of MNCs that used Ireland as an export platform. These firms had limited linkages with local firms such as suppliers of manual printing, localisation of legacy software packages and distribution/logistics services.

Like in India, some of the MNCs have established development centres that provide services for other corporate operational units and outsourcing services to their customers. A case in point is the EDS' Solution Centre, established in 1990 in Dublin with the aim of providing system engineering services to EDS's operational units in Europe[9]. Other examples are Accenture and IBM Global Services.

Table 2. Representative MNCs: Ireland

Firms	*Employees (1)*	*Year of establishment*	*Activities*
Digital Equipment	750	1971	Hardware/packaging
Amdhal	270	1978	Hardware /packaging
EDS	500	1990	Captive systems engineering services, BPO
Ericsson	900	1979	Hardware/telecom software
Apple	Na	1980	Hardware/packaging
Motorola	550	1981	Chip design
Siemens	200	1983	Hardware/software, BPO (Siemens Business Services)
IBM	4000	1983	System software, BPO (IBM Global Services)
Lotus (now IBM)	600	1985	Applications, tools, localisation
Lucent Technologies	350	1985	Telecommunication software
Microsoft	1,200	1985	Mass-market packages, localisation, on-line commerce
Oracle	1000	1987	Database management systems
Accenture	600	1989	Consulting, business process outsourcing
Symantec	350	1991	Security software, system utilities
Corel	16	1993	Graphics software
Sun Microsystems	220	1993	System software
American On Line	120	1997	Internet software and Services

(1) latest available data.

The last wave of entry of foreign firms in Ireland occurred through the 1990s. The most notable examples of these entrants are Intel, Symantec, Novell, Corel and Sun Microsystems (Tallon and Kraemer, 1999). These firms show a higher level of integration in the local economy as compared with earlier entrants and carried out a much larger variety of activities, including software development, on-line multilingual customer support services, localisation, customisation and

[9] www.eds.com

porting of legacy software to new platforms, and centralised back office operations (Hanratty, 1997).

The domestic software industry has developed during the 1990s, even though the earliest indigenous entries date back to the period between the 1960s and the 1970s. The first Irish firms specialised in services for the finance and the banking sectors. Given the small size of the domestic market most of these firms were forced to enter international markets rapidly and some are now part of MNCs. A case in point is Cara Software, which was first acquired by Group Bull of France and then sold to Hibernia Capital Group of the US.

During the 1980s and the early 1990s a new stream of domestic firms entered the service and software product markets. Most of these firms focused on specific niche markets such as computer-based training (CBT) software (*e.g.*, Financial Courseware and Courseware Interactive), telecommunication software (Baltimore Technologies, Euristix, a Baltimore's spin-off, and Vistech), finance-assurance application software (Trintech and Allfinanze, formerly FM Systems), system software and application development tools (Iona Technologies and Piercom). In the 1990s few firms that had been established before grew rapidly and reached an important share of the international markets (*e.g.* Iona, Baltimore and Kindle), while many new firms entered in the industry and remained very small. By and large, domestic firms do not compete directly with MNCs in the product market.

According to the NSD over 900 software firms operated in Ireland by 2000, 770 of which were domestic firms. MNCs represent over 53 per cent of total employment and almost 90 per cent of Irish software exports (NSD, 2001).

It is possible that a significant share of MNCs exports is the outcome of accounting procedures adopted to take advantage of fiscal incentives introduced by the Irish government. Many foreign-owned firms in Ireland, such as Microsoft, Claris Manufacturing and Symantec, still concentrate their local operations on low value added, low skill activities such as porting of legacy products on new platforms, disk duplication, assembling/packaging and localisation (text translation, changing formats etc.). For instance, Oracle, Corel and Novell outsource most of their work and specialise in project management, and administrative or sales backoffice activities (including multilingual customer support)[10]. This category of foreign direct investment is highly mobile. For instance, some MNCs which carried out low value added activities such as packaging of mass-market software programmes have reacted very fast to changes in the comparative advantages of this region or other

[10] The bulk of Irish exports in this industry are accounted for by multinational corporations that use Ireland as an export platform, where most of the value is added before the software arrives in Ireland for localisation, kitting and distribution (FAS, 1998:27).

shocks. A case in point is Corel, a Canadian firm which has dramatically reduced its employees in Dublin in 2000 from 250 to 16 units as a consequence of a corporate-level restructuring.

Except for few examples, such as Sun Microsystems and Motorola, the majority of R&D is probably undertaken in the home country (Coe, 1997). This is also due to the low corporate tax, introduced to attract MNCs, which does not stimulate the location of R&D activities in Ireland (Grimes, 2003).

Israel

The Israeli software industry originated independently from MNCs. Most successful domestic firms were established by researchers and engineers who have served the military apparatus (the Israeli Defense Force) or worked for local universities. The public sector played a role in the formation of a domestic software industry on various grounds. A major contribution is represented by the supply of a public scientific and technological infrastructure which provided an important training ground for software engineers and entrepreneurs. This infrastructure lays at the core of the local technical and business network that has attracted MNCs (Breznitz, 2003).

MNCs' operations were very limited until the 1990s, and they accounted for about 1 per cent of total employment in the 1980s (Felsenstein, 1997). MNCs have established their activities in Israel to poach into the local pool of highly skilled personnel with low turnover rates and the local scientific and technological research in computing and IT security (De Fontenay and Carmel, 2001).

Two major waves of MNCs entries can be highlighted. The first wave is made of MNCs which started their R&D operations in Israel to exploit the comparative advantage of this country in these activities (Felsenstein, 1997; Breznitz, 2003). Motorola and IBM were the first US firms to establish a R&D facility in Israel in the 1950s. Motorola's Israeli R&D activities focus on wireless product development (*e.g.* remote irrigation systems for agriculture). Motorola has been followed by IBM, whose Haifa Research Lab, the largest IBM R&D laboratory outside the US, works on medical imaging multimedia applications.

Intel is another important example of US IT firms who pioneered the establishment of R&D facilities in Israel. Intel set up a VLSI design centre in Israel in 1974 (Felsenstein, 1997). Intel's research lab, located in Haifa's Matam technology park, is now the largest Intel R&D lab outside the US. Intel, which has also located chip manufacturing facilities in Jerusalem and Kiryat Gat, employs in Israel over 5,000 people. In 1985 Intel established also a CPU fab in Jerusalem and later it also set up Intel Capital Israel to support domestic technology startups. Over time Intel's R&D

operations in Israel have become responsible for some critical components of Intel's technology such as the 8088 microprocessor and Pentium MMX technology (Breznitz, 2003).

A second wave of MNCs established their operations in Israel during the 1990s, being attracted by the local pool of talented people and the promising domestic firms. A case in point is Microsoft, which established a R&D center in Haifa in 1991 engaged in Windows and network applications. Like some recent R&D laboratories located in India, research activities conducted by MNCs in Israel often play the role of nodes integrated in the corporate global network rather than being embedded in the local economic environment (Felsenstein, 1997; see Table 3 for a list of MNCs).

Table 3 Representative MNCs - Israel

Name of Firm	*Employees (1)*	*Year of establishment*	*Activities*
IBM	2,100	1950	VLSI design, software R&D, software services
Motorola	4,000	1958	Semiconductor design
Intel	5,000	1974	CPU design an fabrication, laptop CPU, 3G mobile technology
National Semiconductor	200	1978	Semiconductor design
Microsoft	Na	1989	Software R&D, Windows, networking
Texas Instruments	Na	1992	Semiconductor, TLC equip.
Cisco	Na	1996	Network hardware and software
BMC Software	170	1999	Application Management Solutions
SAP	Na	2000	Warehouse management software

(1) Latest available data

The Israeli software industry is made of over 500 firms whose cumulative sales are about $4,100 million. Over 73% of total sales are accounted for by exports (IASH, 2002). Domestic firms specialise in telecommunication software, data security and network management software, chip design and other high-tech software products. Unlike the case of Ireland, domestic firms in Israel account for a large share of software exports – the top 10 domestic firms represent over 50% of total exports[11]. The relatively low share of MNCs probably reflects the type of activities conducted locally. As mentioned before, most MNCs carry out R&D activities which do not result in significant outflows of services while some MNCs offer their services to local customers.

A synthesis

The activities conducted by MNCs and the specialisation of domestic firms show that these countries have different comparative advantages. These differences emerge clearly when one compares the patents granted to domestic inventors of these three countries.

Table 4 shows the patents granted by the USPTO to indigenous firms and MNCs' subsidiaries between 1976 and 2001.

Table 4. Patents granted to domestic inventors, 1976-2001

Country	*Patents granted to domestic inventors employed by domestic firms in ICT and software (1)*	*Patents granted to domestic investors employed by domestic firms (other technologies)*	*Patents granted to domestic inventors employed by MNCs subsidiaries in ICT and software (1)*	*Total*
India	32	564	217	813
Ireland	73	486	300	859
Israel	1,257	4,507	714	6,478

(1) The first 30 USPTO classes in which ICT (Information and Communication Technologies) MNCs were granted a patent plus all patents in USPTO class 700 (software) (including 704 e 702 classes).
Source: elaborations on USPTO data.

Not only Israel shows an absolute advantage in R&D activities measured by the total number of patents granted to domestic inventors. It also shows a comparative advantage in ICT innovative activities, as demonstrated by the share of ICT patents (about 28%) relative to Ireland (15%) and India (6%). Given its comparative advantage, it is not surprising then that the number of patents granted to ICT MNCs located in Israel is larger than the number of patents granted to MNCs in Ireland and India altogether.

These differences in technological capabilities are reflected in the activities carried out by MNCs in these countries. In India most MNCs locate sales and customer support activities, low-end software development activities (*e.g.*, programming and testing) and BPO services for the foreign markets. Only recently, the location of R&D activities by foreign firms has gained momentum thanks to the demonstration effects generated by the R&D laboratories of early entrants such as Texas Instruments and Hewlett-Packard. The increasing number of MNCs which locate BPO services and offshore R&D tend to compete directly with the largest domestic firms.

In Ireland the bulk of MNCs carry out low value added activities such as packaging of software products, localisation and logistics, customer sales and support for the European markets. Their activities appear to be complementary to those of domestic firms and some MNCs activities like localisation and testing are outsourced to small domestic suppliers. Most successful domestic firms specialised in products like financial and telecommunication software applications focus on niche markets and are not in direct competition with MNCs.

In line with the high level of the local scientific and technological infrastructure, several MNCs have established in Israel R&D facilities which focus on areas like digital imaging and chip design. Like in Ireland, MNCs' activities in Israel are not in competition with those of domestic firms which, as mentioned before, focus primarily on internet, data security and network management software applications.

[11] *Israel Business Today*, November 30, 1998, p.23.

3. Linkages with domestic firms

In order to assess more carefully the contribution of MNCs to the growth of the domestic software industry this Section examines their linkages with domestic firms. The analysis focuses on the following categories of potential linkages: i) MNCs' spin-off firms; ii) people mobility and patent citations; iii) alliances with domestic firms (e.g., joint ventures, M&As, minority stakes, strategic alliances and outsourcing agreements).

Spin-offs

A typical channel through which MNCs can transmit their knowledge is represented by spin-offs, i.e., start-ups established by former highly skilled technical or management employees.[12]

Empirical studies highlight the role of MNCs as incubators of spin-off firms. A survey of 36 Irish software firms conducted in the 1990s shows that two thirds of entrepreneurs had worked with for a multinational corporation (in the IT sectors or other sectors), at least at same stage of their career, before establishing their own firm (O'Gorman *et al*., 1997). Another survey of 28 Irish firms conducted in 2000 yields similar results: 50% of their founders had worked for MNCs (Arora, Gambardella and Torrisi, 2001). A recent survey of 52 Irish software firms provides further evidence (Table 5 and 6) of the importance of MNCs as a source of software spin-offs (Sands, 2003). Table 5 shows the 192 founders of the surveyed firms classified according to their earlier occupations.

Table 5. Irish software firm founders by previous occupation (1981-2002)

Founder former employer	*Number of founders*
Irish software company	41
Multinational company	63
Worked abroad	51
Studied abroad	15
NA	22
Total	192

Table 6 compares the shares of founders of two sub-samples, according to the period of foundation - 1981-1995 and 1996-2002.[13]

The significant number of founders of domestic firms who have worked for a MNC shows the importance of MNCs in the creation and development of the Irish software industry. The share of MNCs spinoffs appears to increase over time while that of founders who had worked abroad

[12] To our purposes it is not important to distinguish planned spin-offs, which are backed by the parent corporation, from other forms of spinoffs.

decreases. This is probably the result of the growing importance of the local network of professionals and firms (including MNCs) as a training ground of managers and entrepreneurs.

Table 6. Irish software firm founders by previous occupation and by year of firm foundation (1981-2002)

Founder former employer	*Years*	
	1981-1995	1996-2002
Irish software company	0.123	0.179
Multinational company	0.271	0.380
Worked abroad	0.318	0.250
Studied abroad	0.039	0.080
NA	0.250	0.111
Number of firms	20	32

A typical example of MNCs' spinoffs in Ireland is represented by DLG Services (localisation software development and testing), a firm set up in 1996 by a former Lotus's former employee. The founder and manager director of DLG has been able to transfer the experience accumulated at Lotus to his colleagues. Rather than technical skills, this experience has helped the DLG's staff to learn organisational and management best practices from Lotus. These practices include project management (clear tasks definition, use of milestones, rigorous assessment criteria) and relational and marketing capabilities (ability to conduct a business negotiate, sales skills and formal presentation skills).[14] Finally, the experience with Lotus promoted the consolidation of collaborative links between the two firms and provides an important source of revenues for DLG. An important "incubator" of new domestic firms has been Digital Equipment in Galway after the closing of its operations in 1993. One of these start-ups is AIMware, established in 1995 and focusing on software for process improvement. AIMware is located at the Galway Business Park. However, among the most technical and successful Irish firms there are very few examples of MNCs' spin-offs. Most product-oriented Irish software firms with a sound technical background have been founded by former academic researchers. Notable examples are Iona (Trinity College Dublin) and Massana (University College Dublin). This probably reflects the fact that most MNCs in Ireland still conduct quite low-end activities that offer limited opportunities for high tech spin-offs. Only recently some high tech spin-offs have been spawned by MNCs. A case in point is Airtel ATN. Airtel is a spinoff of Vertel Corporation, a large US telecommunication software that in 1998 decided to withdrew from the aeronautical telecommunication software. Airtel inherited the Vertel

[13] Shares reported in Table 13 are obtained by weighting the number of founders of the same firm; for example, if a company has two founders, one from a MNC and another one from an indigenous company, a 0.5 weight is calculated for each founder.

[14] 'MNCs, especially from the US, have done for the development of this economy more than we can ever imagine especially in terms of confidence in what you do'(face-to-face interview with the Managing Director of DLG, 21/4/2000).

technology and became a leader in segments like telecommunication routers, a software component critical to air navigation and air-ground communication. Another example is Anam, which was established in 1999 by three former MNCs' employees (Siemens Ireland and Logica Ireland). Anam specializes in Internet and mobile telecommunication software, and is one of the leading Irish firms engaged in mobile commerce software. The founders of Anam brought in technical expertise accumulated at the Irish Siemens Internet Security subsidiary. They also inherited expertise in the area of general management, international business management, and project and product management. However, they built upon this expertise to develop new capabilities in a complementary field, wireless software. Thanks to this complementarity Anam cooperates with Siemens. Moreover, Logica represents an important customer for this startup (see Table 7 for a list of spin-offs).

Table 7. Examples of MNCs' spin-offs

Country	*Spin-off Company*	*Main activity*	*Founder's Previous Company*	*Year of Establishment*
India	I-Flex	Financial software	Citibank India	1992
	MPhasis	E-business solutions	Citibank India	1998
	Evalueserve	Business intelligence	IBM India	2000
	Globarena	IT learning	IBM India	2000
	vMoksha	IT services	IBM India	2001
	Aspire	Hardware/software	Intel India	2001
	Ionic Microsystems	Embedded software	Texas Instruments India	1998
	Impulsesoft	Wireless software	Texas Instruments India	1998
	Ittiam	DSP applications	Texas Instruments India	2001
	MindTree	IT consulting/services	Lucent India	1999
	Daksh	BPO services	Motorola India	2000
	Aditi	E-mail software, software development services	Microsoft India	1994
	Tejas Networks	Optical networking	Synopsys India	2000
	Bluefont	Embedded systems	Philips Software Centre India	2000
Ireland	AIMWare	Software tools	Digital Equipment (Galway)	1995
	SyberNet	Telephony applications	Digital Equipment (Galway)	1994
	Toucan Technology	Network and chip design software	Digital Equipment (Galway)	1993
	DLG (Transware)	Localisation software	Lotus Ireland	1996
	Anam	Wireless software	Siemens (SSE) and Logica	1999
	BG Turnkey Services	IT services	Apple Ireland	1984
	Airtel ATN	Air telecom software	Vertel (former Retix Ireland)	1998
Israel	Riverhead Networks	Security software	IBM Israel	2000
	Diligent Technologies	Storage Software	EMC Israel	2002
	Optibase	Communic. hardware/software	Intel Israel	1990
	Topio	Disaster Recovery Solution	IBM Research Lab	2001
	Hyperoll	Business intelligence solutions	Coca Cola Israel	2000

In India and Israel MNCs' spinoffs seem to have played a very limited role until very recently. In Israel, where the largest incubators are the local Universities and Defence agencies, one of the few examples of MNC spin-off is Riverhead Networks, a company engaged in solutions to address distributed denial-of-service attacks (DdoS). One of its co-founders and Chief Architect, Dan Touitou, was a Research Fellow of the IBM Research Lab in Haifa and, at the same time, was a Faculty member of the Interdisciplinary Center in Herzliya. When he founded Riverhead Networks

in 2000, Touitou had considerable technical expertise in distributed computing and communication networks, and managerial skills as project leader[15].

As far as India is concerned, spin-offs have been mostly spawned by large Indian firms or by returning emigrants. A case in point is Eastern Software Systems, a company started in 1990 by two former managers in BMC, a large domestic firm. Moreover, some successful start-ups (*e.g.*, Wipro and TCS) are part of large, diversified domestic groups.

The only significant MNCs' spinoff in the early stages of the Indian software industry is I-Flex. The technical expertise and the domain knowledge developed by Citibanks' offshore operations in India during the 1980a was developed into a product for the financial market and a new firm, CITIL, was established to focus on packaged applications. Later on, I-Flex was spun-off from CITIL, and today I-Flex is one of the few successful Indian software product firms.[16]

More recently, an increasing number of start-ups have been established by former MNC employees.

For example, the IBM Research Lab in New Delhi has spawned some spin off firms, such as Evalueserve, which provides services in the area of business intelligence, market research, and IPR management, and Globarena Web Technologies, which is active in the area of IT learning and digital security software.

Recent MNCs' spin-offs have been established by senior managers and engineers. The background that former engineers and managers bring with them obviously reflects the activities carried out by the MNCs locally. For instance, in the area of offshore development and IT services a notable examples is represented by vMoksha, founded in 2001 by Pawan Kumar, the head of IBM Global Services in India during the period 1996-2000.

Ittiam Systems is an interesting example of spinoff firm active in R&D and embedded software development which has been founded by Srini Rajam, the former managing director of Texas Instruments India. Other six TI India engineers joined Srini Rajam bringing with them a high level expertise in the area of DSP, a fast growing segment in the semiconductor business. Besides the technological expertise, the team inherited by TI capabilities in general management and marketing. Moreover, working in a company like TI provided the founders of Ittiam with a global business perspective. One of the founders and the current Ittiam top management and CEO recognizes that experience gained with TI helped the founding team to choose the market niche and to implement a

[15] It is worth to note that this entrepreneur, like many others in this country, accumulated a considerable experience when he served the Israel Defence Force (IDF) as a software engineer and a team leader (www.intel.com; www.riverheadnetworks.com).

[16] I-Flex is still backed by its parent company which retains a minority stake.

business model centred on the sales of intellectual property rights, which is very different from the typical service-oriented approach adopted by many Indian software firms.[17]

People mobility and patent citations

This analysis thus far clearly shows that in Ireland many new firms in the software industry have been established by former MNCs employees. Another relevant link with the local software industry in Ireland has been the mobility of skilled personnel. Between the 1980s and the 1990s several IT professionals emigrated because of the low job opportunities offered by the Irish labour market. The excess labour supply and low wages attracted several MNCs. Their local activities contributed to reduce the outflows of professionals. From mid-1990s, the rapid growth of software activities, which was largely accounted for by MNCs, resulted in a rapid growth of wages (about 20% a year according to FAS's estimates), which attracted a large numberof emigrants back to Ireland. Thus MNCs in Ireland contributed to maintain a pool of software engineers and managers with expertise in system software, financial applications software, telecommunications software and computer-based training software (or e-learning) (Arora, Gambardella and Torrisi, 2001). Recently some Irish firms have hired former MNCs top managers to improve their marketing and management skills, as in the case of Fineos whose new Chairman was the former IBM Ireland CEO.

Table 8. Examples of people mobility from the local subsidiaries of MNCs

Country	*Current position*	*Domestic company*	*Former employer*
India	VP E-business	Vmoksha	IBM
	VP Sales	Pramati Technologies	IBM
	VP Engineering	AdventNet	IBM
	General Manager	Emuzed	Philips Software Centre
	Vice Chairman	Wipro	General Electric
	CEO	DACS Software	Motorola
Ireland	Chairman	Fineos	IBM Ireland
	Sales Director	Similarity Systems	Lotus Ireland
	CTO	Iona Technologies	Digital
	COO	Horizon Technology Group	Digital/HP/IBM
Israel	President/CTO	Xmpie	IBM Research Lab
	CTO	Seaside Software	IBM/Lotus
	CTO	P-Cube	Digital Equipment
	VP R&D	Gilian Technologies	Motorola
	VP Sales	Sanrad	Lucent
	VP Sales and BD	Backweb	Deloitte & Touche
	VP R&D	Gammasite	IBM Research Lab
	VP Marketing & BD	Riverhead Networks	Cisco
	President/CEO	Nice Systems	IBM Israel
	Managing Director	Panorama Software	Oracle

Instead, there is more evidence of top people mobility in India and Israel (Table 8). In India former IBM employees gained important positions in domestic firms such as Vmoksha, Pramati and AdventNet. In Israel a case in point is represented by the President and CEO of Nice Systems, who worked for IBM Israel before joining the Israeli software firm founded in 1991. Another interesting

[17] Ittiam has also cooperative linkages with Analog Devices in India in the field of DSP products.

case is that of Gilian Technologies, which hired Doron Kolton, the software department manager of Motorola Semiconductor Israel[18].

The analysis of patents granted by the US Patents and Trademarks Office (USPTO) to domestic inventors over the period 1976- 2002 provides further insights over technical spillover from MNCs to local firms. A useful indicator is the number of domestic inventors who have been granted patents during their employment in MNCs and have then moved to a domestic firm. Table 9 shows that Ireland has a higher share of inventors with a former experience in MNCs compared to India and Israel. This is also in line with the longer experience of MNCs in Ireland. On the other hand, the number of inventors moving from MNCs to domestic firms is much larger in Israel; this is in line with the larger scale of R&D activities conducted by MNCs in this country compared with Ireland and India.

Table 9. Domestic inventors formerly employed by MNCs

Country	*Inventors*	*As a share of total domestic inventors*	*Patents*
India	5	0.060	36
Ireland	14	0.100	30
Israel	38	0.022	83

Another proxy for technological spillovers is represented by patent citations. A useful indicator could be the number of citations reported by USPTO patents assigned to domestic firms. As Table 10 clearly shows, Israeli firms' patent citations show a significant share of cited patents assigned to other Israeli firms whereas Indian and Irish patents are cited only occasionally. Patents of MNCs are rarely cited by inventors of these three countries. MNCs' patents are more cited in the patents assigned to Israeli firms compared with citations in Indian and Irish patents. However, even in the case of Israel MNCs account for less than 0.50 per cent of total citations.

Table 10. Domestic patent citations, 1976-2002

Country	*Total patents cited*	*Domestic patents cited*	*MNCs patents cited*	*Total number of citations*	*Citations of indigenous patents*	*Citations of MNCs subsidiary patents*
Ireland	4108	6	3	5294	13	3
Israel	10483	214	14	13960	403	17
India	2184	2	0	3080	2	0
		Percentages				
Ireland		0.15	0.07		0.25	0.06
Israel		2.04	0.13		2.89	0.12
India		0.09	0.00		0.06	0.00

[18] www.gilian.com

These data confirm that Israeli's local network of scientists and engineers is quite dense and rich of connections among people and firms. This is much less the case of India and Ireland, despite the geographical proximity of firms located in areas like Dublin and Bangalore.

Overall, MNCs' R&D activities appear to be quite isolated from the local network of technological activities. A case in point is Texas Instrument in India. The TI's R&D laboratory in India has been granted 75 patents in the period examined but its patents have never been cited by Indian firms.

Inter-firm alliances

Alliances with domestic firms represent another potential source of knowledge transfer and a measure of embeddedness in the local economy.[19] To this purpose, data have been collected from Dun&Bradstreet's Who Owns Whom dataset (WOW) and other national data sources which are described in the Appendix. These data provide a representative sample of the population of domestic software and MNCs operating in our three countries in 2001.[20]

Although the dataset does not provide information about firms that have exited the market before 2001, our sample accounts for various generations of domestic firms and MNCs that have entered the market at different points in time, from the early formation of software activities in our countries until recent years. For instance, the dataset includes Intel Israel, which started with a small chip design centre in 1974, and First Data Corporation, which entered Ireland in 2001 by acquiring a domestic firm specialized in multi-currency card transactions processing. Moreover, the dataset includes a variety of MNCs, including the world largest information and communication technology MNCs, the divisions of several global financial corporations (*e.g.* VISA, American Express, and Citicorp) and general consulting corporations (*e.g.* McKinsey and KPMG).

Table 11 highlights marked differences across these countries. In Ireland MNCs account for about 34 per cent of all sample firms against about 20 per cent in India and only 12 per cent in Israel. Moreover, US MNCs dominate the scene in all countries, especially in Israel where they account for about 83% of all MNCs.

Table 12 illustrates the entry time of domestic firms and MNCs in our sample. There are marked differences between MNCs and domestic firms across our countries which are consistent with the historical evolution of software activities illustrated before. In Ireland, many MNCs entered before the start up of a domestic industry. While about 55% of MNCs currently located in this country have entered before 1990 only 41% of domestic firms entered in the same period.

[19] The literature on MNCs provides different approaches to embeddedness. Some studies focus on alliances as a measure of embeddedness (*e.g.* Castellani and Zanfei, 2002).

Table 11. Sample firms by nationality of the parent company (2001)

India		*Ireland*		*Israel*	
Home country	*Firms*	*Home country*	*Firms*	*Home country*	*Firms*
India	412	Ireland	529	Israel	457
United States	82	United States	149	United States	53
Germany	6	England	50	Japan	3
France	6	Japan	16	England	2
Netherlands	3	Canada	14	Germany	1
Other	12	Other	46	Other	5
Total	521	Total	804	Total	521

Source: Elaborations on various sources (Who Owns Whom, NSD, NASSCOM, and corporate websites).

By contrast, in India and Israel about 25% and 27% of MNCs respectively entered the market before 1990 against 39% and 43% of domestic firms. This picture shows that in these two countries a process of indigenous growth has occurred before or in parallel with the entry of MNCs. This is in line with the evolution of the software industry discussed before.

Table 12. Sample firms by year of establishment

India			
Year of establishment	*Domestic Firms*	*MNCs*	*Total*
Before 1980	35	10	45
1980 to 1990	125	17	142
1990 to 2000	252	82	334
Total	412	109	521
Ireland			
	Domestic Firms	*MNCs*	*Total*
Before 1980	48	41	89
1980 to 1990	168	109	277
1990 to 2000	313	125	438
Total	529	275	804
Israel			
	Domestic Firms	*MNCs*	*Total*
Before 1980	64	5	69
1980 to 1990	134	12	146
1990 to 2000	259	48	306
Total	457	64	521

Overall about 43% of MNCs in our sample have entered these countries before 1990. This shows a long-term commitment to the local economy, which should be reflected in the linkages with domestic firms. In order to explore this issue we collected information about events that involved the sample firms during the period 1998-2002. We classified these events according to the

[20] It is worth to recall that this dataset does not provide the total number of firms that have entered these markets each year since we do not know the number of firms that have exited the market before 2001. Therefore, it is not possible to estimate yearly gross and net entry rates.

following categories: establishment of new plants, units and subsidiaries (new subsidiaries), organisational change (expansion of existing units or subsidiaries), M&As of domestic firms, joint ventures, strategic alliances and outsourcing agreements[21].

The database includes 133 MNCs (active firms) involved in 256 events. As Table 13 shows, MNCs in India have expanded and restructured their operations during the period examined to a larger extent than in the other two countries. They have also established several alliances with domestic firms, such as joint ventures, strategic alliances, and outsourcing agreements. By contrast, MNCs in Israel and Ireland have primarily focused on M&As of existing firms and have set up fewer alliances. In the period 1998-2002 the acquisition of young, promising Israeli software firms represented a typical entry strategy for many MNCs. A case in point is SAP, which entered the Israeli market by acquiring the control of OFEK-tech Software Industries in 2000. OFEK is an Israeli firms founded in 1991 which specialises in warehouse management system software. OFEK started to collaborate with SAP in 1997 and in 2000, after the acquisition, became a wholly owned SAP subsidiary and has been renamed SAP Labs Israel. Before the takeover, OFTEK had got an international reputation with its flagship product, DC-Master, a warehouse management solution which has been licensed to large customers like Nestlé, Colgate Palmolive and Novartis.[22]

Table 13. MNCs internal operations and alliances with domestic firms – 1998-2002

	Active MNCs	JVs	Strategic alliances	Outsourcing agreements	M&As	New subs. & units	Organisational change	Total events
India	51	13	17	21	11	59	3	124
Ireland	33	0	0	1	19	27	10	57
Israel	49	4	8	1	39	20	3	75
Total	133	17	25	23	69	106	16	256

The sample firms have not established alliances in Ireland with the exception of Microsoft (see Table 14 below). In this country several MNCs have signed contractual agreements with domestic suppliers of hardware and services (*e.g.* localization, distribution and customer support) which are not included in our dataset for two main reasons. First, these agreements have limited learning opportunities for local firms. Second, many of these linkages have been established before 1998.[23]

[21] Joint ventures refer to the set up of a new firm while strategic alliances are non-equity alliances such as joint R&D and marketing agreements. Outsourcing agreements include dedicated development centres and other BPO activities managed by local firms in collaboration with MNCs. The category M&As include also minority stakes in domestic firms.

[22] www.sap.com . An important, often overlooked contribution of MNCs to Israel software firms is that they have helped the local industry to shift its attention to more civilian applications.

[23] Table 13 does not report the contractual agreements between Microsoft Ireland and 130 Microsoft Certified Partners.

However, in some cases MNCs have developed partnerships with growing Irish firms and have helped them to reach international customers.

Table 14. Examples of relevant MNCs' linkages with domestic firms

Company	Country	Linkages
Cisco (US)	India	• Establishment of joint development centre with Infosys (2001) • Establishment of joint development centre with Wipro (date n.a.) • Establishment of joint development centre with HCL (date n.a.)
Cisco (US)	Israel	• Cisco and other investors put $25 million in venture capital funds to Israeli telecommunication software firms (2000) • Acquisition of Hynex, software enabling the functionality of voice and data over public ATM Networks (2000)
CommWorks (3Com) (US)	India	• Research and development center managed by Mascon Global (2001)
Creo Products (Can)	Israel	• Creo acquired the digital printing unit of Scitex Corp. Ltd. (2000)
Ericsson (Sweden)	India	• Establishment of an off-shore development centre managed by TCS (2001)
IBM (US)	Israel	• IBM Haifa Research Lab's cooperation with Verisity for language interoperability (2001)
IBM (US)	India	• Alliance with NIIT to train personnel in IBM software technologies (2002) • Partnership with I-flex to provide Syndicate Bank with I-flex Flexcube software (2002) • Knowledge sharing agreement with Infosys on emerging technologies (2002) • Partnership with Tata Elxsi to provide total solutions to the Digital Content Creation Industry (2001)
Intel (US)	India	• Intel capital involvement in Eastern Software Systems (ERP software) (1999) • Involvement of Aspire Communication (management software) in Intel India Partnership Program (2001) • Establishment of a Centre of Excellence in cooperation with Wipro for system design, architecting and performance measurement (2002) • Establishment of a eBusiness Solution Lab with Infosys (2001) • Establishment of an e-business solution lab in cooperation with TCS for activities concerning Intel architecture platforms (2002)
Intel (US)	Israel	• Intel Capital Israel provides financial support to Riverhead Networks (solutions to address distributed denial-of-service attacks) and other domestic software start-ups (2002);
Microsoft (US)	Ireland	• Microsoft signed a licensing agreement with Banta Global Turnkey, for localization, packaging and distribution of Windows XP (2002)
Microsoft (US)	Israel	• Microsoft announced to put $7m into Orion Israel Fund, a venture capitalist focused on Internet software firms (2000)
Nortel (Can)	India	• R&D alliances with Silicon Automation Systems, TCS, Infosys and Wipro (1989-1992)
Texas Instruments (USA)	India	• Involvement of about 40 Indian companies in its Third Party Development Program (2001-2003)
SAP (Germany)	Israel	• Acquisition of OFEK-tech Software Industries, engaged in wharehouse management software (2000) • Acquisition of TopManage in order to improve its product range to SMEs (2002)

Also in Israel only few MNCs have established alliances with local firms. One of these alliances is represented by a joint development agreement on interoperability software signed by the IBM Haifa Research Lab and Verisity in 2001. More frequently, MNCs invest in venture capital initiatives to support emerging start-ups, as in the case of Intel Capital Israel and Cisco.

The small number of alliances with domestic firms is in line with the organisation of R&D activities conducted by MNCs in Israel, which, as noted earlier, often play the role of nodes integrated in the corporate global network rather than being embedded in the local economic environment.

Many MNCs' high-end R&D laboratories, which report directly to their corporate headquarters, abroad tend to be *isolated* from possible interactions with domestic firms. Such strategy could co-exist with a more open approach toward domestic firms within the same MNC. For example, in India the IBM Research Lab, like other MNCs' laboratories, is highly integrated into the IBM Research Division unit worldwide and has limited linkages with domestic firms, while IBM Global Services subsidiary in India has established various outsourcing links with local firms (beyond the

spin-offs mentioned before). A similar dual approach in India has been adopted by MNCs such as Texas Instruments, Motorola and Oracle, which rely on few local subcontractors for short-term or less critical projects while high end R&D activities are conducted in-house (Patibandla and Petersen, 2002). Some MNCs are particularly reluctant to outsourcing their activities for reasons such as the need to control the quality of services offered to their customers or the difficulty to coordinate different stages of the development project from different locations.

Overall, only few MNCs have established R&D cooperative agreements with domestic firms. For instance, in India Nortel Networks established non-equity joint ventures with four large domestic firms (Silicon Automation Systems, TCS, Insofys and Wipro) in the period 1989-1992 before setting up its own subsidiary in 2000. According to a recent report, most R&D conducted by Nortel in collaboration with its Indian partners focuses on development of products whose research activity has been already carried out elsewhere and adaptation of Nortel existing products for the local market; research activities on new products are limited. However, recently these collaborations have focused more on R&D and have yielded some co-patented inventions with one of the local partners (Basant *et al*., 2001). Nortel has also announced the launch of a joint Wireless Centre of Excellence with Infosys. The Centre "will provide research, development and testing" in the combination of "optical, wireless and Internet Protocol (IP) capabilities"[24]. Similarly, Cisco entered the Indian market in 1996 by establishing collaborative linkages with domestic firms (Wipro and HCL) before setting up its own R&D facilities (Patibandla and Petersen, 2002). Today, according to company reports, the Cisco Global Development Centre in India undertakes development and testing activities in cooperation with partner centres established in India by Indian firms such Wipro, HCL and Infosys.

Finally, some recent linkages have provided an important source of technology and business models for young domestic firms. A case in point is Intel Capital Israel which has backed Jungo Software Tecnologies. Jungo's team had the opportunity to work closely with Intel on Jungo's quality testing processes for about a year. This effort has resulted in a stringent product testing program that Jungo has developed with Intel for testing all of its OpenRG flagship software ("Intel has a very rigid quality assurance process, which is a requirement with our product. Jungo's OpenRG has passed all of these quality assurance tests with flying colors"). Finally, Jungo also received technical and business process mentorship from Intel: "When we were still a 35-person company, we had some growing pains. We needed some help in putting the right policies in place for a company that's expanding"[25].

[24] www.nortelnetworks.com

4. The contribution of MNCs to local firms: discussion

MNCs played a different role in the three countries analysed. This Section summarizes the main benefits accruing to domestic firms and answer the question whether MNCs represent the engine of agglomeration and growth of software activities in our countries by spurring the formation of domestic start-ups – a role similar to that played by early entrants in the Detroit car industry at the beginnings of the 1990s (Klepper, 2001) (the *competence & inheritance model of growth*). An alternative hypothesis is that these industries have developed independently of MNCs. It is possible that the development of a critical mass of local firms, spurred by factor endowment, public policies or historical accidents, has subsequently attracted people, key inputs and foreign firms in the cluster. This hypothesis is in line with the idea that the regional professional networks and localized knowledge flows, rather than large firms (like MNCs), represent the main source of new firms and agglomeration of activities in high tech clusters (the *diffused model of industry growth*) (Saxenian, 1994; Porter 1998).

This Section summarizes the role of MNCs in the three countries by taking into account different potential benefits for domestic firms - supply of financial capital to promising domestic start-ups, technology spillovers, access to foreign markets, and demonstration effects. The primary channels through which these benefits have materialised are spin-offs, training and people mobility, and contractual relationships with domestic suppliers/partners. The three cases examined in this paper show different combinations of linkages between MNCs and domestic firms which, to some extent, conform to the *distributed model* or the *competence&inheritance model* of industry evolution.

Israel: MNCs in a distributed model of industry growth

The role played by MNCs in Israel appears to be in line with a model of industry development centred on the externalities generated by the local network of professionals and institutions like the Defence agencies and the excellent university research centres. This regional network represented the main engine of software start-ups. With few exceptions, like IBM, Motorola and Intel, the vast majority of MNCs entered during the 1990s, after an indigenous software industry had started to develop and a highly skilled labour force was available.

Early MNCs have not been a source of spin-offs and people mobility. Instead, these MNCs have tapped the pool of local skills and business ideas spawned by the regional R&D infrastructures and have remained quite isolated from the rest of the domestic industry. This first wave of MNCs have located primarily R&D laboratories in this country, especially in metropolitan regions like Tel

[25] www.intel.com

Aviv, Haifa and Jerusalem, where the presence of academic institutions and the density of firms and skilled people favour the circulation of information. Subsequent waves of MNCs have also entered to exploit the regional network of professionals and firms. Unlike early entrants that have established greenfields facilities, later entrants entered by establishing linkages (M&As, joint ventures and strategic alliances) with promising local firms. These linkages provide domestic firms with managerial expertise and capital. Despite the growth of a domestic venture capital industry, these resources are in short supply amongst Israeli software firms. Intel represents one of the most prominent example of first generation MNCs which offers venture capital and business models to domestic start-ups.

Only recently MNCs spin-offs and people mobility generated by MNCs subsidiaries have become more frequent in Israel.

MNCs apparently do not represent an important source of technological spillovers for Israeli software firms. This is demonstrated by the low share of inventors who have moved from the local MNCs' R&D laboratories to domestic firms (even though the absolute number of these inventors is much larger than in India and Ireland) and the small number of citations of MNCs' patents by domestic firms. By contrast, the patents of domestic firms tend to cite other domestic firms' patents and this suggests that there exists a dense network of local professionals.

Finally, MNCs do not represent important customers for the average Israeli software firm. Most revenues of domestic firms arises from exports while MNCs have limited linkages with local suppliers.

The acquisition of minority stakes in domestic firms by MNCs have increased the overall reputation of Israeli software firms and therefore have eased their access to foreign markets. However, local subsidiaries of MNCs do not represent the main bridge to international markets. This is demonstrated by the fact that a large number of Israeli software firms have moved their headquarters in the US to have a direct access to management, marketing, and financial resources, while maintaining their R&D activities in Israel.[26]

Ireland: MNCs as the engine of software growth

In Ireland most MNCs entered before the formation of an indigenous software industry and have generated a considerable number of spin-offs. They have also contributed to the training and mobility of human capital as showed by the share of inventors who have moved from MNCs to

[26] According to the Crain's New York Business by the end of 2002 there were about 250-300 Israeli technology start-ups in the New York area, most of which specialize in internet and telecommunications (Crain's New York Business, Nov. 13, 2000: 27). One of the few examples of Irish firms which have followed this strategy is Twelve Horses, a firm specialised in XML-based services for e-commerce. This firm has moved its headquarters in Salt Lake City while maintained its R&D operations in Dublin (Client Server News, Nov. 12, 2001).

domestic firms. This share, about 10% of total domestic inventors, is considerable compared with that of India and Israel respectively.

In Ireland MNCs have not generated considerable technical spillovers as demonstrated by the limited share of MNCs' patents cited in domestic firms' patents. It is worth to note that technological spillovers amongst domestic firms, measured by patent citations, are also very limited. This indicates that, unlike the case of Israel, the local network of scientific and technical professionals is quite limited.

MNCs have established few inter-firm alliances in recent years. Earlier alliances with domestic firms were primarily centred on subcontracting low value added activities like localisation, software packaging and logistics. There are examples of domestic firms that have benefited from the experience and knowledge of MNCs not because of geographical proximity but for the reason that they were directly in contact with MNCs, as in the case of former employees. This is in line with the 'competence&inheritance' model of industry growth.

Demonstration effects have probably been quite important in Ireland, where MNCs have shown that high tech activities could be carried out in a country without an industrial tradition. Until the 1960s in Ireland there were limited manufacturing activities, many of which controlled by the state (NSD, 2002).

Moreover, MNCs have often represented an important customer in the early stages of growth of domestic start-ups and have favoured the establishment of new contacts with foreign customers. And they are still important customers of domestic firms specialized in localization, logistics and sales activities. Even in the case of domestic firms that have become international players, like Iona and Kindle Banking Systems, MNCs have often represented the initial channel to reach customers abroad. More recently, also promising high tech software start-ups have enjoyed the reputation effects arising from their linkages with MNCs.

Although MNCs in Ireland have clearly played a more important role than in Israel, their overall impact on the domestic software industry is debatable. They account for about 90 per cent of Irish software exports in 2000. Therefore domestic firms, whose average number of employees was about 16 units in 1999, have still a marginal position in this industry. Overall, about 62 per cent of domestic firms' revenues are accounted for by exports. However, only one per cent of all domestic firms account for about 30 per cent of domestic exports.[27] This suggests that, except for few firms like Iona, Massana and Kindle Banking Systems, the majority of domestic firms have a limited presence in the foreign markets. And some of these firms supply customised development, software localization and other services to MNCs. Therefore, the question arises as to whether MNCs in

Ireland have hampered the growth of a domestic software industry - by hiring the most skilled and experienced software professionals and attracting the demand away from domestic firms. It is possible that MNCs have produced some negative externality in the labour market but this is not the case of the product market where most domestic firms do not directly compete with MNCs.

India: an hybrid model

The role of MNCs in the evolution of the Indian software industry does not conform neatly with one of the two models discussed before. Except for few examples of early entrants (*e.g.* Texas Instruments and Citibank), the bulk of MNCs have entered during the 1990s.

The clustering of most domestic software firms and MNCs firms in Bangalore, Mumbai, and Hyderabad have been favoured by the presence of good educational institutions and a network of skilled professionals. For instance, Bangalore has been chosen by many MNCs because of the high level of local Universities and suppliers, and also by the quality of life in Bangalore, which has attracted Indian returning immigrants, Indian engineers living in other Indian cities and foreign managers (Balasubramanyam and Balasubramanyam, 2000).

These location advantages are in line with the 'distributed model' of industry evolution, centred on the regional advantages which attract people and firms from outside. Moreover, like in Israel, the contribution of MNCs in terms of people mobility and spin-offs appears to be quite limited. Only recently the number of software engineers who leave MNCs to join smaller domestic firms appears to be on the rise while in the past most domestic firms suffered from high attrition rates, which in part resulted from the attractiveness of MNCs.

Some early MNCs generated substantial demonstration effects. The geographical proximity and, on some occasions, subcontracting agreements have allowed domestic firms to have access to the R&D and business practices of large, global organizations. The potentialities for spillovers are limited in the case of high end R&D since these activities are mostly carried out in-house by the MNCs and are protected by secrecy. Organisational and managerial spillovers are often more important than technology transfer. For example, Texas Instruments and Citibank have shown the viability of a business model (offshore development) to domestic firms.

Moreover, the majority of MNCs have established few R&D alliances with Indian firms until recently. Typically domestic firms have been involved in low value-added activities such as customised programming and testing. In the last few years, the number of R&D alliances have grown and several spin-offs have been spawned by MNCs. It is possible then that a new generation of Indian software firms is emerging by drawing on the expertise inherited from MNCs.

[27] Estimates based on data collected through interviews with a sample of domestic firm which includes the

Like in Ireland, for some domestic firms MNCs represented the first source of revenues and a bridge to international markets. Some small domestic Indian firms still rely on MNCs as an important source of revenues while larger firms, like Wipro, TCS and Infosys, are much less dependent on MNCs even though they have entered long-term contracts with MNCs for offshore outsourcing services. Domestic firms overall account for the largest share of Indian software exports. The Indian software industry then appears to be much more independent of MNCs as compared with its Irish counterpart.

5. Conclusions

This analysis leads to two final considerations. First, it shows that the evolution of software activities and the role of MNCs vary considerably across these three countries. The main differences concern the time of entry of MNCs relative to domestic firms and the type of activities conducted by MNCs, which appear to reflect different regional comparative advantages. Many MNCs in Ireland entered before the formation of a domestic industry and their activities have largely remained focused on low value added activities. By contrast, in India and Israel the bulk of MNCs have entered after the emergence of a domestic industry. Their activities, however, are different. In India, with few exceptions, MNCs mostly carry out offshore outsourcing services while in Israel the majority of MNCs conduct higher value added activities (including R&D). Recently, MNCs have started to shift to India also higher end R&D operations (*e.g.* in the field of chip design, telecommunication software and application software) following the successful examples of few early entrants like Texas Instruments and Motorola.

The differences across these countries concern also the contribution of MNCs in terms of people mobility and spin-offs, which appears to be relatively more important in the case of Ireland. MNCs have also played a different role in terms of demonstration effects, which appear to be stronger in the case of India and Ireland compared to Israel.

These differences suggest that only in the case of Ireland MNCs have helped starting the process of growth by providing the domestic industry with inputs (people mobility, spinoffs and business models) and market opportunities (including linkages with foreign customers). This experience represents then a partial example of the *competence&inheritance model* of industrial evolution. In Israel MNCs have provided important complementary resources, like finance, marketing and managerial capabilities, to domestic firms after the regional software cluster has developed independently from the MNCs. In this case, MNCs have been attracted by a dense regional network of highly skilled professionals and domestic start-ups with expertise in security, telecom and chip

largest exporters in 2000.

design software. In line with the *distributed model* of industry evolution, the engine of domestic entrepreneurship and industry growth is represented by the regional network rather than the single firm, including MNCs. The example of India shows features of both these models.

The second final conclusion is that the overall impact of MNCs on the development of the domestic software industry in the three examples analysed is quite controversial. Ireland is the only case where many MNCs entered before the domestic industry and contributed on various grounds to its emergence. However, domestic firms on average are still small and account altogether for a tiny share of Irish software exports. In Israel and India, the positive effects of MNCs on domestic firms, such as reputation, access to capital and managerial capabilities, have become apparent only in recent years and it is too early to forecast their impact on the future growth of the domestic industry. This suggests that analysts of MNCs' linkages and policy makers in emerging regions should pay attention to the timing of entry of MNCs in new industries. The examples of Israel and India show that an early entry of MNCs is not a necessary condition for the growth of a domestic industry while the experience of Ireland indicates that it is neither sufficient.

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APPENDIX

Data and methodology

We have collected firm-level data from various sources, including publicly available material such as annual reports and corporate web sites. For Irish software firms and Indian firms we obtained information from their respective national industry associations and public agencies – i.e., ISA and NSD for Ireland and NASSCOM for India. Publicly available information from the Association of Israeli software firms is more limited.

We integrated these data with information derived from Dun and Bradstreet's *Who Owns Whom Linkages* database (2001 edition) and from InfotrackWeb database (*Business and Company Resource Centre* and *Expanded Academic ASAP*). The former provides information about firms located in the sample countries by sector. The following data were extracted for each firm: primary and secondary SIC code (industry) of the firm, number of employees, year of establishment, name and country of the ultimate parent company.

For our purposes we selected all domestic firms operating in the software and IT services industry (SIC 737x, see Table A for the full list of sectors). We also selected all foreign firms with local subsidiaries operating in ICT sectors (including computers, telecommunications equipment and services, microelectronics).

InfotrackWeb database reports articles in English from various press sources. We could gain access to detailed information about events and firms involved in each event only for the period between 1998 and 2002.

Table A - Industry sectors

- Communication equipment: broadcast communication equipment (SIC 3663); comm. equip., telephone and telegraph apparatus (3661)
- Computers: computers (357X, incl. computer peripherals, 3577); general industrial machinery (industrial automation and robots only) (3569); electrical appliances (5064, only computer pheriperals such as monitors)
- Electronics: electronic tubes, capacitors, resistors, transformers, components, parts and equipment, semiconductors, printed circuit boards (367X); records/audio/tapes discs (3652)
- Communication serv: radio telecommunications services (4812); phone communications (4813); other communications services (4899); radio broadcasting stations (4832)
- Information Technology services: IT services (737x, excluding 7372); computer equipment and software distribution (5045); office equipment (5044); data processing schools (8243); help supply services (7363)
- Software: prepackaged software (7372)
- Other: business services, nec (7389); holding companies (6719); unclassified establishments (9999)

Our analysis draws some information on the role of MNCs from interviews conducted in a previous project where one of the authors was involved. We had access to the reports of 64 interviews with representative firms and sector experts conducted in Ireland in 2000 and 75 interviews with senior managers and software professionals of 40 Indian firms in Bangalore, Bombay, Hyderabad and Delhi conducted in two separate visits in 1997-98 and in 1999 (Arora *et al*. 2001; Arora, Gambardella and Torrisi, 2001).

Table B list of telephone interviews, 2003

Position	*Company*	*Country*
CTO	Irish company	Ireland
Editor-in-Chief	Irish Emigrant Publications (former Digital Equipment)	Ireland
Managing Director	Hewlett-Packard Software Operations	Ireland
Managing Director	SAP Service and Support Centre	Ireland
CEO	Anam	Ireland
Country Manager	Microsoft Ireland	Ireland
Chairman	Fineos	Ireland
Country Manager	Intel Capital	Israel
Vice-president	NASSCOM	India
CEO	Philips Software Centre	India
CEO	Aspire Communication	India
Director	Eastern Software Systems	India
CEO	Ittiam Systems	India
Chairman	Evalueserve	India