Title	The Role of MNCs in Knowledge Accumulation, Absorption and Utilization in Indigenous Irish firms: A case study of the Galway Medical Technology Cluster
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Publication Date	2010-06
Publication Information	Das, S. and Ryan, P. (2010) "The Role of MNCs in Knowledge Accumulation, Absorption and Utilization in Indigenous Irish firms: A case study of the Galway Medical Technology Cluster", CISC Working Paper no. 37.
Publisher	CISC
Item record	http://hdl.handle.net/10379/2465

NUI Galway
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Centre for Innovation and Structural Change Working Paper Series

The Role of MNCs in Knowledge Accumulation, Absorption and Utilization in Indigenous Irish firms: A case study of the Galway Medical Technology Cluster

CISC Working Paper No. 37
June 2010

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Ireland's EU Structural Funds Programmes 2007 - 2013
Co-funded by the Irish Government and the European Union

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The Role of MNCs in Knowledge Accumulation, Absorption and Utilization in Indigenous Irish firms: a case study of the Galway Medical Technology Cluster

Abstract

This study examines the multifaceted role of MNCs in capabilities development of indigenous firms within a high-tech industrial cluster. The paper explores how MNCs and indigenous firms are involved in producing related product varieties. Furthermore, it indicates that the industrial dynamics of the cluster involve significant networking, learning and spillovers. The research shows that MNCs are strongly involved in asset exploiting R&D and asset acquisition along with routine production. These processes have a positive impact on the development of the core competencies of the cluster and the formation of indigenous startups. The core competencies encompass the development of resource management capabilities as well as low cost search for technological information and knowhow. The research found a two way loop involving spillovers. Exposure to MNCs' corporate structure allows Irish entrepreneurs to identify technology and market gaps. It also enables them to understand regulatory procedures and facilitates connection to foreign markets. The new indigenous startup firms network with the original equipment manufacturers, suppliers and team up with other value adding agents and MNCs inside and outside of the cluster to create a global presence. However, the rate of growth in indigenous firms is bounded by improper coordination of the innovation value added chain at the national level. Second, the cluster is gradually locked into the routine of the member MNCs. The study found that access to clinicians, inadequate finance model, and lack of critical skills in marketing are the three most important impediments to successful startup. Galway's credibility as a medical technology cluster, the presence of leading global medical technology MNCs as the source of learning and networking, and the presence of a skilled work force are the three main driving forces of innovation in this high-tech cluster. The study employed a novel quantitative database (ref.LUCERNA, CISC) and extensive qualitative information from interviews with new venture founders and CEOs from existing indigenous firms.

The Role of MNCs in Knowledge Accumulation, Absorption and Utilization in Indigenous Irish firms: a case study of the Galway Medical Technology Cluster

1. Introduction

The development of the medical technology sector in Ireland typifies the nature of economic growth that the country has experienced over the past two decades. Led by the presence of significant operations by top foreign-owned multinational corporations in the field, the Irish medical technology sector has contributed to rising high-tech exports and knowledge-based employment. The purpose of this paper is to undertake a data analysis exercise utilising the Lucerna database and methodology to understand the development and dynamics of this sector. In particular, the study provides an understanding of the underlying capabilities and skills of the sector by analysing the prevailing industrial dynamics. Based on this analysis, the main argument presented is that the distinct capabilities are in place to allow a transition to a new business model based on endogenous development. However a caveat is the danger of lock-in to a technology through over-specialisation. Cognisant of the specialisation of activity at a regional level, we examined more closely the medical technology sector in the Galway city region. A description of the emergence and development of this regional cluster is provided, the interplay between university and industry outlined, and emerging and converging technologies identified. Finally, certain conclusions are drawn.

2. Medical Technology sector in Ireland

The successful development of the Irish medical technology sector is a consequence of the policy drive to attract high-tech FDI. The presence of significant operations by the world's top companies such as Boston Scientific, Abbott, Johnson & Johnson, Medtronic, Stryker, Merit Medical, Baxter and Tyco Healthcare has resulted in the Irish sector being compared to leading global medical centres: Massachusetts and Minneapolis. The initial investments by foreign-owned MNCs (multinational corporations) in the country were predominantly low-cost assembly manufacturing sites, whereby the corporation was attracted by the low corporate tax rate and special grant aid incentives. However, the sectoral share of R&D performed by foreign-owned firms as a percentage of total R&D investment by overseas firms for the instrumentation sector that includes medical instruments increased significantly between 1993 and 2007 (GERD, OECD, 2009). The presence of these firms has stimulated the growth of an indigenous base of small companies providing mainly sub-supply and

support services. The indigenous base of enterprises involved in producing medical devices or diagnostics is relatively small and has developed mainly as a result of ex-employees of foreign MNCs establishing local enterprises or start-ups from universities. This is an export-oriented sector with the US as a major export destination for the products manufactured in Ireland. The US companies based in Ireland carry out major manufacturing activities with an aim to export products to US and European destinations. The majority of companies are clustered in the Galway regionwhich is the particular focus of this paper.

To understand the capabilities that underscore this TBC we use the methodology described in the previous section of this report. The cluster as presently constituted includes 657 individual products that, according to Kompass, can potentially be produced in the medical diagnostics and testing areas. Our objective was to see what proportion of this 657 products were manufactured in the Irish medical technology sector (see Table 1). Kompass updates the list of products each year so longitudinal study of the sector's evolution is possible.

The entire product portfolio of this technology-based cluster is regrouped into 16 medical device sub-groups (MD Sub-Groups) as presented in table 1. Each subgroup consists of number of a 'related variety of products'. This generally denotes common technology and engineering platforms, production process or medical specialisation.

Data mining methods are employed to decipher the pattern and structure of clusters and sub-clusters. Information on which firms produce which product(s) is illustrated on scatterplots in figures 1 and 2. The procedure behind this data mining technique is that the product portfolio of this TBC in Galway are scattered in a matrix format in which the system specifies each product produced in Ireland. All the potential products that can be produced in medical technology (ref our methodology and kompass classification) are organised into the technology sub-groups and represented on the x-axis, while all the existing firms in this TBC in Ireland are represented on the y-axis.

Table 1: Sub-groups of Medical Devices and Services

Medical Device Sub-Groups	No of Available Products
Surgical & Medical Equipment - Specialised (SME-S)	87
Surgical & Medical Equipments - Basic (SME-B)	21
Surgical & Medical Equipment - Support System (SME-SS)	15
Surgical & Medical Equipment - Sterilization & Preservation (SME-SP)	40
Surgical & Medical Equipments - Monitoring(SME-M)	33
Basic Surgical & Medical Instruments (SMI-B)	91
Dental Equipments (DENT)	82
Medical Reproduction Equipments (MDRE)	65
Orthopaedics & Prostheses (ORPR)	49
Medical Products - Basic (MDPD-B)	43
Veterinary Equipments (VETE)	37
Electro-medical and electro-biological equipment (EMBE)	33
Diagnostics Equipments & Testing Devices (DETD)	28
Rehabilitation Device & Equipment (REDE)	24
Medical Services (MDSV)	6
Medical Products - Other (MDPD-OT)	3
TOTAL	657

The scatterplots show that there are concentrations of product and services in a few subgroups, these are, MDSV (Medical Service), MDPD-B (Medical Products – Basic)…..The concentrations of activity in these particular sub-groups indicates capabilities in precision engineering and plastics. These sub-groups also exhibit unique employment patterns. For example, the MDSV sub-group consists of firms that have less than 250 employees with the majority employing 10 to 49 employees; MDPD-B (Medical Products – Basic) and ORPR (Orthopaedics & Prostheses) groups have sizable employment. This may be linked to the nature of their investment, that is, foreign or indigenous. Overall, in this TBC, firms are involved in the production of a few related varieties and complementary products around a few medical speciality groups, irrespective of their size of employment.

Figure 1 illustrates a typical concentration of indigenous activities mostly confined to those specialised MD sub-groups where foreign owned MNCs also operate. This is particularly true in MDSV (Medical Services), DETD (Diagnostics Equipments & Testing Devices), MDPD-B (Medical Products – Basic) and SME-Sp (Surgical & Medical Equipment - Sterilization & Preservation) sub-groups. An in-depth analysis of the product portfolio indicates indigenous firms are mostly involved in the production of related and complementary products to MNCs or produce niche products in the same medical specialisation of MNCs subsidiaries in the

Galway region. This is true irrespective of employment size and age. Young and old firms as well as indigenous and foreign-owned firms operate within the same MD sub-groups and activities are related as illustrated in figure 2 suggesting transfer and learning of capabilities.

The summaries of these findings that shed light on industrial dynamics and evolving capabilities in this TBC are listed as follows:

- There is an inherent specialisation around a few medical speciality products and services, and technology and engineering platform.
- Production in most of the MD sub-groups is distributed around related varieties and is complementary to MNCs activities.
- The profiling exercises suggest significant organisational learning but also reveals the exposure and potential vulnerability of the medical technology cluster to technological lock-in.

These summary findings can act as 'triggers' for further more detailed empirical studies, particularly qualitative analyses. Indeed based on these points a more detailed empirical study of the cluster in Galway was carried out and is presented in the next sub-section.

Figure 1: Product Landscape of the Medical Device Sector in Galway by Origin

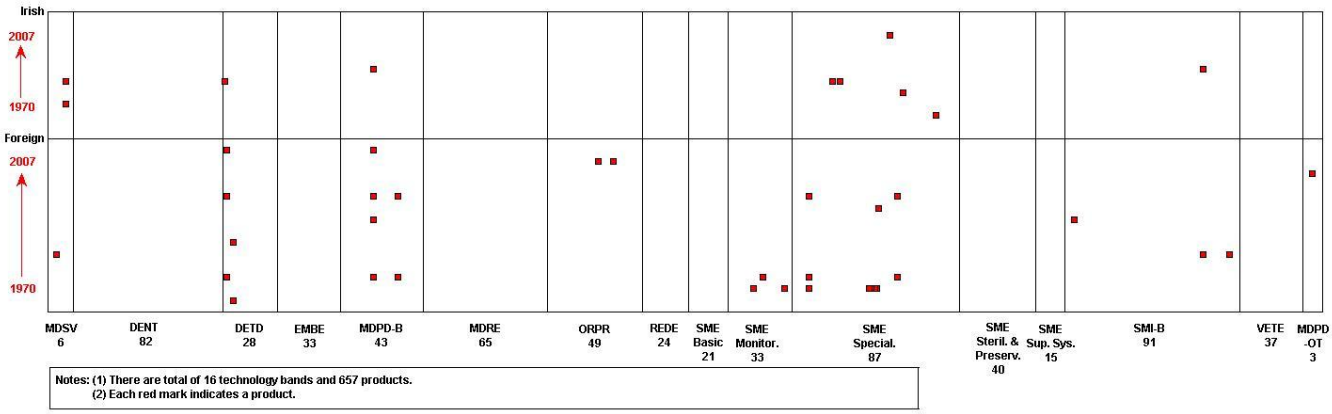
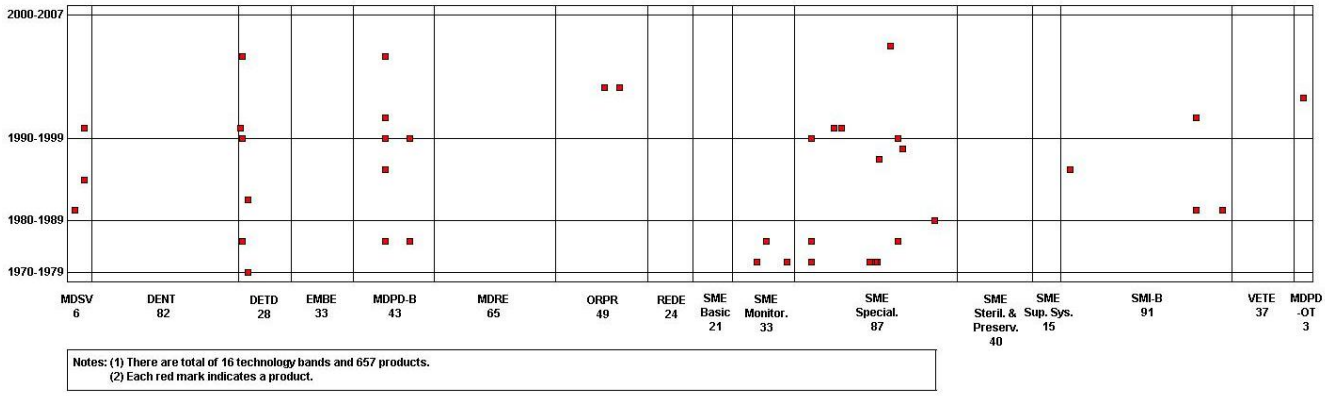


Figure 2: Product Landscape of the Medical Device Sector in Galway by Incorporation Year



3. A Regional Case: Galway's Medical Device Cluster

3.1 Cluster emergence and development

The first major investments in technology-related activities in the Galway region were the establishment of a manufacturing facility by DEC (Digital Equipment Corporation) in 1971 and the Canadian telecommunications corporation, Nortel Networks in 1973. Digital in Galway was set up as a computer hardware assembly and distribution centre for the European market (Wijnekus 1997). Software, which was imported primarily from the US and used to support the hardware business, was assembled into kits and distributed with the hardware from the facility in Galway (Wijnekus 1997). The facility originally opened with 109 employees but the number employed grew consistently to over 1000 workers by 1981 (Wijnekus 1997). The software side of the facility also developed quite rapidly and within the first three years of the operation a software entity, distinct from hardware manufacturing, had emerged, namely the European Software Distribution Centre (ESDC) (Wijnekus 1997). This reflected the growing knowledge-intensity of the activities being undertaken at the Digital facility (Wijnekus 1997). Similarly, while Nortel Networks initially established a Galway-based manufacturing site in the telecommunications domain, it subsequently invested in and expanded activities at the site to include considerable research and software development responsibilities.

In line with the growing electronics and software sector, medical technology activity in Galway was initiated with the CR Bard investment in 1982. CR Bard's facility involved the development and manufacture of products in the area of coronary and vascular disease. CR Bard continued to make significant investment in the facility in Galway through the 1980s and 1990s across various functions, including research, development, manufacturing and marketing (Murphy 1998). Ireland provided corporations like CR Bard, Digital and Nortel Networks access to the European market, tax incentives and an English speaking and educated workforce (Wijnekus 1997).

The closure in 1993 of the Digital manufacturing facility in Galway resulted in a number of initiatives being undertaken by Digital, the Government and local business groups that resulted in the foundation of start-up enterprises in the region (Needham 1999). Digital itself offered internal services to redundant staff that included job search facilities, career change programmes and an enterprise development/start your own business programme (Needham 1999). In addition, the Government along with national industrial development agencies and local business support groups formed an inter-agency task force from which the most significant outcomes were the provision of funding for start-up enterprises, access to advisory services and the establishment of the Galway Technology Centre (Green et al. 2001). The Centre provides workspace for early stage and developing high-technology enterprises.

As a result of these initiatives, many ex-Digital staff used their acquired managerial skills to form businesses in various areas including, electronics, software, manufacturing and services (Needham 1999). In addition, existing foreign investments in technology were encouraged to remain in the region while new foreign investment was sought (Green et al. 2001). In particular, one of the world's leading medical technology corporations, Boston Scientific, established a facility in 1994, occupying some of the redundant Digital space. Whilst initially it was a relatively low-value added manufacturing facility, over the 1990s and early 2000s the MNC opened an R&D facility to develop as well as manufacture medical devices particularly drug-eluting stents within the field of cardiology. Furthermore, in 1998 the cardiovascular division of CR Bard was acquired by AVE (Arterial Vascular Engineering), which was subsequently acquired by Medtronic the following year. Both AVE and Medtronic retained this division in Galway and the facility concentrates on the development and manufacture of drug-eluting stents and their components.

While Medtronic and Boston Scientific are presently by far the largest employers (employing over 4000 people between them in the region), a number of smaller-sized indigenous and foreign-owned companies have been established in the past decade adding to the vibrancy of the cluster (Giblin and Ryan 2010). The establishment of these new firms as well as the frequent mergers, acquisitions and management buy-outs taking place underscores the cluster's dynamism. However, foreign investments from world-renowned corporations, including Tyco Healthcare (renamed Covidien and formally Nellcor Puriten Bennett in the region), Beckman Coulter and Merit Medical as well as Boston Scientific and Medtronic drive the cluster (Giblin 2007, Giblin and Ryan 2010). While divestments from the region, most notably Abbott in 2007 also mark its landscape and accentuate the vulnerability attached to a dependence on foreign investors, it is the upgrading of many of these investments from initial manufacturing sites to product development facilities that has resulted in a transfer of knowledge, skills and capabilities to the locality (Giblin 2007, Giblin and Ryan 2010). The next subsection explores these capabilities and skills in more detail using explicitly the Lucerna dataset.

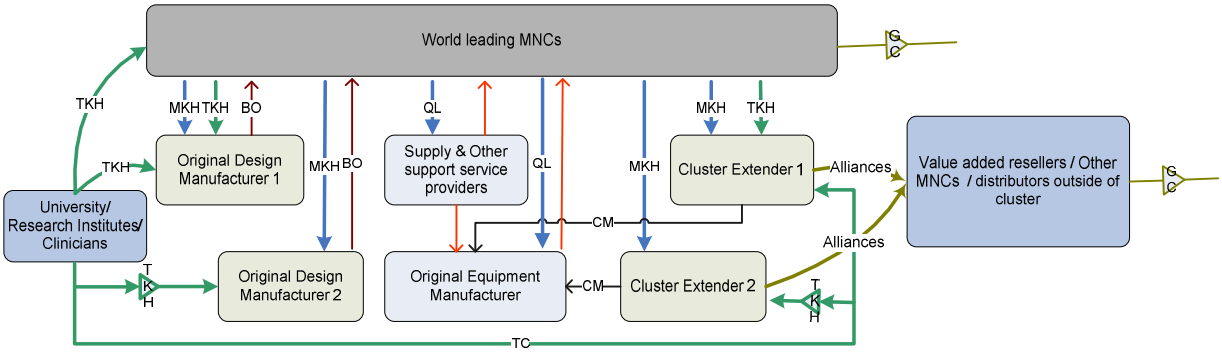
3.2 Cluster capabilities and skills

The influential presence of Boston Scientific and Medtronic has resulted in many of the companies being involved in cardiology-related devices, particularly drug-eluting stents and their components, such as guide wires, balloon catheters, hypo-tubes and filters. As result the Galway region has been recognised for its specialisation in coronary devices. The products within this sub-group are mostly minimally invasive cardiovascular interventional products. It is not surprising to observe that Diagnostics Equipment and Testing Devices (DETD), Basic Medical Products (MDPD-B) and Surgical and Medical Equipment Monitoring (SME-Monitor) and Specialised (SME-Special) products are manufactured by the firms that have 500 or more employees considering the fact that some of the top global medical device companies have manufacturing plants in Galway.

Figure 3 is a schematic illustration of industrial dynamics for the Galway medical device cluster. This sector is highly regulated and successful product development heavily depends upon critical management skills, knowhow and contacts specific to this sector. That includes access to top clinician and R&D centres; understanding of the regulatory standards; accreditation and regulatory approval by the FDA, marketing expertise; and connection to

government agencies, industry bodies, suppliers and distributors. The MNCs play a pivotal role as they are the main sources of 'managerial knowhow' in the cluster. Required international connections are often made through MNCs. Knowledge transfer occurs through the movement of people between firms. New indigenous start-ups by previous MNCs employees emerge as different forms of knowledge, both tacit and codified, get circulated among cluster members. MNCs also act as the most important source of 'technological knowhow' for indigenous firms. Indigenous entrepreneurs avail of the gaps in the innovation value chain of the MNCs activities which provide opportunities for new product developments.

Figure 3: Galway medical device cluster: Actors and flow of information



Legend: MKH – Manegerial Know-How, TKH - Technological Know-How, BO – Buy out, QL -Quality Standard, CM – Contract Manufacturing, GC – Global Connection

In terms of origin, products in DETD, MDPD-B, SME-Monitor, SME-Special and SMI-B technology sub-groups are produced heavily by foreign owned companies in Galway The establishment of the CR Bard cardiovascular products plant in the early 1980s was followed by many other Galway plant openings in the 1980s and 1990s. The scatter plots demonstrate the region's specialisation and capabilities in tackling design and production challenges of complex medical products. In the absence of a strong third level education/research institutes and industry interplay, developing an internal technical infrastructure to challenge complex design and product development tasks is not feasible. The next section addresses the historic interplay dynamics in the Galway region.

3.3 Third-level institutes and industry interplay

The Government establishment of Centres of Science Engineering and Technology (CSETs) through Science Foundation Ireland (SFI) at Irish Universities facilitated the creation of partnerships between academic researchers and industry to conduct leading-edge research. Within Galway, the Regenerative Medicine Institute (REMEDI) CSET was established in 2004 at NUI Galway. REMEDI is involved in stem cell biology and manufacturing, gene therapy, orthobiologics, immunology, cardiovascular, socio-economic and bioethical research (REMEDI 2009). One of its main industrial partners is the local foreign-owned medical technology corporation, Medtronic, which invests funding in the institute and has people working on the Insitute's research activities. The collaboration with Medtronic builds a reputation for REMEDI, opens opportunities for students and further funding, and from Medtronic's perspective, provides the possibility for the development of a beneficial licensing arrangement from the research (Brady 2006). REMEDI is also embedded within the activities of the National Centre for Biomedical Engineering Science (NCBES) based at NUI Galway. In conjunction with the growing local medical technology sector, the Centre was established in 1999 and undertakes research activities under four main themes; biomedical engineering, cancer, neuroscience and regenerative medicine through REMEDI. Since its establishment the NCBES has engaged in numerous formal research contracts with the medical technology sector and participates in Enterprise Ireland Innovation Partnership projects that provides funding for research projects involving third level institutes and Irish-based companies.

In addition to these collaborative research activities, NUI Galway has also participated in meeting the labour skill requirements of the medical technology sector. The University introduced a new degree programme in Biomedical Engineering in 1998, the first students of which graduated in 2002. The degree programme was established under the Department of Mechanical Engineering, which changed its name in 2002 to the Department of Mechanical and Biomedical Engineering. This reflected its focus on biomedical research and education activities. On average, twenty-two students have graduated each year since 2003 and it was the first biomedical engineering degree programme to be accredited by the IEI (Institution of Engineers of Ireland).

Such developments in NUI Galway, which are embedded within the overall policy context, have been significant for building the capabilities of the medical technology sector in Galway.

Given that the local sector is driven by foreign-owned MNCs, the need for the cluster to develop endogenously-based capabilities is significant, particularly for its sustainability. In this respect, and as argued in the literature on clusters and regional growth (e.g. Feldman and Braunerhjelm 2006, Feldman 2008, *Giblin and Ryan, 2010*), the development of local research and entrepreneurial activity is essential. Therefore, the following section concentrates on cases of entrepreneurship in the region and examines the potential for the convergence of technologies that may underscore the future of the cluster.

3.4 Indigenous Growth, Emerging Technologies and Convergence

The effects of the DEC closure on the formation of start-ups in newly developing subsectors within ICT such as integrated-circuit design and software are highly visible (Sheridan, 2007; Giblin, 2007; Needham, 1999). Medical device start-ups, in the Galway region in particular, were also emerging as a result of indigenous-focused policies that have been implemented through various government agencies. Post-DEC era policies, as discussed previously, created incentives for redundant but skilled DEC employees (Needham, 1999) and ex-vendors to link with the globally emerging new sectors. There are strong links amongst affiliates of foreign-owned and local start-up medical technology companies as well as key serial entrepreneurs in the Galway region. The Galway region has been home to a small number of serial entrepreneurs who have prior MNC managerial experience.

Desk-based internet research found that John O'Shaughnessey, Charles Taylor and Paul Gilson were originally senior executives of CR Bard[1], the first US medical device firm to locate in the region. The CR Bard acquisition was followed by the first wave of start-ups by the O'Shaughnessey, Taylor and Gilson trio. The first series of start-ups, Salviac, Carotid Interventional Systems (CIS) and MedNova, were successful. CIS and its parent company MedNova were acquired by the vascular division of Abbott, the US life science company. Another successful Irish Start-up, Crospon Technologies, was also a team effort this time by John O'Dea, John O'Shaughnessey, and Conor McNamara. Prior to Crospon, John O'Dea set up the R&D facility for Puritan Bennett before starting Caradyne in 1997, which was acquired by Respironics, a US company, in 2004 (Daly, 2007).

[1] CR Bard was later acquired by Arterial Vascular Engineering (AVE) which was later acquired by Medtronic.

Most importantly, the development of capabilities in electronics through the presence of companies like Digital in the region provided an initial platform from which medical technology activities have grown. The Galway-based company, Creganna provides a case in point. This company, established in 1980, was involved in contract manufacturing to the electronics industry but by 2003 it had divested interests in electronics to focus solely on the medical device market. It is now one of the largest indigenous employers in medical technologies in Ireland with over 520 employees across its Irish and US bases (Corrigan 2008a). With Boston Scientific and Medtronic both involved in the production of drug-eluting stents in the region and the growth of companies like Creganna around this activity the convergence of pharmaceutical and medical technologies has also been at the core of the cluster's development.

As companies look for new opportunities, the potential for product development in the convergence of particularly ICT and medical technologies has received attention recently (Allen 2008) and is one in which Galway is ideally placed to exploit. Along with the growing medical technology cluster in the 1990s, the closure of Digital signalled the growth of an ICT cluster in Galway (Green et al. 2001), particularly in the area of software (Giblin 2007). Although it entails a smaller concentration of firms than in Dublin, the software industry in Galway is characterised by the presence of foreign-owned affiliates, such as Hewlett Packard and Nortel creating most of the employment and a larger number of small and medium sized enterprises. Many of the firms are involved in software product development, particularly bespoke software, systems software and application software development as opposed to lower value-added localisation activities (Giblin 2007). With clusters of software and medical technology firms in Galway, the potential for using local expertise in the convergence of these technologies is significant but has not as yet been greatly exploited.

The endeavour to integrate IT and medical technology has been undertaken by one medical company in the region by collaborating with Hewlett Packard in the US. Through a license agreement with HP the indigenous company Crospon will produce and commercialise a drug-delivery patch applied to the skin, which enables "precise control of dosage timing, access to dosage history, patient activation mechanisms and inherent safety protocols for preventing adverse drug interactions" (Crospon 2007). The skin patch, developed by HP Labs based on the core technologies of their thermal inkjet printer (Brown 2008), will involve a three-way convergence of IT, medical technology and pharmaceuticals. While Hewlett Packard initially foresaw regulatory barriers in bringing the concept to market but were considering it as a

potential business partnering project, the bringing together of the corporation with Crospon through Enterprise Ireland led to the licensing out of the intellectual property (Brown 2008). Hewlett Packard runs an IP licensing programme and Enterprise Ireland approached the corporation in Palo Alto, California to encourage them to consider Irish companies for licensing agreements. From this, the relationship with the Galway-based medical technology company developed.

Another company in the region, Vysera, which is involved in the design of anti-reflux valves based on biomimetic material and used for the digestive tract, has recently undertaken a "software modelling project that will add value to future product design" (Corrigan 2008b). Although, perhaps not a direct use of software for the functioning of a medical device, the increased awareness of companies of the use of software to add value in different ways is significant for the industry and local economy. Indeed, John O'Dea of Crospon states that "the proximity between the IT and medical device sectors could be harnessed here with Ireland playing a key role in the emerging technological space" (Allen 2008). The opportunities of using IT technologies to develop systems that communicate with implantable medical devices (Allen 2008) or to control and manage the delivery of drugs as in the case of the HP-Crospon skin patch are considerable.

However, there are challenges to the development of this technological convergence whether at a local or national level. It requires a collaborative environment (Allen 2008) with connectivity linkages between various actors; including firms from different technological domains, regulatory bodies, end-users (e.g. clinicians), legal bodies, funding agencies and research centres. Industrial development authorities, like Enterprise Ireland and IDA Ireland can be used as a means for opening and building communication linkages between these various actors. Most significantly however, such a collaborative environment necessitates inter-organisational trust (Allen 2008) and long-term commitment to capitalise on local technological expertise in the highly competitive industries of IT and medical technology.

4. Discussion and conclusions

As one of the success stories of the Irish economy over the past two decades, the Irish medical technology cluster is examined in this section using the Lucerna database. It shows the evolution of the industry from low value-added branch plant manufacturing to upgraded product development and world-class manufacturing capabilities. Three main results from the

data analysis are identified. First, there are significant clusters of product activity around basic medical products, medical services and orthopaedics and prostheses in this sector in Ireland. Secondly, foreign-owned and indigenous companies tend to engage in the same product activity bands, which is indicative of a competency transfer effect. Finally, a spatial effect is also occurring in this sector as the data shows concentrations of activity in orthopaedics and prostheses in the South-West and Dublin region, while specialised surgical and medical equipment is clustered primarily in the West of Ireland.

The data has then been filtered to examine the product composition of the Galway medical technology cluster. An examination of the evolution of this regional cluster shows the early stage establishment of manufacturing sites by foreign-owned multinational corporations and the increase in indigenous start-up activity, primarily since the mid-1990s. Furthermore, the convergence of technologies around electronics, medical technology and pharmaceuticals has been a key factor in the evolution of the regional cluster and its future development will depend on the exploitation of local opportunities for new technological convergences.

Indigenous start-ups principally lack the state of the art process management capabilities of the MNCs. MNCs also commonly acquire the indigenous start-ups after a successful product development as part of their asset augmentation strategies. These indigenous firms (innovation gap fillers) use specific niche strategies (particularly development of products with shorter regulatory paths) to maximise potential success through commercialisation . The other (original indigenous manufacturers) also use MNCs as the source of knowledge. After a successful product development they connect to value added resellers, other MNCs and distributors, both inside and outside of clusters, for their global connections. This dynamic is conceptualised in a capability framework and presented in figure 4. Being the main source of knowledge in-house MNCs substantially influence the organizational learning and routines of the cluster. On the one hand it leads to a technological trajectory where new product development is concentrated on a few medical speciality product(s) (e.g intravental cardiology in galway). On the other hand, the cluster can get locked-in to too few routine activities.

Figure 4 Conceptual Framework for Understanding MEDEV Cluster Capabilities

		Product Development Capability	
		High	Low
Process Management Capability	High	First Follower - Innovation Mode ***Cluster Strategy*** **Original Manufacturer** (Innovator – Cluster Enhancer)	Process Capability - Pioneering Mode ***Niche Strategy*** **Original Equipment Manufacturer** (High end component manufacturer / suppliers)
	Low	Product Technology Innovation /Pioneering Mode ***Niche Strategy*** **Original Design Manufacturer** (Innovator-gap fillers)	Application Specialist Mode ***Free-Riding Strategy*** **Supply and Service Provider** (Low end component suppliers)

Overall, the analysis in this working paper provides a systematic understanding of the internal dynamics of the medical technology industry in Ireland. As the economic model of attracting FDI based on cost competitiveness and grant incentives has now become relatively inadequate in Ireland, the challenge is to make the successful transition to a new model based on endogenous development. The argument made here, substantiated by an analysis of the medical technology sector using datamining techniques, is that the skills and capability legacy can be leveraged to make this transition. The old model has been successful in establishing a global and vibrant high-tech industry within a few decades. However, to advance such an industry to a level comparable, and complementary, with other high-tech regions internationally, like Massachusetts, requires encouraging skill transformation processes, exploiting new skill formation in the form of indigenous enterprises and entrepreneurship, and most significantly promoting the convergence of technologies to lead the way in the development of next-generation technologies and products.