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University–industry links in R&D and consultancy in Ireland's indigenous high-tech sector

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Between 1995 and 2007, the Irish Government implemented a variety of measures designed to enhance the infrastructure and profile of research activities in Irish Higher Education Institutions (HEIs). The aim was to foster a culture of innovation-led academic entrepreneurship and, thereby, develop links between HEIs and indigenous industry in Ireland, with particular emphasis on research and development (R&D) links. This paper analyses the barriers and stimulants to the creation and maintenance of links between HEIs and industry and focuses specifically on R&D and consultancy links. The findings indicate that indigenous high-tech firms are not the key benefactors of Ireland's science and technology (S&T) base. Whilst firms are engaging in innovative activities, HEIs are excluded from such developments. Teaching and training links constitute the most common form of interaction, not R&D links and consultancy links, as might have been expected.

Keywords: university–industry links; R&D; consultancy; Ireland

Introduction

Since the early 1990s, much attention has focused on the emerging global knowledge economy and the associated need for collaboration between industry and academia. This perception is premised on the belief that such interaction will generate positive economic and social outcomes for national and regional economies. Whilst there is a growing body of work which analyses university–industry (U–I) interaction from the perspectives of: science and technology (S&T) policy (Buenstorf 2009, Haessler and Colyvas 2011); innovation (Organisation for Economic Co-operation and Development [OECD] 1999, Bercovitz and Feldman 2007); the role of HEIs in technology transfer (Cooke *et al*. 2000, Bishop *et al*. 2011); the 'triple helix' model of innovation, based on integration between the institutional spheres of government, HEIs and industry (see Figure 1, Etzkowitz and Leydesdorff 1998, 1999); entrepreneurship education (Fenton and Barry 2011, Matlay 2012); and the science–industry relation (Faulkner 1992, Faulkner and Senker 1994, OECD 2002, Arvanitis *et al*. 2008), the literature lacks empirically based research which is inclusive of the perspectives of indigenous firms from a broad spectrum of high-tech sub-sectors. Whilst policy-makers, regional planners and economic development agencies purport that Higher Education Institutions (HEIs) can play a significant role in fostering

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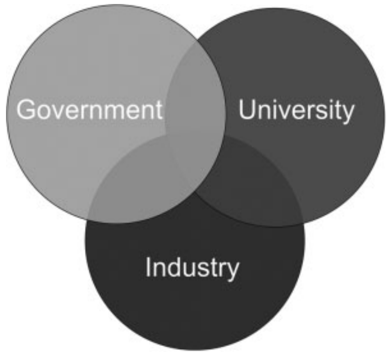

Figure 1. Triple helix model. Etzkowitz and Leydesdorff (1998).

regional development supporting indigenous growth, there is little empirical evidence to suggest that this is the case (Florida 1999, Bishop *et al*. 2011, Goldstein and Glaser 2012). Furthermore, few empirical studies have been able to quantify the wide range of benefits that firms accrue from their interactions with HEIs (Rosenberg and Nelson 1994, Westhead and Storey 1995, Bruneel *et al*. 2010, Bishop *et al*. 2011). In small geographically peripheral regions, knowledge technology transfer becomes all the more important in terms of achieving competitive advantage and ensuring sustainable economic development. This is particularly true of small peripheral economies in the developed world, with small economies in the European Union (EU) being prime examples.

HEIs have been viewed naively as 'engines' of innovation providing new knowledge and ideas which are translated into commercial entities, thereby enhancing regional economic growth (Florida 1999). This has generated a range of mechanistic national and regional policies seeking to convert new ideas to commercial practicality and transfer them to the private sector. The functions and societal expectations of HEIs have broadened considerably following the realisation of their potential economic value for a commercially viable research base. Volatile international markets allied with increased turnover of technological innovations have encouraged the development of partnerships between HEIs and industry.

Whilst the purpose of HEIs is to create, disseminate and extend knowledge, it is increasingly recognised that HEIs have a pivotal role to play as a source of competitive advantage for national economies (Figure 2). Effective interactions between regional development authorities, industry and academic partners have the potential to facilitate the creation and development of regional innovative capacities. The perception of HEIs merely as institutions of higher learning is gradually being replaced by the view that they are important engines of economic growth and development with increasing evidence that the higher education sector can undertake a variety of roles in developing the technological and industrial profiles of a region (Jones-Evans *et al*. 1998, Pandya and Cunningham 2000, Pandya *et al*. 2001). Accordingly, HEIs are seen as crucial in facilitating the growth of local high-tech industry (Jones-Evans *et al*. 1997, 1998). In addition, HEIs have the expertise to build partnerships with local enterprise, promote technological innovation in the indigenous *Small- and Medium-sized Enterprise (SME) sector* and assist in technology transfer. Such measures are vital in ensuring the sustainable development of local and regional economies. HEIs have the potential to establish a variety of links with indigenous firms in areas of R&D, teaching/training,

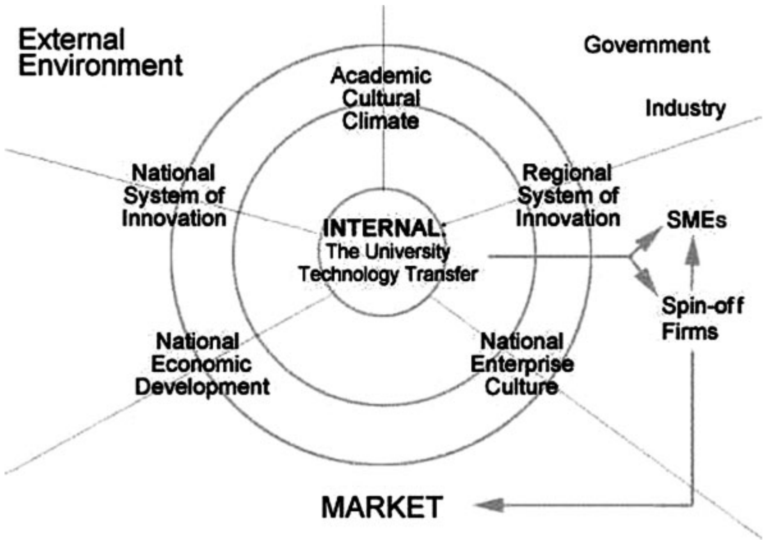

Figure 2. Internal and external factors that affect technology transfer.

consultancy and also in the commercialisation of the S&T base. For the purpose of this research, the authors completed an analysis of levels of interaction across three areas, namely R&D links, consultancy, and teaching and training links. This paper will focus on the complementary areas of R&D and consultancy links.

Ireland is a particularly interesting case-study as it is a geographically peripheral EU region which has recently moved from dependence on manufacturing to an increasing government emphasis on the importance of a knowledge-driven economy. At the time this research was completed (January–July 2002), Ireland was experiencing unprecedented levels of economic growth, largely driven by foreign direct investment (FDI) in the high-tech and financial services sectors. Furthermore, the Irish Government had invested heavily in R&D in the HEIs with the expressed intent of enhancing commercialisation of HEI research and creating links between HEIs and indigenous enterprise (Barry 2004, 2009). With the existence of a strong third-level educational sector in Ireland, allied to the increasing research, consultancy and training requirements of an expanding high-tech sector, there is an assumption that relationships between HEIs and industry are common. This research was undertaken within this context of high economic growth rates in order to analyse the role of Irish HEIs in enhancing the innovative capabilities of indigenous high-tech firms.

Research methodology

Results are presented from a questionnaire survey of a total population of 1980 indigenous high-tech companies which were assisted by Enterprise Ireland (EI), the government agency responsible for the support and development of indigenous enterprise in Ireland. As one of the parameters for defining the population of firms in this research is ‘high-tech’, it is important to first provide a critical analysis of the definition of high-tech, before analysing the results.

Definition of 'high-tech' industry

Providing an appropriate definition of the term 'high-tech' is problematic (Malecki 1997) and is highly contestable, from the perspectives of sectoral distribution, level of innovativeness and/or product/service produced. Researchers in the past have tended to use the OECD classification of R&D intensity (OECD 1995). However, within this classification, it is only the category 'high technology', that is really high-tech, spending more than 4% of turnover on intra-mural R&D expenditures. Whilst this is still the most commonly used classification of R&D intensity, it is problematic. First, from a conceptual point of view, this classification is too focused on a linear model of innovation, which views innovation as a set of development stages originating in research. Innovation, however, is also a social, non-linear process based on interactive learning, which emphasises the importance of co-operation between firms and external actors (such as universities and public research institutes) in national and regional systems of innovation (Asheim 1998). Second, from a practical point of view, the definitions of R&D in the OECD's Frascati Manual (OECD 1994, 1995), which structures R&D data collection in OECD economies, exclude a wide range of activities that involve the creation or use of new knowledge in innovation.

In contrast to the OECD approach, modern innovation theory, where innovation is considered to be based on interactive learning, views knowledge creation in a more diffuse way. Firstly, innovation rests not on discovery but on learning. According to Gregersen and Johnson (1997), innovation can be defined as the introduction into the economy of new knowledge or new combinations of old knowledge. Learning, therefore, does not necessarily imply discovery of new technical or scientific principles and can equally be based on activities that adapt existing forms of knowledge. This, in turn, implies that activities such as design and trial production (which is a form of engineering experimentation) can be knowledge-generating activities. Hence, learning leads to new knowledge, thus enabling entrepreneurs to use this knowledge to form innovative ideas and projects that can be transported into the economy in the form of innovations (Gregersen and Johnson 1997). Secondly, a key emphasis in modern innovation analysis is on the external environment of firms. Firms interact within industrial networks in a range of ways; these include, for example, the purchase of intermediate or capital goods embodying knowledge. Thirdly, in a vertical disintegrated globalising learning economy, where the adequate focus is on local and global production systems with suppliers and subcontractors, the use of intra-mural R&D expenditures becomes even more irrelevant.

According to Porter (1998), the distinction between high-tech and low-tech has little relevance, particularly in relation to achieving productivity and competitive advantage. The mere presence of 'high-tech' activity in an industrial sector does not guarantee prosperity, if firms are unproductive. What is becoming more and more relevant is the distributed knowledge base of firms, where a value-chain or value system perspective is applied when the knowledge intensity of a product or the knowledge base of a firm is evaluated. For example, while food and beverages ranks at the bottom of the low-tech branches, this sector is becoming more and more knowledge-intensive. This change is due to the incorporation of bio-technology and food engineering in the production of functional food, fish and farming. However, the most knowledge-intensive parts are located relatively early in the value-chain and are not registered as intra-mural R&D expenditures according to the OECD classification, because the knowledge base is distributed. Increasingly, researchers are focusing on the knowledge-intensive industries, the subsequent emergence of a new type of knowledge-driven economy and the resultant

Table 1. Responses from EI-assisted high-technology firms.

Industry	Total number of firms	Number of completed surveys returned	Percent of total firms in that industry
Digital Media/E-Commerce	226	64	28
Electronics and Precision Components	360	189	52
Engineering	351	95	27
Financial/Healthcare Services	274	84	30
Healthcare Pharmaceuticals	667	203	30
Information/Communication/ Telecommunications Services	102	37	36
Total	1980	672	34

implications of the distributed knowledge base for regional innovation systems (Asheim and Isaksen 2002).

Initially, for this study, the use of the OECD classification was considered as a primary indicator and parameter of high-tech sub-sectors from which to select a random sample of firms. However, in light of the issues and problems associated with the OECD classification, the authors decided instead to use the population of high-tech firms as defined by EI, although this classification is not without its own problems. EI was unable to provide a definition of what it considers to be ‘high-tech’ industry, although in practice, EI classifies firms as being high-tech if they came under the remit of seven sub-sectors (see Table 1). It is possible, therefore, that not all of the firms on EI’s list can indeed be assumed to be high-tech. To counteract this to some extent, one of the questions in the industry survey asked: if firms considered that they engage in high-tech activities. Despite its limitations, in the absence of an alternative ‘defined’ population of high-tech indigenous companies, it was decided to use the population of EI-assisted high-tech client companies in this study. Whilst the EI client list provides a profile and geography of the total population of EI-assisted indigenous high-tech firms in Ireland, it does not differentiate firms across the spectrum of low-, medium- or high-tech activities.

Administering the questionnaire survey

The research was conducted between January and July of 2002. A postal questionnaire was sent to the total population of 1980 EI-assisted high-tech firms in two mail shots. The research did not involve the authors pre-selecting a random sample from the total population, as there was no way of knowing which respondents would participate in the study. Instead the total population was sent a questionnaire and respondent firms were considered to represent a random sample within the specific population, by self-selecting themselves. EI-assisted firms located in the National Technological Park, Plassey (Ireland’s only science park) in the Mid-West Region, were also included in the study (see Figure 4).

EI high-tech firms were selected for two reasons. First, EI has designed and implemented a range of initiatives and programmes specifically focused on developing and maintaining U–I links in Ireland. Second, it was difficult to acquire a full and complete list of non-EI-assisted firms. Whilst the majority of indigenous firms in Ireland receive EI assistance, a small proportion do not. As some of the 34 County Enterprise Boards (CEBs) were not willing to return their client lists, it was not possible to acquire a complete and definitive list of this population of firms, and therefore, it was decided not to include non-EI-assisted firms.

A total of 672 firms responded, a 34% response rate (Table 1). Of these, 167 firms (just under 25%) had links with HEIs, while 505 did not. This population of firms represents a 'blackbox' of information on HEIs as a source of innovation for industrial development. This paper will focus exclusively on firms with HEI links. It aims to assess the level of interaction between the 167 indigenous high-tech SMEs and HEIs, the types of links established and the factors contributing to and impeding such interaction in both R&D and consultancy. First, however, it is important to provide an assessment of existing literature on what might be defined as barriers and stimulants to U–I interaction.

Defining barriers and stimulants to U–I links

The success or failure of U–I links differs across industries, sectors, academic disciplines and research areas (Mowery 1998). Furthermore, due to the wide and varied nature of U–I links as a field of academic study, the implications of such links are relative to the locational and institutional contexts in which they are set. Moreover, there is a high degree of diversity in the manner in which U–I links evolve in different countries (Oyebisi *et al*. 1996, Wong 1999). Regardless of spatial scale, Arvanitis *et al*. (2008) posit that determining the meaning of knowledge transfer 'effectiveness' is a difficult task. U–I links are multi-purpose, highly complex and diversified (OECD 1984). Vedovello (1997) argues that such diversity makes it difficult to undertake research in this area. Further compounded by the high economic expectation associated with U–I links, the tendency of governments and policy-makers has been to exaggerate the positive outcomes of such interactions. This level of sectoral, institutional and geographical variation in U–I links made it difficult to select the barriers and stimulants to be used in the questionnaire. The stimulants and barriers selected for inclusion in this research were derived first by a reading of the literature (see Warda 1995, Council for Industry and Higher Education [CIHE] 1998, Policy Research in Engineering, Science and Technology (University of Manchester) [PREST] 1998, Lee 2000, Business-Higher Education Forum 2001, Centre for Urban and Regional Development Studies [CURDS] 2001). From the perspective of firms, a number of problems were noted in the literature. First, the focus is exclusively on R&D links, with little attention focused on the factors which contribute to and impede consultancy and teaching/training links. Each type of link elucidates specific barriers and stimulants. Second, there has been little attention focused on the relative importance of stimulants which encourage firms to initiate and maintain links with HEIs. Third, there is a narrow focus on selected high-tech sectors, with little or no attention paid to the activities of firms engaging in the lower spectrum of high-tech activity. This introduces a bias in sector coverage and excludes some high-tech sectors which are also likely to have links with HEIs. In order to address these issues and draw up as definitive a list of barriers and stimulants as possible, the authors conducted 90 semi-structured interviews with key innovation actors in Ireland and Scotland in 2001. Interviews were conducted with government development agencies, policy-makers, industry, HEI management and academic staff, in two different EU countries with a similar economic history, to elucidate what the key barriers and stimulants might be in relation to the creation and maintenance of U–I links. This enabled the authors to draw up what they considered to be a broad range of relevant barriers and stimulants to use in this research (see Tables 4–8).

Level of interaction with HEIs

In relation to the level of U–I links as a whole, universities accounted for 67% and Institutes of Technology (IoTs) accounted for 33% of industry interaction. This almost certainly reflects the fact that universities have a longer history of engaging in research. It is only since 1992 that IoTs have been permitted to undertake R&D, technology transfer, consultancy and the promotion of spin-off companies (McCarthy 1998).

In relation to the universities, three Dublin universities (University College Dublin (UCD), Trinity College Dublin (TCD) and Dublin City University (DCU)) combined accounted for 52% of all interaction with respondent firms with links (Table 2). Universities in the mid-west of Ireland (Figure 3) (National University of Ireland Galway (NUIG) and University of Limerick (UL)) accounted for 29% of interaction. In the south, University College Cork (UCC) accounted for 13%, and in the East region (outside Dublin), National University of Ireland Maynooth (NUIM) accounted for just 6%. A number of factors combine to facilitate the concentration of U–I interaction in the Greater Dublin Area (GDA), of which two are worthy of attention. The first is the concentration of both EI-assisted companies and HEIs in the GDA. As demonstrated by Vedovello (1997) in Surrey, geographical proximity to a HEI increases the likelihood of interaction. The second attests to the research activities and commercial focus of each of Dublin's universities. However, the level of interaction at NUIG and UL was only marginally below that of TCD and DCU. This is significant considering the dispersed geography of EI-assisted companies in the mid-west and surrounding regions. In relation to UCC, the level of interaction by firms with HEI links was relatively low, considering it to be the site of the Tyndall National Institute (one of Europe's leading research centres, specialising in information and telecommunications technologies (ICT) hardware research and commercialisation of technology) and is located in close proximity to two high-tech industrial parks. In addition, Cork City is the second largest city in Ireland after Dublin and is one of Ireland's premier locations for high-tech industry in sectors such as pharmaceuticals, chemicals and electronics (Barry 1999, Barry and Brunt 2002). NUIM emerged as the university with the lowest level of interaction by firms with HEI links. At the time the survey was undertaken, the teaching focus in NUIM was predominantly in the humanities and social sciences. As the number of academics in S & T subjects was significantly lower in NUIM than in any of the other universities, the propensity for links with high-tech industry was also less.

The geographical pattern of interaction between industry and the IoTs showed far less of a Dublin bias, when compared to the Dublin universities. This was the case despite the fact that there are four IoTs in the Dublin area (***Dublin Institute of Technology (DIT), Blanchardstown IT, Institute of Art, Design and Technology, Dún Laoghaire (IADT-DL)

Table 2. Level of interaction with universities.

Universities	Proportion of total interaction (%)
University College Dublin (UCD)	20
Trinity College Dublin (TCD)	16
Dublin City University (DCU)	16
National University of Ireland Galway (NUIG)	15
University of Limerick (UL)	14
University College Cork (UCC)	13
National University of Ireland Maynooth (NUIM)	6
Total	100

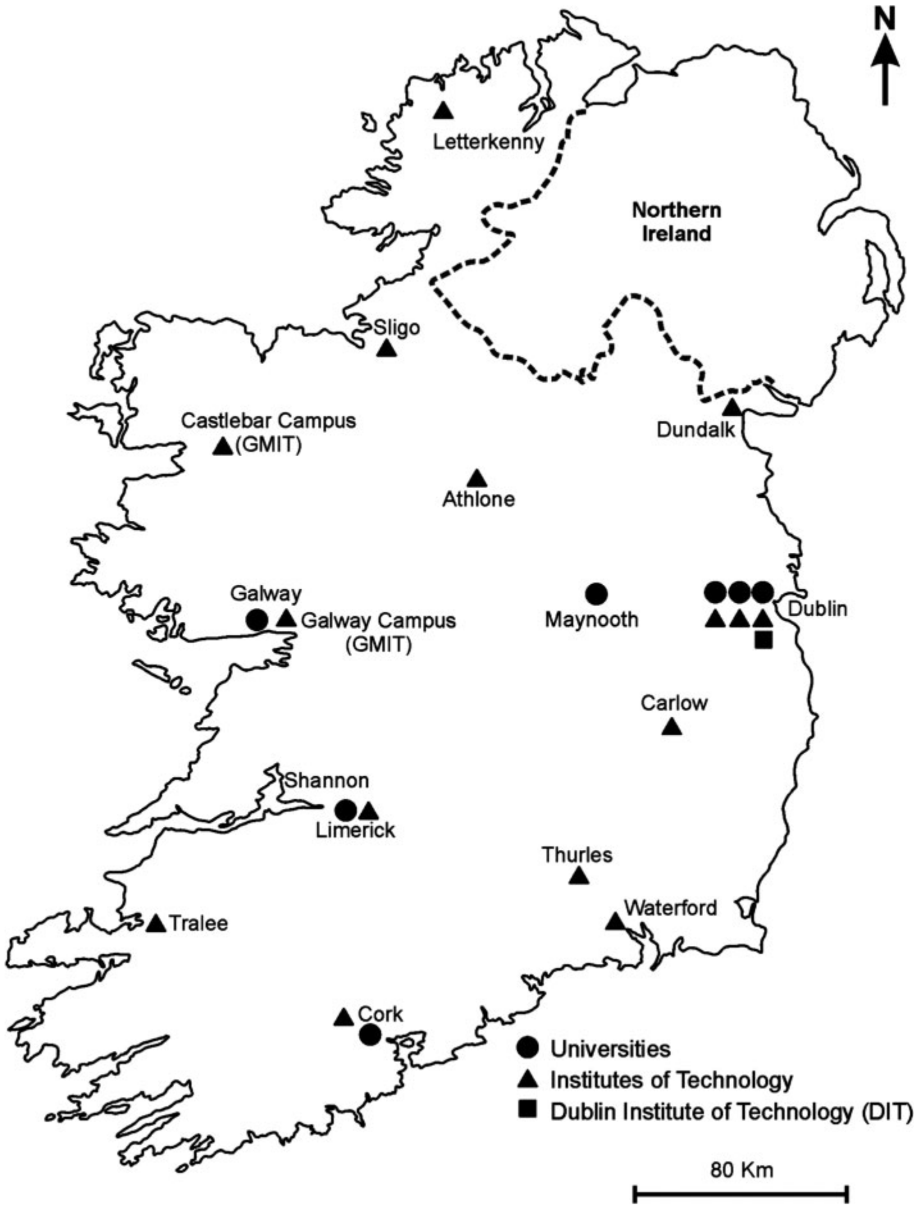

Figure 3. HEIs in Ireland.

and IT Tallaght), and it is probably a reflection of the total number of universities and IoTs in the capital. Whereas Dublin has three of the seven universities, it is the location of just four of the 15 IoTs.

DIT accounted for 19% of all interaction with respondent firms (Table 3). This high figure reflects a number of factors. First, the DIT has a long history, extending back to the late nineteenth century, with the establishment of technical training in Ireland. Second, the teaching profile of DIT encapsulates a broad range of S&T orientated subjects. Third, DIT has one of the most well-developed Industrial Liaison Offices (ILOs) in the HEI

Table 3. Level of interaction with IoTs.

IoTs	Proportion of total interaction (%)
Dublin Institute of Technology (DIT)	19
Cork Institute of Technology (CIT)	10
Athlone Institute of Technology (AIT)	10
Dundalk Institute of Technology (DKIT)	9
Sligo Institute of Technology (IT)	9
Waterford Institute of Technology (WIT)	8
Galway-Mayo Institute of Technology (GMIT)	7
IT Tallaght	7
IT Carlow	6
Limerick Institute of Technology (LIT)	4
Institute of Art, Design and Technology, Dún Laoghaire (IADT-DL)	3
IT Tralee	3
Letterkenny IT (LIT)	3
Blanchardstown IT	1
Tipperary Rural and Business Development Institute (TRBDI)	1
Total	100

sector. The full spectrum of industrial liaison activities in DIT's ILO is divided among 18 ILO personnel, each of whom has a specialist subject focus. This contrasts sharply with the position in other Irish HEIs at the time that this research was completed, when the average number of personnel in each ILO was just three.

In the remainder of IoTs, there was more or less equal representation in Cork IT (10%), Athlone IT (10%), Dundalk (DKIT) (9%), Sligo IT (9%), Waterford IT (8%), Galway-Mayo IT (7%) and IT Tallaght (7%). With the exception of Cork Institute of Technology which, like the DIT, can trace its origins date back to the early nineteenth century, the other colleges listed were established from the early 1970s as RTCs, and subsequently renamed IoTs. The other IoTs which opened in the 1990s exhibited less interaction with industry. These include Dún Laoghaire Institute of Art Design and Technology (IADT-DL) (established 1997), Tipperary Rural Business Development Institute (TRBDI), now a school of LIT (established 1998) and Blanchardstown IT (established 1999). While there are exceptions in the case of Limerick IT (established 1852, when the Athenaeum Society started a School of Arts and Fine Crafts in Limerick), Letterkenny IT (established 1970) and IT Tralee (established 1977), the evidence suggests that the longer an IT is established, the more likely it is to have interaction with industry.

Characteristics of respondents firms

This section of the paper compares and contrasts the characteristics of firms with and without R&D and consultancy links to HEIs. Firms will be profiled from the perspectives of: age, size, sectoral composition, activities and geographical proximity to HEIs.

Firm age, size and sectoral composition

The average age of respondent firms in both samples was 23 years. A 'prob-value' of .98 indicates that there is no statistically significant difference in mean length of establishment for firms with and without links to HEIs. However, there were significant differences between the two categories of firm in relation to size. The proportions of firms with 1–9 employees ('prob-value' = .72) were the same, but a significant difference existed in the 10–49 employee category ('prob-value' = .00), in the 50–249 employee category ('prob-value' = .06) and in the 250+ employee category ('prob-value' = .00). More of the firms with links were in the larger size categories. In interviews with EI personnel, the principal reason offered was the fact that many larger-sized corporations have dedicated personnel whose role is specifically focused on establishing and maintaining HEI links. In general, SMEs do not have sufficient personnel, time or resources to engage in the development and maintenance of HEI links.

In the sample of firms with links to HEIs, 77% were new independent start-ups, compared to 88% of the firms which did not have HEI links. An independent samples t-test was used to establish that this was a statistically significant variation. The evidence suggests that a significantly higher proportion of firms without links are new independent start-ups when compared to firms with links.

Sectoral composition of firms

Whilst statistically significant differences in firm size were found between firms with and without HEI links, there were less significant differences in the sectoral composition of the companies. In the 1990s, Ireland's 'Celtic Tiger' economy was based predominantly on the attraction of high-tech multinational companies (MNCs). Proximity to EU markets, access to Industrial Development Authority (IDA) grants and a highly skilled labour force were key pull factors for foreign high-tech firms considering investment in Ireland. These incentives also provided a favourable environment for the growth of indigenous high-tech industries through the provision of support services for the foreign sector or the identification of niche markets for company products both in Ireland and Europe. The profile of indigenous high-tech investment in Ireland became more diversified. In general, the tendency is for small-sized indigenous high-tech firms to act as suppliers to MNCs; also they play a central role in the location investment decisions by foreign firms in Ireland.

The target population of firms for this research was categorised into seven high-tech sectors specified by EI (see Table 1). A t-test was undertaken for each of the seven sectors, in order to examine whether a significant difference existed in relation to the proportion of firms with and without links. The null hypothesis tested was that no difference existed between the proportions in both samples. The 'prob-values' indicated that there was a statistically significant difference in sectoral composition in relation to digital media/E-commerce ('prob-value' = .02) and electronics ('prob-value' = .01). A significantly higher proportion of digital media/E-commerce firms (16%) did not have links compared to the percentage of firms (10%) with links to HEIs. The opposite is the case in the electronics sector, where a significantly higher proportion (20%) of firms had links compared to the firms (11%) without links. This is surprising given the presumption that digital media would have a higher propensity to engage in links with HEIs when compared to electronics, given the requirement for on-going R&D in the former sector. However, these findings in relation to electronics are consistent with the 2004 UK-based study by Bishop *et al*. (2011) of 475 firms that collaborated with universities. They noted that chemical and chemical-related industries, instruments and electrical and electronics had a far higher propensity for collaboration with universities than any other sector. In the remaining sectors of engineering ('prob-value' = .18), financial services ('prob-value' = .69), healthcare pharmaceuticals ('prob-value' = .30) and information/communications ('prob-value' = .24), there was not enough evidence to suggest that a statistically significant difference existed between the proportion of firms with and without links to HEIs. Given that the IDA selected these sectors in the 1980s as the key growth industries which would secure Ireland's place in the global knowledge economy, it is interesting that such sectors appear not to have responded to the government's innovation policies aimed at enhancing U–I links.

Firm activities

As previously discussed, although the population of firms surveyed was based on the EI definition of 'high-tech', respondent firms were asked whether or not they considered that they engaged in high-tech activities. Of the firms that had links with HEIs, 73% considered that they engaged in 'high-tech' activities compared with 45% of firms without links, which was again shown to be a statistically significant difference between the two samples. This suggests that a higher proportion of firms with links to HEIs consider themselves high-tech compared to those without such links. Whilst a higher proportion of firms with links consider that they engage in high-tech activities, this is not an indicator of engagement in higher order activities compared to firms without links; rather, the opposite seems to be the case.

In relation to the activities of respondent firms, a t-test was undertaken to establish whether or not a significant difference existed between the proportion with and without HEI links. The resultant 'prob-values' indicated that that there was a significant difference in all but one of the activities, namely distribution. Distribution was engaged by 20% of the firms with links and 24% of those without links. With a 'prob-value' of .27, this is the only activity in which there is no evidence to suggest a significant difference between both samples. In each other case, the resultant t-test produced a 'prob-value' of .00, indicating a statistically significant difference between samples. Whilst a significantly higher proportion ('prob-value' = .00) of firms without links (68%) engaged in manufacturing compared to firms with links (56%), in each of the remaining activities – marketing, provision of services, R&D and software development – statistically significant differences were found. In particular, a significantly higher proportion of firms without links to HEIs engaged in these activities when compared to firms with links. While it is difficult to ascertain why firms without links engage in higher order activities and do not engage in links with HEIs, two possible reasons are suggested. First, they do not see HEIs as compatible partners in terms of marketing, R&D and software development. Second, firms with links do not have the resources or in-house personnel to engage in such activities. Consequently, they outsource such functions to HEIs or consider HEIs to be compatible partners in such activities.

Geographical proximity of firms to HEIs

There is an urban bias in the location of EI-assisted firms. The majority of respondent firms in each of the high-tech sectors were located in Dublin City and in the GDA. In general, firms locate in Dublin in order to benefit from economies of scope and scale associated with proximity to a range of services in the capital, access to markets and a transport infrastructure facilitating the movement of goods and personnel to mainland Europe. In particular, the growth of both indigenous and foreign high-tech sectors in Ireland has enhanced Dublin as a prime location from which high-tech investment can serve national and international markets. The concentration of high-tech investment in the

Figure 4. IDA Planning Regions.

capital highlights the advantages of major urban-based regions for such investment and reflects the inability of both EI and the IDA to decentralise such sectors to Ireland's remaining planning regions (Figure 4).

However, an urban location is not in itself a prerequisite to engaging in links with HEIs. In order to assess whether or not geographical proximity plays a role in the development of links between firms and HEIs, the respondents were asked to specify whether or not they felt it facilitated the establishment of such links. The hypothesis is that the greater the geographical proximity between the industrial firm and HEI, the more likely it is that the firm will have a link to the HEI. In relation to firms with links, 62% considered geographical proximity to be an important factor in comparison to 49% of those without links. A t-test yielded a 'prob-value' of .00, indicating that firms with links appreciate the benefits of geographical proximity to a greater extent than firms without links. The perceptions of firms as to the importance of geographical proximity were emphasised by the data on the mean distance of firms from universities and IoTs. The mean distance between firms with links to the nearest university was 19.5 miles, compared to 28.0 miles for firms without such links. A t-test, yielding a resultant 'prob-value' of .00, indicated a statistically significant difference between both samples. Similarly, in relation to distance from the IoTs, firms with links were on average located 9.5 miles from the nearest IT. The corresponding figure for firms without links was 13.0 miles. Again, a t-test yielding a 'prob-value' of .00 showed that there was a significant difference between samples in relation to distance from the nearest IT. This suggests that geographical proximity plays a strong role in the establishment of links between industry and IoTs.

These findings support much of current literature on the important role of geographical proximity between the firm and the HEI with respect to the development of U–I links (for example, Jaffe 1989, Mansfield 1995, Vedovello 1997, Storper and Venables 2004, D'Este and Iammarino 2010, Bishop *et al*. 2011). Furthermore, according to Santoro (2000), the industrial firm's proximity to the university research centre is not only crucial in terms of establishing a partnership, but it also plays a consequential role with respect to the intensity of the U–I relationship and generates greater levels of tangible outcomes. Laursen *et al*. (2011) argue that the level of intensity in the relationship between both partners is dictated by the research profile and excellence of the university. Whilst they found that geographical proximity was important, they noted that co-location with top tier universities promotes collaboration, whereas closeness to a lower-tier university reduces that propensity. Boschma (2005) goes further and aligns geographical proximity with cognitive (skills and knowledge) and social proximity, the latter of which refers to the development of inter-personal networks, which promote the communication of knowledge, which is facilitated by geographical proximity. Thus, despite advances in new information and communication technologies, geographical location remains a crucial strategic consideration for firms seeking to engage in links with HEIs (Santoro 2000), with face to face interactions/social networks and the research standing of the HEI being critical to the creation and maintenance of partnerships. Overall, this Irish study found that firms with links to HEIs were more likely to consider geographical proximity to be an important factor, facilitating the establishment of U–I links compared to firms without links. Furthermore, firms with links are physically closer to universities and IoTs than firms without links. Whilst geographical proximity to universities or IoTs may play a role in the establishment of links with HEIs, it is also important to consider what factors encouraged firms to locate in a certain region.

Stimulants for the development of links with HEIs

In order to establish the factors which encouraged firms to interact with HEIs, each respondent firm was asked to indicate the level of importance that they associated with each of six factors on a scale from 1 to 5 in terms of encouraging such interaction. It is

Table 4. Stimulants to the development of links with HEIs.

Stimulant	Mean Score	Std. Dev.
Access to highly skilled graduates for recruitment	2.62	1.35
Gain exposure to current academic research and expertise	2.83	1.41
Access to newly emerging technologies	3.03	1.39
Access to consultancy services	3.30	1.47
Access to specialist education and training programmes	3.34	1.36
Access to management and marketing skills	3.94	1.12

important to note that these stimulants referred to links in general and were not specific to any type of link.

The factor cited by firms as the most important stimulant was ‘access to highly skilled graduates for recruitment’ with a mean of 2.62 (Table 4). The standard deviation of 1.35 suggests less variation existed in respondents’ answers relative to most other stimulants in Table 4. The potential to ‘Gain exposure to current academic research and expertise’, with a mean of 2.83, was evaluated by firms as the second most important stimulant. However, a standard deviation of 1.41 highlights greater variation in the responses to this factor. Response variation ranged from very important and important, to moderate and minor, with most considering it to be an important factor. Of least importance was access to management and marketing skills with a mean of 3.94, which also had the lowest associated standard deviation. Thus, despite the existence of a well-developed HEI sector in Ireland allied with the implementation of government initiatives aimed at technology transfer in R&D, access to skilled graduates is the most important priority for EI-assisted firms. In Ireland in the 1980s, industry valued HEIs for their excellence in supplying graduates for the labour market rather than for their ability to leverage their S&T capacity to meet the needs of industry (Fenton and Barry 2011). From the perspective of the firms which participated in this research, it would seem that little has changed.

Whilst the stimulants outlined provide an indication of the reasons why respondent firms engaged in links with HEIs, a comparison of the types of links established provides a more precise analysis. It is important to note that firms can engage in more than one type of link. Teaching and training was the most common type of link, cited by 96 firms (57% of firms with HEI links) (Figure 5). This is surprising given that ‘access to specialist education and training programmes’ was rated in fifth place (Table 1). R&D

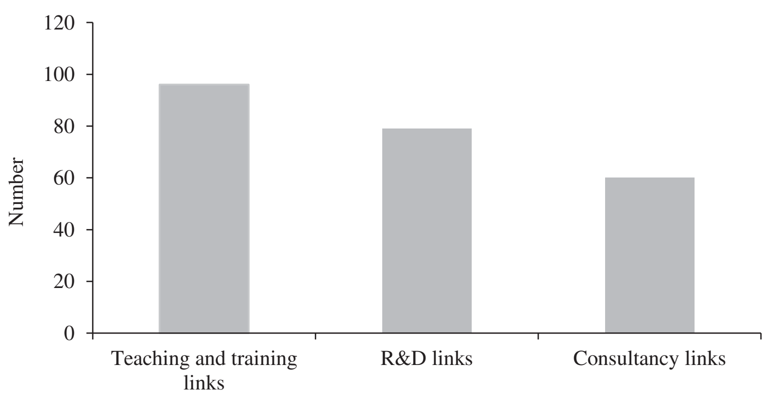

Figure 5. Types of links established with HEIs.

links were the second most common type of link with 79 firms (47% of firms with HEI links) participating. Again, one would expect this figure to be much higher, given that 'gaining exposure to current academic research and expertise' was placed second in terms of importance. Only 60 firms (36% of firms with HEI links) engaged in consultancy links with HEIs. This is not surprising given that the stimulant 'access to consultancy services' was rated fourth in terms of importance. In order to provide more in-depth analysis, each of the two types of links (R&D and consultancy) is deciphered in detail in the following sections.

R&D links with HEIs

HEI-generated R&D remains the principal source of innovation for industry (Warda 1995), and there are a variety of different ways in which *U–I* R&D links are constructed. R&D links can be categorised into three types; (1) basic research links (e.g. creative stage/initial phase of research), (2) applied research links (e.g. prototype development) and (3) experimental research links (e.g. adaptation and fine-tuning of products). R&D can be conducted collaboratively, based on the development of an academic–industry partnership. Companies may contract HEIs to conduct R&D, or they may hold a license for a technology or a product developed by HEIs. Governments in western economies recognise the beneficial role that R&D plays in social and economic development and have implemented a series of publicly sponsored R&D programmes in an effort to increase the number of R&D partnerships between industry and academia. Whilst this may have served as a key incentive for both industry and academia to engage in R&D partnerships, other stimulants also play (and continue to play) a pivotal role in the formation of links between both partners.

From a company or industry perspective, the opportunity to access specialist knowledge and support in industrial R&D is the key stimulant which motivates companies to collaborate with HEIs. Whilst other stimulants encourage firm*'s* engagement in such activities, it may be the case that certain companies are more likely to engage in links than others. According to Caloghirou *et al*. (2000), firm size, R&D intensity and scientific capability emerge as the crucial determinants of firms entering into this type of collaboration. This is the case not only in relation to R&D links, but with all forms of U–I interaction.

From an academic perspective, there are a series of incentives encouraging academics to engage in R&D links with industry. Principal amongst such incentives is the finance generated from such activities which benefits HEIs, the research director(s), his/her research team and faculty department. *Lee (2000) conducted a questionnaire survey in the USA in 1997 among affiliate members of America's* Association of University Technology Managers (AUTM). *One of AUTM's responsibilities is to represent firms which collaborate with HEIs*. In a study of the benefits experienced by academics who completed industry-sponsored R&D projects, Lee (2000) found that 67% agreed that they had acquired a 'substantial' or 'considerable' amount of funds necessary to support graduate students and to purchase laboratory equipment. The study showed that the most important factor motivating academic staff to engage in R&D links with industry was the opportunity to complement their own academic research agenda. However, within the academic environment, certain academics are more predisposed to participate in industry-commissioned R&D projects. A number of studies have looked at the profile and characteristics of academics who engage in links with industry (Barry 2009, Bercovitz and Feldman 2003, Perkmann and Walsh 2008, Barry 2009, D'Este and Perkmann 2011, Perkmann *et al.* 2011, D'Este *et al.* 2012, O'Connor *et al.* 2012, Perkmann and Salter 2012, Perkmann *et al.* 2013). D'Este and Patel 2007 argue, one of the main reasons for focusing a lens on academics who link with industry is that we need to improve our understanding about who in academia interacts with industry, and why. No attention has been focused on the characteristics of academics who do not engage in links with industry. Again it would be important to know who they are, and why they chose not to engage with industry. In a study that is focusing on the barriers and stimulants to the development of U–I links, it is important to be inclusive of all academics and firms. In the absence of such comprehension, it would not be possible to find ways to eliminate the barriers and enhance the stimulants that may forge more positive and fruitful synergies between academics and industry in areas such as R&D.

In this research in Ireland, 47% (79 firms) of firms (with HEI links) engaged in R&D links with HEIs. This is surprising, given that much of the focus of the literature on innovation is on the need for firms to engage in R&D links with HEIs as a means towards enhancing competitive advantage. This result is, however, also reflected in international research. In the USA, the now infamous 'Yale Survey' (Klevorick *et al.* 1995) found that a lower than expected number of firms derived their key sources of innovation from the R&D laboratories of HEIs. The majority of firms were either self-sufficient in their ability to generate innovation in-house, or they derived such knowledge from networks within the industry itself (i.e. buyers and suppliers). Similarly, Lee's (2000) research found that of the 698 US-based affiliate members, only 44% (306 firms) engaged in R&D collaboration with a university. Whilst there is a perceived need in the literature for firms to engage in links with HEIs, the results of this research corroborate the evidence found by Lee (2000), indicating that less than half of firms with HEI links engage in R&D interaction with HEIs. Cohen *et al.* (2002), in their study of 1275 indigenous firms in the USA, also found buyers and suppliers to be important sources of knowledge on innovation for firms. In all, 78% of respondents reported that knowledge from manufacturing operations contributes to R&D project completion. Firms relied more on HEIs for R&D project completion rather than R&D initiation or emphasis on 'blue skies' research. In a knowledge-based economy, whilst firms need to be innovative and creative, the evidence across a number of different international studies indicates that HEIs are not as important a source of R&D for firms as policy-makers, regional development agencies, governments and HEI managers would like. However, when firms do engage in knowledge technology transfer activities, Arvanitis *et al.* (2008), in their study of 2582 Swiss firms, found that the innovation performance of firms improves dramatically in terms of sales of new and modified products. In order to assess the experience which firms have had in their R&D interaction with HEIs, they were asked to indicate the level of importance which they associated with each of five barriers and five stimulants, on a scale from 1 to 5.

Barriers to R&D links with HEIs

With a mean of 2.25, the most important barrier to R&D links with HEIs was 'R&D is expensive' (Table 5).

The standard deviation of 1.16 indicates less variation in responses relative to most other barriers in Table 5. The cost of R&D is a critical factor which dictates firm's interaction with HEIs. Firms perceive the cost to be expensive, while some also consider that such R&D should be free, given that HEIs are funded by the exchequer. Furthermore, firms do not take into consideration the cost of developing an in-house R&D facility and

Table 5. Barriers to the development of R&D links with HEIs.

Barrier	Mean Score	Std. Dev.
R&D is expensive	2.25	1.16
R&D completed by HEIs is not always relevant	2.49	1.11
HEIs are too slow to respond to R&D demands of industry	2.64	1.23
Equipment base and facilities of HEIs are insufficient	3.31	1.19
R&D links increase risk of breech of confidentiality/risk of disclosures	3.31	1.29

conducting the same R&D for the same price as they receive from HEIs. Given that innovation is critical to the resilience and sustainability of firms in a competitive global market, it is counterproductive that firms would question the cost of R&D either within a HEI R&D lab or in relation to setting up their own independent R&D operation in-house. Similar levels of importance and variation in responses were recorded for the barrier 'R&D completed by HEIs is not always relevant' (rated second) and the barrier 'HEIs are too slow to respond to R&D demands of industry' (rated third). Lack of industrial relevance and slow response by HEIs are problematic to the creation of U–I links. Following the creation of an R&D link, Warda (1995) argues that industry's requirements for external outsourcing in R&D differ from the capabilities which HEIs can offer. In addition, Warda (1995) found that the most significant barrier to R&D collaboration was the culture gap between the two communities. Key actors within industry stipulated that faculty culture was not aligned to business collaboration, while industry had little understanding of HEI culture. These views are confirmed by the CIHE (1998) in the UK, which recognises the existence of a cultural gap between HEIs and SMEs. In light of this, if HEIs are to become more entrepreneurial based on government policy strategies, they need to market their capabilities to industry and set up a communications interface which facilitates dialogue between industry and academia. Only then will cultural differences be reduced.

Stimulants to R&D links with HEIs

The most important incentive for respondents to form R&D links with HEIs was the ability to 'access specialist knowledge and support in industrial R&D' (Table 6). The standard deviation of 1.22 indicates less variation in responses compared to the other stimulants in Table 6. The ability to source external support for internal innovative activities was the most important stimulant which motivated firms to engage in R&D links with HEIs. Firms utilise R&D links as a support for innovative capabilities which initially derive from within the firm. According to Berman (1990), firms expect to benefit from R&D collaboration mostly through improved in-house research projects and skill enhancement of existing and recruited personnel.

Table 6. Stimulants to the development of R&D links with HEIs.

Stimulants	Mean Score	Std. Dev.
Access specialist knowledge and support in industrial R&D	2.20	1.22
Produce high-quality products that meet changing market demands	2.85	1.42
Increase the speed at which the firm produces products	2.92	1.41
Increase the competencies/skills of the R&D staff of the firm	2.98	1.23
Secure answers to problems associated with production	3.47	1.34

This research indicates that, despite their growing importance, HEIs are not the key source of technology for industry. Instead, firms source innovative ideas from HEIs in order to complement in-house R&D activity. This is consistent with the findings of the benchmarking study of Strategic Management of Technology (SMOT) completed in 1994 in Singapore (cited in Wong 1999). SMOT surveyed 103 high-tech firms (both indigenous and foreign) and found that, from an industry perspective, the purpose of R&D interaction with HEIs was to pursue collaborative R&D (rated first), to obtain innovative ideas (rated second) and to determine technology trends (rated third). Evidently, these firms considered access to innovative ideas to be an important stimulant of interaction. Similarly, respondent firms for this research considered access to specialist knowledge and support in industrial R&D to be an important factor which motivated firm's decisions to interact with HEIs.

In the knowledge-based global economy, firms acquire competitive advantage through R&D partnerships with external sources such as HEIs (Yang and Sun 2001). Not surprisingly, in second place, with a mean of 2.85, was the stimulant 'produce high-quality products that meet changing market demands'. The increasing responsiveness of firms to market demand is a key motivating factor which encouraged R&D interaction with HEIs. Allied to this, and rated third in terms of importance, was 'increase the speed at which the firm produces products'. Enhancing the R&D skills of staff was rated fourth. Similarly, SMOT found that the training of company personnel was rated fourth (cited in Wong 1999). Of least importance in this research was 'secure answers to problems associated with production'. Overall, the evidence suggests that respondent firms engage in R&D interaction with HEIs in order to complement their in-house R&D capability and increase their product profile. Firms are less driven by the need to enhance the skills profile of R&D staff or to secure advice in relation to production problems.

Types of R&D links

In order to delineate the level of interaction by firms with HEI links in each of the various forms of R&D, respondents were presented with six different types of R&D interaction and asked to indicate which forms were applicable to their firm. The most common type of R&D link established was collaborative research. Thirty-five percent of all R&D interaction was channelled through collaborative partnerships between academia and industry. Contract R&D was the second most important form, responsible for 29% of all R&D interaction. Innovation partnerships were in third place and constituted 16% of R&D links. This figure is relatively low, given that EI funds half of the partnership cost, and it may be indicative of the lack of knowledge of firms as to the existence of this initiative. Research grants and donations to specific departments in HEIs accounted for 14% of R&D interaction. This suggests that firms are not interested in simply making donations to fund research in universities and instead are more interested in making an investment and seeking a return. Finally, the two areas where a significantly low level of interaction by firms with HEI links was recorded were in firms holding a licence for HEI technology (3%) and firms holding a licence for a product developed by a HEI (3%). Evidently, efforts by HEIs and EI to commercialise HEI technology have failed, as licensing does not constitute a significant level of R&D interaction between respondent firms and HEIs.

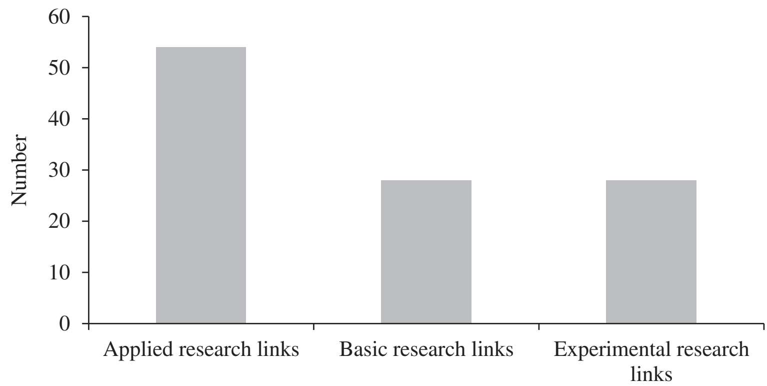

Figure 6. Categories of R&D links.

Categories of R&D links

Firms were asked to specify whether or not they engaged in basic, applied and/or experimental research links with HEIs. They were permitted to select one or more of the categories of R&D links.

The results indicate that of the 79 firms with R&D links, 54 engaged in applied research, while a number of basic and experimental research links were cited (Figure 6). A comparison can be made between the categories of R&D conducted in-house and the level of interaction by firms with HEI links in each of the three categories of R&D. In all, 52% of firms with HEI links and with an in-house R&D facility engaged in in-house basic research. However, the findings here indicate that 25% of firms which engage in R&D interaction participate in basic research links with HEIs. Similarly, 92% of firms with links and with in-house R&D facilities conducted applied research, while only 50% of all firms with links engaged in applied research links with HEIs. In relation to experimental research, as observed earlier, 64% of firms with an in-house R&D facility engaged in experimental research. Yet only 25% of firms with R&D links engaged in experimental research links with HEIs. These findings further indicate that the key source of innovation for firms was internal to the firms and/or within the industry networks. HEIs did not feature prominently.

Consultancy links with HEIs

The diffusion of scientific and technical knowledge through consultancy by academics for external customers represents one of the most cost-effective and rapid methods of technology transfer between HEIs and industry (Stankiewicz 1986). Consultancy typically involves relationships between academics (or a team of academics) and a customer (usually from industry) over a specified period of time. Academics provide technical assistance, information and advice based on specialist knowledge. The role of academics as consultants includes the provision of expert advice on particular projects undertaken by firms, providing assistance with production matters, business plans and the introduction of new technologies and providing assistance with technical/analytical problems experienced by firms.

Consultancy constitutes the most effective two-way channel of communication between HEIs and industry. Academic scientists and engineers engaging in consultancy become aware of industry needs and can, therefore, identify ways in which HEIs can meet the requirements of industry. Distance from the commercial world creates space for academics to devise more approaches to problem-solving for industry. Academics can also provide firms with knowledge about accessing alternative sources of expertise within HEIs and, therefore, provide firms with opportunities to create and/or expand their links with HEIs. Accordingly, consultancy can assist firms in deciding whether or not to initiate and/or develop research partnerships with HEIs (Association for University Research and Industry Links [AURIL]/Confederation of British Industry [CBI] 1997).

Within the academic community, there are certain barriers which may prevent academics from engaging in consultancy links with industry. Very often, academics cite a lack of time as a barrier to their engagement in consultancy activities. Primarily, this is due to the time commitments associated with teaching, research and administrative responsibilities. Second, if a mistake is made or poor consultancy advice is provided, the liability for the indemnity may rest with the HEI. As a result, the reputation of the HEI is at stake. Third, the nature of the consultancy services required by industry is often considered to be routine by the academic community who would rather focus their services in areas of original scholarly research. Consequently, consultancy may not further the prospects of promotion in an academic's career. Fourth, the consultancy requirements of industry are often short-term and sporadic, with little opportunity for the development of long-term objectives. Fifth, the rate of tax on pay from earnings accrued from provision of consultancy services may be considered to be too high. In light of the high tax returns associated with money earned from activities over and above the normal salary of an academic, consultancy services are often provided by academics privately in their own time on an informal basis. Such activities are not formally registered or administered by ILOs of HEIs and, therefore, it is difficult to quantify the level of private consultancy practised by individual academics. In light of each of these potentially negative outcomes, academics are often reluctant to engage in consultancy activities. On an individual level, the main factors which may encourage the academic community to provide consultancy services for industry are: the potential to enhance teaching, generate new ideas for research and/or the financial gain accrued from such activities.

In this research, it was found that 36% of respondent firms with HEI links engaged in consultancy links. This activity represented the lowest level of interaction between firms and HEIs. Furthermore, consultancy has received little attention in the literature and thus, there is virtually no empirical base from which to compare the findings of this research. PREST (1998) is the only substantive source in this regard. However, the PREST (1998) survey did not include an empirical assessment of consultancy activity from an industrial or academic perspective. Instead, it focused exclusively on the experiences of HEIs as institutions in their engagement in consultancy activity with industry. That approach analysed consultancy activity from the biased perspective of the governance role undertaken by HEIs in relation to consultancy links with industry. It failed to include the perspectives of both partners in terms of their consultancy interaction. Many HEIs are only able to provide limited data on the number of firms engaging in consultancy links, because much of this activity is not centralised within HEIs (CURDS 2001). Even where it is centralised, there may be considerable activity which is not declared by academics involved. This creates difficulties in estimating actual levels of consultancy using HEI sources. A more accurate level of interaction in consultancy between both partners can be estimated from that indicated by firms. The purpose of this section is to analyse consultancy's activity from an industrial perspective. In order to address the lack of an empirical base, respondents in this research were presented with a number of questions on their experiences as recipients of consultancy services provided by HEIs.

Barriers to consultancy links with HEIs

As a means to providing an empirical assessment of the factors impeding the development of consultancy links, respondents were presented with five barriers and asked to score each in terms of importance from 1 to 5.

The factor considered to be the most important barrier was 'HEIs are slow to respond to the consultancy's needs of the firm', with a mean of 2.75 and standard deviation of 1.36 (Table 7). In relation to R&D links, the evidence suggested that firms considered the HEI reaction to R&D demands as slow (rated third as a stimulant and first as a negative outcome). Yet, R&D is a time-consuming process – a factor which may not always be appreciated by industry or included in their time schedule for work-in-progress. Therefore, it is likely that firms would consider the associated issue of delayed time to be more significant with R&D links rather than with consultancy links. However, as already noted, the barrier 'HEIs are too slow to respond to R&D demands of industry' was rated third for firms with R&D links (Table 5), whilst in the case of consultancy links, respondents considered the issue of slowness to be the most important barrier. According to Geisler and Rubenstein (1989), there are two reasons for the time-delayed response from academia. First, most HEIs formally require the faculty member to obtain permission to provide consultancy services to industry from the Dean or Head of Department, potentially adding a bureaucratic hurdle to the initiation of consultancy interaction. Second, HEIs tend to impose organisational limitations on the time expended on and the scope or content of consultancy activities. Furthermore, HEIs impose an administrative overhead, making it more expensive.

The second most important barrier cited by respondents was 'consultants are unaware of the specific and changing needs of industry', with a mean score of 2.90. According to Geisler and Rubenstein (1989), academics do not lack such knowledge; it is more the case that firms have not learned to use academic consultancy effectively. Increased interaction between firms and HEIs through the creation of an informal networking agency is one of the mechanisms which would enhance the creation and sustainability of consultancy interaction. Greater engagement in consultancy by both industry and HEIs would facilitate increased knowledge and understanding of each other in a variety of ways. From an industry perspective, consultancy would provide companies with a unique opportunity to tap into a large 'knowledge bank' and gain access to insights into new problem-solving techniques and emerging technologies. From a HEI perspective, the provision of consultancy services would enable academics to keep informed on developments in industry, particularly in relation to changes in R&D and in the organisation of production. This would facilitate a greater understanding in HEIs of the changing skill requirements of industry and would further inform undergraduate and graduate teaching.

Table 7. Barriers to the development of consultancy links with HEIs.

Barrier	Mean Score	Std. Dev.
HEIs are slow to respond to the consultancy needs of the firm	2.75	1.36
Consultants are unaware of the specific and changing needs of industry	2.90	1.36
It is time-consuming to build a working relationship with consultants	2.96	1.39
Consultancy services are too expensive	3.18	1.39
Getting in touch with relevant consultants is difficult	3.11	1.30

Stimulants to consultancy links with HEIs

In relation to the development of consultancy links, respondents were presented with five stimulants and asked to score them in terms of importance from 1 to 5.

With a mean of 2.32, 'access to complementary research and technical expertise' was considered to be the most important motivating factor which encouraged firms to establish consultancy links with HEIs (Table 8). The standard deviation of 1.17 indicates less variation in responses relative to each of the other stimulants. Similar to assigning importance to the stimulants to R&D links, respondents placed the factor 'access specialist knowledge and support in industrial R&D' in first place (Table 6). This would suggest that firms consider HEIs to be a critical source of knowledge in industrially relevant areas. However, the evidence suggests that HEIs are less important sources of business development and marketing know-how. In relation to consultancy links, the stimulant 'access to appropriate business mentoring and development advice' was rated fourth and 'access to specialised knowledge in marketing and management' was rated fifth. This is in accord with earlier evidence in relation to the stimulants to the development of links in general which found that 'access to management and marketing skills' was rated sixth (Table 4). In terms of the development of consultancy links, the second most important stimulant was 'access to HEI-owned technologies for testing/analysis', with a mean of 2.63. One of the reasons why this factor was considered to be so important is that the technologies used by HEIs for testing/analysis are too expensive for firms to acquire. To defray such costs, it is cheaper for firms, particularly SMEs, to gain access to HEI-owned technologies.

Types of consultancy links

As a form of technology transfer, consultancy differs from R&D in that it does not have the generation of new knowledge as its prime purpose (AURIL/CBI 2001). In addition, consultancy has usually been carried out on an *ad hoc* and short-term basis, with little commitment to long-term interaction between industrial and academic partners over time (Mitra and Formica 1997). Little is known about the U–I interface from the perspective of consultancy. In particular, researchers have not attempted to categorise consultancy activity into its various forms. For the purpose of this research, respondents were asked to indicate the various types of consultancy activity in which they have engaged with HEIs.

The most common type of consultancy link was technical/laboratory analytical services, accounting for 40% of interaction. As already noted, access to HEI-owned technologies was a key stimulant to the development of consultancy links. Appointing an academic as a consultant to the firm on a specific project was the second most common type of consultancy, accounting for 34% of interaction. This concurs with AURIL/CBI (2001), which stipulated that one of the most common forms of U–I consultancy entails a

Table 8. Stimulants to the development of consultancy links with HEIs.

Stimulants	Mean Score	Std. Dev.
Access to complementary research and technical expertise	2.32	1.17
Access to HEI-owned technologies for testing/analysis	2.63	1.39
Seek help in developing new and commercially viable business ideas	3.48	1.38
Access to appropriate business mentoring and development advice	3.63	1.46
Access to specialised knowledge in marketing and management	3.68	1.34

relationship between a specified academic (or a specified team of academics) and an individual firm arranged on a project-by-project basis and over a specified period of time. The three remaining types of consultancy were deemed by respondents to be of less importance, i.e. consult academic staff in production matters (13%) and appoint an academic advisor or an academic as a board member of a firm (7%). Consulting academic staff over business plans constituted only 6% of all consultancy interaction. This reflects the inability of the HEI sector to respond to the business development needs of firms and was earlier mirrored in the fact that 'access to management and marketing skills' was considered to be the least important stimulant encouraging the development of links with HEIs.

Conclusion

Within academia and government development agencies, there is recognition of the need for HEIs to be creative in assuming new and different roles in relation to economic and regional development. This is particularly important, given changes in the level of public funding for HEIs and the globally competitive environment for finance and students. Golstein and Glaser (2012) suggest that those universities failing to read the winds of economic, political and social change, by becoming key participants in writing and implementing development policy, will lose support from civil society and the business community.

This research shows that, while Irish HEIs have significant potential to enhance industrial innovation, encourage regional development and promote long-term sustainable growth in the Irish economy, they are not as rooted in national and regional innovation systems as might be expected. Despite the existence of a well-developed HEI sector in Ireland allied with the recent implementation of government initiatives designed to enhance the infrastructure and profile of research activities, EI-assisted firms are not major benefactors of Ireland's S&T base. Whilst firms are engaging in innovative activities, HEIs are excluded from such developments. This is significant, given that a strong association was found between geographical proximity and the propensity for firm engagement with HEIs. In relation to firm location, the majority of firms from both samples were located in urban areas. In terms of the activities of firms, a significantly higher proportion of firms without HEI links engage in marketing, provision of services, R&D and software development. Focusing on R&D, firms without HEI links are engaging in basic research and new product development activities. Firms with HEI links are engaging in similar levels of innovative activity but are not utilising HEIs as sources of such knowledge. Rather, such firms are interacting with HEIs to complement existing in-house R&D activities and to sporadically use the teaching/training and consultancy services available in HEIs.

Delayed responses from HEIs, combined with the perception that HEIs lack relevance to industry's needs, were found to be the primary influences impeding interaction between firms and HEIs. While the evidence suggests a distinct lack of compatibility between HEI and industrial firm cultures, it does not preclude the potential of effective two-way interaction between both partners. Effective communication between firms and HEIs is crucial for the development of U–I links. HEIs must market their capabilities to industry and develop support systems which facilitate the requirements of indigenous high-tech enterprise. By the same measure, firms interested in developing links with HEIs need to understand that the U–I relationship involves a high level of commitment and is not premised on providing just-in-time quick fixes to the demands of industry.

This has important ramifications for future industrial policy and development in a peripheral EU region such as Ireland, currently experiencing high rates of long-term unemployment and net migration of highly skilled and educated people. Overall, the evidence would suggest greater potential for U–I interaction, based on more effective communication between both firms and HEIs. This can be achieved via four mechanisms. First, HEIs need to become more proactive in terms of marketing their capabilities to industry. The firms stated that they are not aware of the capabilities of HEIs in relation to research, consultancy and teaching/training. HEIs now have an obligation to market their activities to the industrial community in Ireland with a view to creating and sustaining viable interactions with industry. Furthermore, the ILOs of HEIs need substantial investment in terms of resources and personnel, without which they cannot be considered to be fully integrated into Ireland's national innovation system. Second, a database of information on the research capabilities of HEIs, listing the research interests and activities of academics, should be developed and made available to industry. Third, EI should continue their range of financial initiatives designed to create U–I interaction, and market such support schemes both to their client companies and to the S&T-based academic community in Irish HEIs. Fourth, a government-sponsored science park should be created in the GDA, with links to the relevant third-level educational institutions (i.e. four universities (TCD, UCD, DCU, NUIM), the Royal College of Surgeons, DIT and three IoTs (IT Tallaght, IT Blanchardstown and IADT-DL)). McBrierty and O'Neill (1991) suggested that a science park should be built in Dublin as a location for campus-originated high-tech ventures after they have spun out of the university sector. Such a science park would also serve as an access point for both indigenous and MNCs to harness the appropriate research resources necessary for industrial development and competitiveness. The creation of a science park in the Dublin region, effectively interfaced to the reservoir of research competence in the university sector, would lead to a number of positive outcomes for the region and the Irish economy. In particular, it would contribute to maximising the return to the state for its investment in higher education; it would enhance the competitiveness of the indigenous high-tech sector in Ireland, it would place Ireland as a key player in the global knowledge economy, and it would enhance the region's infrastructure and promote it as a viable location for potential FDI.

This is significant given the recent downturn in the Irish economy and the decline in government expenditure in R&D and higher education, allied with the exodus of FDI from Ireland. It would be far more effective if HEIs assumed a more proactive role in encouraging indigenous SMEs to deepen their technological capacity by engaging in the commercial exploitation of university R&D and by participating in a wide range of partnerships with the higher education sector. Such a move would generate positive developments towards the creation of sustainable economic growth in the Irish economy. In order to lever the multiple resources of HEIs to benefit the development of indigenous high-tech enterprise in Ireland, it is important to remove all barriers (real or perceived) to effective collaboration and to enhance effective government-funded programmes, with the aim of making linkage opportunities more accessible to indigenous high-tech companies. The absence of such action will result in a crucial underutilisation of a scarce but valuable resource in Irish HEIs and will limit the potential of the Irish economy to move successfully into a phase of stronger self-sustaining growth.

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