

UNIVERSITY OF GLAMORGAN
BUSINESS SCHOOL



TARGETED SOCIO-ECONOMIC RESEARCH PROJECT NO 1042

**UNIVERSITIES, TECHNOLOGY TRANSFER AND SPIN-OFF
ACTIVITIES – ACADEMIC ENTREPRENEURSHIP IN
DIFFERENT EUROPEAN REGIONS**

FINAL REPORT

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Abstract.

As the recent Green Paper on Innovation suggests, the European Union must be more effective at placing its technology-base at the service of industrial competitiveness and the needs of the market. In particular, it is recognised that one of the greatest challenges facing European firms is the comparatively limited capacity to convert scientific breakthroughs and technological achievements into industrial and commercial successes. As a result, there is growing awareness of the proactive approach being undertaken by academic institutions, with many adopting a direct entrepreneurial role in collaborating with industry. Such activities can include the licensing of patents to industry and the creation of spin-offs that are based on technology developed within university laboratories.

This report presents an examination of the process of technology transfer from universities to industry within seven different regions of Europe namely Ireland, Sweden, Portugal, Northern Ireland, Wales, Spain and Finland. Through a multi-methodological approach, the research was undertaken in five distinct phases:

- the previous evidence and factors affecting the development of academic entrepreneurship in seven regions of the European Community
- a study of university policy and practice towards academic entrepreneurship, focusing in particular, on the industrial liaison function
- the identification and analysis of specific cases of 'good institutional practice' of university initiatives, within each region, to develop closer links with industry
- a study of academic entrepreneurs in universities in different regions of Europe - this gives a profile of academics in science and engineering departments; the degree to which they are involved in academic entrepreneurship; the type of entrepreneurial activities undertaken; and the influence of personal, occupational and university factors
- specific cases of academics' entrepreneurial activities (where academic entrepreneurship includes contract research, technical consultancy, patenting and licensing activities, as well as the creation of spin-off firms, by university staff).

This study has established a new and detailed picture of the state of academic entrepreneurship within the different regions of Europe. It has shown that academic entrepreneurship is a phenomenon that exists in a range of different institutional and regional settings, often having to overcome the same barriers for success in all countries. Most importantly, it has ascertained that there is a strong potential for developing increased university-industry linkages across Europe if the right institutional policies can be put into place. However, in terms of developing policy initiatives to establish closer academic-industry links, the role of the European Commission should be essentially as a facilitator. The study has demonstrated that for any initiative to succeed, it must take into account the local circumstances - for both university and the industrial partners. Policy instruments will only work if they are applied at the level of the institution, and if they reflect the strengths of the individual institutions and the needs of local (as well as international) industrial firms.

EXECUTIVE SUMMARY

BACKGROUND AND OBJECTIVES OF THE PROJECT

1. A strong and vibrant science and technological base and the ability to exploit new technologies commercially are key components in generating economic growth, and a major input, which determines the strength of the science and technological base is the educational infrastructure. Universities, in particular, have an important contribution to make in this process, as the perception of universities as merely institutions of higher learning may be gradually giving way to the view that they could be important engines of economic growth and development. This is not surprising, as regional and national governments view the high technology sector as a source of direct and indirect employment opportunities, and universities are seen as crucial to facilitating the growth of the local high technology potential, especially if the right mechanisms are in place. Such developments have tended to be isolated, and there have been almost no policy initiatives on the successful technology transfer from universities to small technology-based firms within peripheral regions. The problem raised by the White Paper on growth, competitiveness and employment five years ago - namely the successful commercialisation of technology - is still a major issue today, especially with respect to the successful commercialisation of university research into industrial success.
2. This study examines the process of technology transfer from universities to industry within seven different regions of Europe namely Ireland, Sweden, Portugal, Northern Ireland, Wales, Spain and Finland. Through a multi-methodological approach, the research was undertaken in five distinct phases:
 - the previous evidence and factors affecting the development of academic entrepreneurship in seven regions of the European Community
 - a study of university policy and practice towards academic entrepreneurship, focusing in particular, on the industrial liaison function
 - the identification and analysis of specific cases of 'good institutional practice' of university initiatives, within each region, to develop closer links with industry
 - a study of academic entrepreneurs in universities in different regions of Europe - this gives a profile of academics in science and engineering departments; the degree to which they are involved in academic entrepreneurship; the type of entrepreneurial activities undertaken; and the influence of personal, occupational and university factors
 - development of specific cases of academics' entrepreneurial activities (where academic entrepreneurship includes contract research, technical consultancy, patenting and licensing activities, as well as the creation of spin-off firms) by university staff.

The research will therefore examine the growth and development of the phenomenon of 'academic entrepreneurship' not only from the viewpoint of the institution (university), but also from the viewpoint of the individual (academic). The study will focus on developing an understanding of the role of universities in developing innovation and entrepreneurship. In particular, it examines whether the universities are undertaking a proactive role in encouraging the growth of academic entrepreneurship. It will discuss also discuss the different factors which lead to the success or failure of academic entrepreneurship, taking into account the different clashes that may exist between business and scientific cultures.

AN EXAMINATION OF PREVIOUS RESEARCH

1. In the medium to long term, sustained competitiveness in the global economy will depend on technological or innovation-based strengths. These include the ability to develop new products, to access successfully new markets, to apply new technology, to incorporate best practice in the management of enterprises and to develop skill levels across the full spectrum of the labour force. These are all elements to which the university can make a substantial contribution. However, there continues to be little co-operation in the exchange and absorption of knowledge between industry and third-level institutions such as universities. As a result, if the situation does not improve, then the limited capacity of Europe's research and technology base to convert scientific breakthroughs and technological achievements into industrial and commercial success will continue. This is particularly the case on the periphery of Europe, where countries such as Ireland, Spain and Portugal need to have a much broader spectrum of R&D capabilities if they are to successfully exploit technologies in industry.
2. Research from the US and some parts of Europe has shown that universities can play a variety of roles in developing the local economy. These include the creation and enhancement of employment opportunities, initiating new technology-based firms, technology transfer (via consultancy and patenting/licensing), provision of technical facilities for local small firms, and development of entrepreneurial graduates. However, there is little evidence from previous studies into this area to suggest that there is substantial interaction, within many European regions, between the local science and technology infrastructure (such as universities) and the indigenous technology sector. The reasons for this are complex, although the evidence suggests that this is due to a clash of two quite different organisational cultures. On one hand, the traditional culture within many academic institutions does not encourage the development of links with small-scale industry. On the other hand, there is also evidence of reluctance by small firms to become involved in relationships with their local universities although large companies regularly access universities for external sources of technological expertise.

THE ROLE OF THE INDUSTRIAL LIAISON FUNCTION

3. There has been a growing amount of research undertaken during the last few years that has attempted to examine the relationship between academia and industry. These studies have failed to discuss, in any real depth, the important role that the industrial liaison office (or its equivalent function within the university system) can play in the technology transfer process. There is, therefore, very little information to suggest that universities, through the ILO, are undertaking a proactive role in bridging the gap between academia and industry and that, at most, industrial liaison offices at higher educational institutions are merely providing marketing services for their parent organisation. For example, it has been suggested that the majority of university R&D co-operation with industry is based on direct contact of researchers and their industrial counterparts. Therefore, whilst the ILO function may, in theory, be considered as essential, practice demonstrates that many industrialists tend to bypass these contact points, often because of an unsatisfactory earlier experience with comparable institutions.
4. The first part of the research examined the industrial liaison function to compare and contrast the general policies for developing academic entrepreneurship within a sample of universities in a number of European regions and small countries on the periphery - Ireland,

Northern Ireland, Sweden, Finland, Wales, Spain and Portugal. The research will therefore illustrate whether there are significant differences and similarities in the approaches undertaken by the university sector in various European regions with regard to bridging the gap between academia and industry. The universities to be studied in each country were chosen to reflect the possible diversity of academic entrepreneurship that may exist within each country. The main method of gathering data during this study was to be face-to-face semi-structured interviews with individuals representing the industrial liaison function in both countries. It examined the general role and function of the industrial liaison office and how has this changed, direct involvement of the university with industry, the main opportunities and barriers to the development of links between university and industry, and the benefits to the university from industrial links and the perception of industry's assessment of the relationship with universities.

5. The research shows that in all of the universities studied, the general mission of the ILO function within the university is broadly similar, namely to devise and increase the links between the university and external organisations. However, study has indicated that there are a number of different models of organising the industrial liaison function within different regions of Europe. Within countries such as Spain, Portugal and Finland, only the most basic tasks are undertaken by the ILO function, whilst in countries such as Wales and Ireland, where the ILO function is an integral part of the university administrative system, there may be higher level tasks undertaken. However, it is clear that these particular models have not been deliberately chosen as part of a definitive strategy, by the institution, to develop linkages with industrial firms. Rather, the process has been largely reactive, reflecting current administrative models or, in some cases, being driven by European funding initiatives to work with industry.
6. The ILOs undertake a number of functions, which also tend to vary across institutions. Many of these technology transfer functions tend to be developed reactively rather than proactively as part of a coherent strategic aim of the university to match its particular institutional strengths to the needs of the firms. Whilst there are successful models of a strong ILO structure, particularly in Sweden, there is no guarantee that such a model could be transferred successfully to a rural region or a smaller, less technologically-oriented university, as the local needs for technology transfer differ widely across regions. In addition, the ability (and structure) of institutions to provide technology transfer capabilities to local firms can also vary.
7. Given the lack of funding and support for such activities, it is evident that within many institutions, the industrial liaison function is not seen as an important part of the overall administration of many universities. This is despite the ILO function being the primary official route by which links between the academic institution and external organisations are formed. Within some universities, the linkages with industrial firms are driven at the departmental level, often because of an absence of any substantial administrative support by the core. In many instances, this is due to a lack of resources being made available to support the industrial liaison function.
8. Internal marketing procedures were also considered to be inadequate in the majority of universities examined. The minimum degree of internal effort towards this process should ensure the university should be geared towards further integration between the industrial liaison function and academic departments so as to encourage a two-way process of communication. Whilst ILOs need to be informed of academics' specific expertise and requirements, academics must also be aware of the full range of facilities and services offered at their institution to help them in their industry-related activities. One option is for

an accreditation system, administered from the Commission, which would deliver the minimum standards for the role of industrial liaison function within European universities.

9. Only a small number of the universities were working actively to develop links with local small firms. In Sweden and Finland, most of the funding for industrial research is generated from collaborative research with larger firms. However, the majority of universities also have a strategy of working closely with high technology SMEs. This is quite different to Northern Ireland, Wales and the Republic of Ireland, where technology transfer is undertaken predominantly with larger organisations. In Wales, institutional links tend to be established with larger firms primarily based outside of Wales, whilst Irish universities tend to concentrate their activities in serving the branch plants of larger foreign companies. In Northern Ireland, the universities are closely linked with large local firms that tend to provide funding for fundamental high-tech university research. In Spain and Portugal, both large and small firms are seen as potential partners for R&D and industrial collaboration.
10. It is not surprising that links such as research funding and sponsorship of chairs, research centres and researchers are to be found in nearly of the universities studied. Such links are the traditional methods by which universities and industrial organisations have become involved in the development of co-operative research and development activities. Training partnerships with firms are also present in the majority of universities studied, which reflects the industrial content of many science and engineering courses within these institutions. Indeed, there is very little difference among the regions examined in terms of access to resources and relationship with industry. However, one notable exception is the with regard to the establishment of 'industry clubs' involving organised networking activities as well as a focus for management activities and support from the university to industry. This practice was most important within Swedish universities than any other country examined.
11. The major benefit, perceived by the university, of working with industry was that an increase in collaboration activities would result in greater funding for research from industry. This, in turn, would lead to better teaching and research facilities, as well as access to new ideas, techniques and the development of specific research initiatives within industrial firms. In addition, it was believed that the widening of the scope of academic activities would result in the university being able to make a greater and more relevant contribution to the economic needs of the region. It was also felt that closer collaboration with firms gave researchers the opportunity to focus on real-world problems and to broaden the researchers' experience. In particular, close partnership with industry can also add to the quality of research, especially through feedback on the applicability of research results. This is because firms, as customers, play the role of "efficient testing instruments", and can be used to reveal the relevant research areas that are of interest to the industry. These experiences can then be exploited for learning opportunities for students and researchers.
12. One of the main barriers to develop increased collaborative links with industry was a lack of internal resources at both an individual and institutional level. On an individual level, academic staff have increasingly less time to both establish and undertake collaborative projects with industry in addition to their teaching and administrative duties for the University. In addition, the continued emphasis on traditional outputs for academic work, such as publications, has meant that collaborative industrial R&D is not valued, except as a source of income. Therefore, there is a distinct lack of motivation to undertake applied research or technology development activities related to firms. Indeed, the general lack of academic recognition for commercialisation and rewards for publications, as opposed to patents, had been a major barrier in many countries. As a result, many academics have been

faced with the dilemma of either publishing their results for short-term revenue and academic recognition or withholding them until they are patented, with the risk of the technology becoming obsolete.

13. On an institutional level, it was considered that there was not enough emphasis, especially in terms of internal funding within the university, to sufficiently develop linkages with industry. As stated earlier, it was considered that there was a lack of a proper infrastructure for developing academic-industry collaborative activities, especially in the marketing of research expertise. It was felt that universities were not proactive enough, with not enough promotional activities to ensure businesses' awareness of the expertise available.
14. Another finding, which reflects previous research in the area of university-industry links, is the gap of knowledge, by researchers and industrialists, about each other's organisational cultures. These cultural differences are mainly down to a lack of communication by both researchers and industrialists about the advantages (and disadvantages) of collaborative activities. It was therefore evident that there was a need to set up guidelines as part of a policy for industry working with a university, with a particular need to increase awareness, and to market the university in a more professional light. Great potential does exist within many countries for increased university-industry collaboration. The reasons why this potential has not been fully realised include a lack of information about these activities, coupled with the fact that such arrangements have never been previously considered by university authorities. This is clearly one area where policy makers can influence further developments by providing more information on the potential benefits of such relationships. For example, one clear benefit for industry from universities is the provision of highly trained and technologically literate graduates who will become the labour force of scientists, engineers and technicians, and provide the key ingredient for the growth of technologically advanced industrial centres.
15. There can also be a gap in the priorities of each partner relative to the research results produced from collaborative projects. Whilst firms require research results either to be patented or, in some cases, to be kept confidential, the career structure of academia, based on published works, requires that the collaborative R&D is placed within a scientific journal. Therefore, links with industry can, in some cases, restrict the free flow of information between academics and institutions. As a result, the impression existed, within both countries, that the lack of academic recognition for commercialisation, and rewards for publications as opposed to patents, was a major barrier. Finally, universities, are, by their nature as large public-sector organisations, are bureaucratic. As a result, many smaller firms can have problems in dealing with the labyrinthine procedures of the academic institution.
16. Universities were not always the problem in developing a collaborative culture with industry. There was an underlying theme, throughout the interviews, that the clash of different cultures was also due, in part, to the attitude of business (especially smaller firms) towards academic institutions. Whilst the universities had an open door policy to cooperate and work with all types of industry, industry's perception was rather dependent on the type of industry and the nature of the link with the university. In particular, the 'ivory tower' stereotype of academics - as inefficient, out of touch with the real world and impractical - was found by the ILOs to exist in many firms. This was particularly the case in low technology SMEs, where the owner-managers tended not to have any previous experience of academia. This usually led to a lack of trust in the ability of academics to perform tasks efficiently and to a pre-determined time-schedule.

CASES OF UNIVERSITY GOOD PRACTICE

17. Twenty four different 'good practice' initiatives, developed by the university to strengthen academic-industry relationships, were identified. These included innovation networks, campus companies, enterprise training, research contract management, patenting/ licensing support, career and training services, service provision and industrial professorships. Hence they can be regarded as reflecting eight different approaches which will be outlined in this report. In addition, the nature of those initiatives is strongly linked with the national and/or regional institutional context, the profile of the regional economic fabric and the role that individual agency or higher education institutions (HEI) organisational culture plays in stimulating their emergence and design.
18. One of the key factors contributing to the success of the different initiatives examined appears to be the acknowledgement and incorporation of mutually beneficial activities for all partners involved and an awareness of the economy in which they participate. It is important to note that such initiatives have not been developed on an ad-hoc basis. They have been carefully planned to take advantage of the particular strengths of each university, and a system of procedures, programmes, incentives and policies are necessary to form a successful technology transfer mechanism between universities and businesses. As a result, if any single initiative is to succeed, it must fully acknowledge the economic implications for all parties and the kinds of approaches that would be most beneficial to all partners in view of their position and role within the economy. The keyword for success seems to be 'mutual benefit'. The various university initiatives all illustrate this in practice as they addressed the problem in a different way in relation to their specific needs, specialisms and resources. This is naturally a practical technique that could be transferred elsewhere, as innovation is evidently the key in responding successfully to a lack of resources (especially within the university sector). This reinforces the development of a specific policy instrument that will aid universities in determining a strategy towards the development of academic-industry linkages within their locality.
19. It is therefore imperative that there is both an awareness of the structure of the local and national economy and of mutually beneficial activities for all partners within any initiative aimed at further developing universities' collaboration with industry. As stated earlier, however, there can be considerable cultural problems in developing such relationships. However, as some of the cases demonstrate, whilst industry's confidentiality and ownership requirements need to be respected, compromises should be sought wherever possible.
20. It can be argued that many successful initiatives require originality if they are to be interesting and attractive to potential participants. Despite this, the study indicates that there are common 'types' of initiative, all of which have been developed independently of each other. Many of these initiatives could have learnt from each other's development - for example, campus companies development programmes usually have very much the same content, although the context is adjusted to local or regional circumstances. A membership organisation of ILOs could be one policy instrument in ensuring that universities can learn from each other's initiatives.
21. The research suggests that on the whole, policy-makers at European and national levels have tended not to focus on developing mechanisms or instruments to strengthen the links between academic institutions and other actors in the innovation system, leaving much of the activity to individual universities. As a result, not only has there been a considerable 're-inventing of the wheel' in the development of various initiatives by universities

working independently of each other. Therefore, 'good practice' of technology transfer initiatives should be disseminated to other institutions.

22. The various university initiatives examined during this stage of the research also reveal a diversity of mechanisms to reinforce linkages with industry. As the results have shown, these can be grouped according to the different types of initiative developed. Although not possible during this research project, further research needs to be undertaken to examine the characteristics of each type of technology transfer mechanisms, and concentrating on similarities and differences in each scheme. This may lead to a 'best practice' guide for each particular type of initiative, especially if this is based on case study material of 'good practice' from different institutional settings. However, the institutional (as well as regional) context needs to be taken into account when developing a new initiative.
23. The detailed analysis suggests that three main 'customer groups' can be identified in relation to develop closer academic-industry links, namely students and graduates (training/career services; graduate enterprise programmes); academics (campus companies, entrepreneurship training, patenting/licensing), and firms (firm birth, networking and technology transfer, research contract service provision and training). Two of these markets, students/graduates and academics, are essentially internal. As a result, these are probably the types of initiative that many universities would be most comfortable in establishing, assuming that some of the barriers to technology transfer, as discussed earlier, are overcome. The third market - industrial firms - is probably where the university can have the most problems in developing different initiatives, mainly due to the clash in institutional and organisational cultures which exists. This could indicate that the industrial liaison function within the university sector should concentrate on the two 'markets' with which it has direct contact.
24. Liaison activities with firms should be left to an external organisation that acts as a true bridge between the two institutions. However, given the plethora of such organisations already in existence, then this could lead to further confusion among potential customers for university services. Indeed, as the Action Plan for Innovation points out, businesses, particularly smaller firms, often get lost amongst the plethora of support services which have burgeoned at local, regional, national and Community level. Given their reluctance to become involved with the university sector for other reasons, the emergence of another support organisation may add to the confusion. However, if such an organisation was operated on a regional basis (and within a regional innovation strategy), acting as the 'liaison-animateur' for all universities, then such an organisation may be possible. Another option would be for the universities to form closer links with Business Innovation Centres (BICs) which have been shown to be a successful vehicle for technology transfer in Europe - the study shows that this approach has been very successful in Dublin. Therefore, collaboration between universities and enterprise support organisations may be a strategy for future development, particularly within smaller countries.
25. SMEs are an important characteristic of the economy and universities in all regions in the study have acknowledged this fact through the development of initiatives to support technology transfer to this sector. However, it is clear that this kind of effort requires considerable resources from both partners - the university and the small firm. This is another area where the European Commission could make a direct policy intervention - by making finance available to support interaction between local small firms and academia (without the concept of subsidiarity applying as it does for numerous Framework programmes). It is imperative that universities develop links with local firms first, before attracting international SMEs to any future research project.

26. While the cases examined can be grouped according to function and market, the diversity encountered in this study actually reveals a deliberate effort to adapt to both structural and regional circumstances. In particular, the nature of initiatives examined is affected by differences existing in national and regional institutional contexts, namely in what concerns either the role of central, regional and local government or the role of the private sector. Therefore, the diversity stemming from both different target groups and the need to adapt to structural and conjunctural circumstances leads to the conclusion that the European Commission should define strategic objectives and guidelines for academic-industry linkages, but the design of policy should be left to either regional bodies or the universities themselves.

A SURVEY OF ACADEMIC ENTREPRENEURSHIP

27. Whilst the first part of the project has examined the infrastructural reforms and institutional innovations that promote a culture of entrepreneurship within the institution, the other major part of the work is to discuss the role of the individual academic and the different types of entrepreneurial activities s/he can undertake to develop linkages with industry. These activities include not only the creation of spin-off firms, but also large scale science projects, contracted research, consulting, patenting/licensing, external teaching, sales and testing. Such activities are outside the two main duties of academics, which are recognised by educational establishments in many countries as being teaching and personal research.
28. A questionnaire survey was administered during 1997 to all researchers and teachers at the faculties of Science, Engineering and Medicine in three regions in each country. A total of 4,672 respondents answered the questionnaires giving a response rate of 38%. This questionnaire examined the background of the respondents on an aggregated level such as dispersion between countries, sex, age, job classification, academic qualifications and previous employment outside the university sector. It also discussed issues such as direct contact with industry and the kind of academic entrepreneurship activities being pursued in the universities. In addition, the support of the university environment towards industry collaboration is of particular interest as well as the academics attitudes about the industrial liaison services.
29. Overall, 77% of the respondents are male, although this may reflect the faculties targeted for the study - Science, Engineering and Medicine. The age of the average respondent is 41 years old, which is higher than the average age of other entrepreneurial types (usually mid 30s). This is to be expected, given the additional postgraduate work. In terms of academic job classifications, approximately a quarter are lecturer/senior lecturers, with about a third working as research assistants/fellows, and 17% having a professorial appointment. In terms of the highest academic degree achieved, it is not surprising to find that the majority of the academics are Ph.D.'s. The second largest category is postgraduates followed by a small number of graduates. In terms of previous industrial experience, half of all respondents have been employed, prior to their academic appointment, in a full-time position outside the university, most commonly in the public sector.
30. Much of the early research examining entrepreneurial behaviour has indicated that owner-managers tended to have fathers who were themselves entrepreneurs, and that this was a major factor in influencing the decision to establish a new venture. Despite this, it is still surprising to find that overall, 56% of the respondents have had some kind of previous small business or entrepreneurial experience. Such a large degree of previous

entrepreneurial experience has not been noted in other studies. In terms of the type of prior entrepreneurial experience, there were almost as many of the respondents who had worked in a small business - 35% - as those with immediate family members who are owner-managers. However, the most surprising finding is that 18% of all the academics questioned having either started or owned their own business. Whilst it is probable that many of these businesses are 'convenience' consultancy firms for channelling external income earned through various activities, they do, nevertheless, constitute an act of organisational creation. This was a completely unexpected finding.

31. The study also demonstrates that previous employment outside the university sector or previous small business experience has a positive effect on the likelihood of academics engaging in contact with industry. This is not surprising, as it would be expected that academics with previous industrial experience would be utilising industry contacts made during their employment or, in some cases, be given contract work directly by their previous organisation. Previous small business experience would also encourage academics to become entrepreneurial, especially outside of normal duties such as teaching and research. This finding suggests that experience of industry is highly important in developing linkages with firms.
32. Approximately 70% of the respondents have had some type of contact with industry during the last five years, with nearly a third of those questioned concentrating solely on either their teaching or basic research activities. The study shows that in terms of initiating contacts with industry, universities tended to be slightly more reactive (than proactive) to the needs of industry. While this may suggest a demand-led technology transfer system, it is also probable that there is a distinct lack of marketing, by universities, of the services they can offer, as academic institutions, to industry. However, this figure is still quite high for a sector that has been accused of being passive in forming linkages with industrial partners
33. Overall, 70% of the respondents are involved in academic entrepreneurship activities. The main types of activities undertaken by academics in both countries were (in order of popularity) contract research, consulting, large-scale science projects and external teaching. The less popular activities were those of testing, patenting/licensing, spin-offs and sales. The fact that consultancy and contract research are the most popular form of activities is not surprising, as both have been recognised as effective means of linking universities with industry. However, it is surprising, given the importance that policy-makers place on patenting and spin-off developing, that the incidence of these activities in both countries is relatively low.
34. In terms of general policy implications, this is probably one of the most interesting findings of the survey. Consultancy and contract research activity has been identified as the type of entrepreneurial activity, which can, if the right mechanisms are in place, lead to a technology-based spin-off being established. However, given the low degree of spin-off incidence in this study, it would seem that the programmes and support might not be in place in sufficient quantity for this to occur. On the other hand, many academics may be satisfied with undertaking 'low-level' activities such as consultancy to gain extra income without the trials and tribulations of starting a new business. Obviously, it is in the interest of both the academic institutions and industrial partners to determine which activities can be further developed within their own institutional and regional setting. More importantly, they need to determine whether the support mechanisms in place will encourage or hold back certain types of entrepreneurial activities. Given that most of the support mechanisms at a European and national level encourage the establishment of spin-off firms there needs

to be a thorough understanding of the activities which academics wish to become involved with prior to moving to organisational development.

35. The majority of academic entrepreneurship activities tend to be undertaken by professorial or senior lecturing staff with a Ph.D. This is not surprising as senior academics with a higher degree should be individuals with more experience, influence and position where it is easier to attract resources for undertaking external activities. It is also worth noting that building up a personal network (which is important for all kinds of contacts and collaboration) can take a number of years. However, institutions should consider whether younger staff members could become increasingly involved in entrepreneurial activities as part of their training process.
36. About half of the respondents considered their university environment supportive for academic entrepreneurship, with only one in ten stating that the environment is a direct hindrance for such activities. The high proportion of academics - 40% - describing their university environment as having no effect, despite the existence of an industrial liaison function at each institution, is particularly surprising. Therefore, whilst half of the respondents considered their university environment to be supportive, the remainder consider themselves not supported at all in their entrepreneurial activities. This is unexpected, considering the present climate described earlier with institutions actively developing linkages with industry through proactive technology transfer initiatives. Another interesting result is that the respondents from Sweden were most negative towards the university environment. This is despite the fact that it the one country in the study where linkages between universities and industry are well developed.
37. Whilst 65% of the respondents were aware of the ILO function, only a small number actually utilised the ILO in developing external links. This suggests that many academics are bypassing the industrial liaison function within the university and dealing directly with the industrial firms themselves. This calls into question the actual role of the ILO within the university. If academics and university departments are most comfortable in working directly with industry, then the industrial liaison function should be left merely as an administrative position to deal with issues such as contract management and information on European programmes. However, on average, only a small proportion of those respondents who were aware of the industrial liaison office actually used it in developing external links.
38. The use of their university's industrial liaison function has a direct influence on academics' perceptions regarding the supportiveness of their university environment towards academic entrepreneurship. This finding is particularly interesting because it enables an informed evaluation to be made as to respondents' opinions about their university environment by considering the opinions of only those who have used their ILO in developing external linkages. This suggests, as other parts of the study have indicated, that the whilst the services offered by the ILO function may be relevant to developing technology transfer linkages with industry, there needs to be a greater awareness, through internal marketing, of the role of the ILO in facilitating such relationships. This result is of varying importance to different countries. For example, in Finland and Sweden, the contacts between academics and the ILO are very rare, with very few of respondent group using the ILO services. On the other hand, in Spain and Northern Ireland, where many respondents have used the ILO services, the result is more relevant. As a result, the ILO could be increasingly utilised as a catalyst for developing a more positive university culture towards academic entrepreneurship.

39. Given the more sophisticated level of policies and mechanisms to support university-industry links within Sweden, it was an unexpected to discover that Irish, Welsh and, to some extent, Spanish, academics (with a relatively less-developed system of support) had a similar, if not higher, involvement in significant entrepreneurial activities such as contract research, large scale science projects and consultancy. However, it is clear that the Swedish system does support the creation of spin-off more successfully than any of the other countries in the study. Therefore, if spin-offs are to be encouraged, then the relative success of Sweden in generating such organisations may generate models of 'good practice' of such business development, as other parts of the research has demonstrated.
40. The implications of the increasing pressures to institutionalise entrepreneurship (especially informal activities such as consultancy) within the university environment may actually result in a decrease in these activities. This may be particularly the case within economies such as Ireland, where universities have tended to exert little control over university-industry links and, as a result, entrepreneurial activities have developed naturally as a result of the needs of both the individual academic and the industrial firms. Therefore, whilst academic entrepreneurship in Sweden has been encouraged as a result of 'top-down' strategies through institutional reforms and initiatives, the Irish approach has been one of 'laissez-faire'. As a result, academics have been allowed to develop their own initiatives relative to their own interests. However, it is worth noting that both countries have a high degree of academic entrepreneurship, and the differences observed may be due to cultural, as well as economic, differences.

CASES OF ACADEMIC ENTREPRENEURSHIP

41. The final part of the research study was to build on the quantitative data presented in the previous section and present examples of good practice of academic entrepreneurship activities. Thirty-seven examples of successful university-industry interaction from six different countries were selected to illustrate a diversity of forms of university-industry interaction. These would illustrate individual initiatives to develop academic entrepreneurship, rather than institutional programmes. The cases would be based on the different types of entrepreneurial activities identified earlier in the study - large scale science projects, contracted research, consulting, patenting/licensing, spin-offs, external teaching, testing and sales.
42. Analysis of the cases has found that one of the most important factors in the success of any academic entrepreneurial activity in any of the universities studied is the presence of motivated and driven academics. The presence of successful academic entrepreneurs can often overcome many of the internal obstacles in developing links with industry. The development of the initiative can also be helped enormously by supportive colleagues and a supportive department, which can allow individual academics to overcome any resistance from within the university.
43. The attitude of the academic towards external organisations can also be an important factor in building linkages with industry. As the previous research has indicated, many firms are often reluctant to approach the university sector for solutions to technical problems. However, the correct approach by the individual academic can convince the firm to work with the university department. More importantly, the success of such individuals' endeavour could be utilised in increasing the links with industry within the university. The presence of such successful 'role-models' of entrepreneurial success can be used by the institution to encourage other academics to develop academic entrepreneurship activities.

This should be undertaken by the ILO as part of an overall internal marketing process to encourage academic-industry links.

44. As stated earlier, the benefits of industrial research to the academic can be additional funding for new equipment and other research resources. However, the cases also clearly demonstrate that entrepreneurial activities can result in a significant degree of personal gain for those individuals involved. However, it is clear that this is not universal across all cases. Whilst the attainment of commercialisation of ideas is often sufficient, the energy and effort expended by the academic entrepreneur in the creation of the new venture needs to be appropriately rewarded. As entrepreneurship is a relatively new phenomenon within the academic sector, many universities have yet to develop an adequate reward system that is adequate in terms of pay and promotion. In many cases, the traditional reward within a university structure - promotion - is often not sufficient, as the motivation behind the development of the idea is often not career advancement. More importantly, entrepreneurs seldom make good academic managers, as they rarely have the temperament for coping with the university structure. One option for universities, therefore, may be reward entrepreneurial academic is through giving them a position of freedom within the organisation to develop new ideas, or even setting up the academic in a separate venture.
45. Entrepreneurship can only be developed within an organisation by creating the right climate for such individuals to flourish. However, the evidence from this study indicates that, in general, the majority of the academics do not utilise the industrial liaison function within the university. Instead, they form a direct relationship with industry, with the university having little or no influence in setting-up contracts or in finding new potential clients. As a result, the gradual build up of trust between academics and industrial partners, based on the achievement of tangible mutual benefits seems to be the key of success. In some cases, the maintenance and development of co-operation activities is deeply rooted in the informality of relationships and in personal contacts.
46. In most of the universities studied, the role of the ILO is restricted to mainly undertaking administrative functions, with many institutions lacking an infrastructure that is relevant to the needs of the academic entrepreneurs and, more importantly, the industrial clients. As a result, the management of technology transfer work is dealt with largely on an ad hoc basis.
47. This report shows that there are significant barriers and difficulties experienced by individual academics when they become involved with industry. Principal among these difficulties is the considerable difference between a traditional university culture and an entrepreneurial culture, with the former having an emphasis on a system that tends to favour caution in decision-making. There are therefore considerable differences in organisations, cultures and missions, not only in the reality of the institutional framework, but also in the perception of the academics as to what their goal is and what are the resultant behaviours and decision-making processes.
48. Industrial partners saw different problems compared to those seen by the academics, and as recent research indicates, the challenge is to match these. While academics frequently believed their technological ideas had commercial potential on a global scale, industrial partners often complained that these ideas had not been fully researched for commercial viability. This caused conflict as the industry players focus on marketing and balance sheets, while academics tend to place more emphasis on researching new ideas. However, albeit on a personal and ad-hoc basis, some academics are becoming more commercially aware, although universities (and other policy-makers) may need to develop specific programmes to encourage this further. This could involve a secondment or placement

within and industrial organisation. Whilst it is clear that universities must not abandon teaching and basic research, it must, nevertheless apply the same professional standards to the transfer of technology to industry as it does to the other two functions.

49. The cases described in this report show that university-industry linkages could be very successful for both the industrial and academic partners. There are considerable benefits for both partners, especially through a greater understanding of each others milieus, valuations and cultures which, as has been repeatedly emphasised, is fundamental to be able to success in academic-industry partnership. The development of such partnerships do take time and patience and as a result, there needs to be a longer term philosophy towards the success of academic-industry collaborative ventures. The adoption, by the university, of a purely 'market-oriented' approach may lead to a focus on short-term market performance, in order to 'prove' the success of the new venture. Therefore, the university must be prepared to establish a long time horizon for evaluating the success of individual ventures as well as the overall entrepreneurship programme. An entrepreneurial climate should not be established within an organisation unless it is willing to invest money with no expectation of return over a number of years. It is also important that ideas are allowed to develop fully, and that the resources allocated to such entrepreneurial project are not withdrawn before that idea has progressed to commercialisation.
50. Most academics emphasised the importance of identifying industrial linkages that provide a benefit to both partners. Consequently the choice of industry partner is critical to ensuring that the academic achieves the expected benefit from the project. The benefits identified by most of the academics in this study include the focusing of the research activities of the university on the needs of industry, funding for research activity, facilities and research staff, improved teaching within the university and increased job opportunities for graduates, and the development of new knowledge within the university.
51. The benefits described by industry partners relate to the solving of specific industrial and commercial problems. In the majority of cases, the industrial partner measured the success of the university-industry linkage in terms of the delivery by the academic of a solution to a specific short-term industrial problem. Few identified the development of an ongoing linkage with the academic as a critical benefit of the project. Overall the industrial partners did not identify problems in working with universities and academics such as a lack of professionalism or poor project management. The industrial partners of those entrepreneurs were, obviously, aware that these academics are in possession of skills than can be commercially utilised and have thus placed a high degree of value on nurturing these relationships. However, a number of industrial partners did state that they initially had a 'culture-shock' when first dealing with universities, particularly in respect of time-scales and project scheduling.
52. Therefore the examination of the case studies of academic-industry interactions supports similar findings from other parts of the research, that most important condition for successful university-industry interactions is the ability to understand each other's cultures and values. This is a fundamental issue, among all participant countries, in the development of successful co-operation between the academic and the industrialist. There are still some basic misconceptions, by both parties, of each other's attitudes towards collaboration. However, the development of such an understanding, based on the achievement of tangible mutual benefits, seems to be the key to the success of any venture. From the examination of these cases, it is also clear that many of the initiatives have taken place despite the university, and the industrial liaison function. As a result, the actual strategy of the university (and the role of the industrial liaison function) needs to be clearly defined.

MAIN POLICY RECOMMENDATIONS

53. Universities must develop their own individual strategies that reflect their strengths and the needs of local (as well as international) industrial firms. The European Commission should facilitate this action by developing a programme similar to the RITTS initiative that would part-fund the employment of independent consultants to determine an appropriate technology transfer strategy for the university. This would overcome many of the other problems, relating to academic-industry relations, which have been encountered in this study, especially with regard to the structure for industrial liaison and the barriers to closer collaboration. For example, recent research has called for universities to evaluate key researchers and facilities in order to develop industrially relevant research. Such an initiative would help to facilitate this development.
54. The study also shows the importance of focusing on, and developing, the efficiency and effectiveness of the different forms of technology transfer in order to bridge the gap between university research, technological development activities and the commercial market. Whilst the impact of scientific research might be the formation of skills and competences necessary to develop and use science-based research, perhaps what seems to be missing in some of the universities examined in the study to date is a lack of experience and expertise in the exploitation of science and technology. Another complementary measure for this programme, again to be developed by the Commission, would be the establishment of a databank of good university practice, which the above initiative could draw on in developing relevant policy initiatives. The cases of good practice highlighted in the research of successful university-industry relationship could, obviously, be adopted and adapted by other institutions. However, this diffusion of ‘good-practice’ may be dependent on whether these organisations are flexible and innovative enough to be able to absorb such policy changes. Indeed, whilst new forms of organisation are needed to interact with external actors, the analysis of the data from universities suggest that the skills related to co-operation and building relationships may be lacking in a number of universities.
55. The Commission could also initiate a new professional body for European Industrial liaison Functions. This would play the same role that the European Business Network (EBN) does for the Business Innovation Centres (BICs) in Europe. It could take responsibility for minimum accreditation, thus raising standards among ILOs. It could also determine a set of guidelines for working with industry in an attempt to break down the cultural barriers that have been prevalent in all stages of this research project.
56. In terms of more general policy issues, the European Commission could influence national educational bodies within member States to recognise the importance of collaborative work with industry. It could also encourage greater university-industry linkages through the Fifth Framework programme. Indeed, whilst it is widely acknowledged that the age of ‘science push’ as the dominant influence on innovation policy has passed, there remains a vacuum in terms of Europe-wide policy initiatives to address the crucial issue of increasing the dissemination of the technologies from the research sector to the commercial sector. To a large extent, this has continued through to the planned proposals for the Fifth Framework programmes. Whilst it can be argued that some of the horizontal initiatives, such as “Innovation and the participation of SMEs”, and “Improving human potential” could be applied within the context of the development of closer links between industry and academia, there is no specific proposal which attempts to address, on a European policy level, this vitally important issue. In particular, the European Commission could make

further resources available to support interaction between small firms and academia. However, this should be based at a local, rather than international level.

57. The study also demonstrates that academic entrepreneurship is not merely related to the development of 'campus companies' or 'spin-off firms'. Many academics have no desire to establish a new organisation and to learn the new competences required to successfully manage an entrepreneurial venture. Instead, they wish to apply their existing technological skills and experience in the context of industry. Currently, one of the main foci of the First Action Plan for Innovation has been the issues of start-up and growth of technology-based enterprises, especially in relation to campus companies. Given that this study (supporting previous research) suggests that the most effective forms of technology transfer are consulting and contract research, the whole issue of the development of 'campus companies', at least in relation of effective technology transfer, needs to be considered in more detail. In particular, increasing the efficiency of collaboration between universities and existing high technology firms should be a priority

2. BACKGROUND AND OBJECTIVES OF THE PROJECT

Rapid technological advance can give competitive advantages in local, regional national and international markets, which can result in increased industrial output, employment and prosperity. As a result, policy-makers have indicated that the future competitiveness of industry, and success in accelerating growth and increasing employment, depends on the capacity of firms to innovate in response to changing external conditions, including the continuing rapid pace of technological development. However, it has been widely recognised that a further issue needs to be addressed in relation to European industry - namely the limited capacity of Europe's research and technology base to convert scientific breakthroughs and technological achievements into industrial and commercial success. Indeed, one of the major obstacles to the general development of a vibrant technological base of European industrial firms (particularly within less-advanced or peripheral regions) is the lack of co-operation in the exchange and absorption of knowledge, especially with third-level institutions such as universities.

A strong and vibrant science and technological base and the ability to exploit new technologies commercially are key components in generating economic growth, and a major input, which determines the strength of the science and technological base is the educational infrastructure. Indeed, a sound educational infrastructure is a necessary (although on its own not sufficient) condition for the genesis of high technology industry. Universities, in particular, have an important contribution to make in this process. For example, research on the patterns of industrial success in ten leading industrial nations and the company strategies and national policies that achieved that success has suggested that a common and central characteristic of an effective science and technology policy is the existence of a strong university R&D capability¹.

With increasing evidence that the university sector can undertake a variety of roles in developing the technological and industrial potential of a region, the perception of universities as merely institutions of higher learning may be gradually giving way to the view that universities could be important engines of economic growth and development². This is not surprising, as regional and national governments view the high technology sector as a source of direct and indirect employment opportunities, and universities are seen as crucial to facilitating the growth of the local high technology potential. With evidence that the majority of jobs in high technology industries have been created by small firms³ there are opportunities, if the right mechanisms are in place, for this sector to benefit directly from the research carried out by university scientists. As an examination of previous research in this area has shown, such developments have tended to be isolated, and there have been remarkably little policy initiatives on the successful technology transfer from universities to small technology-based firms within peripheral regions. The problem raised by the White Paper on growth, competitiveness and employment⁴ five years ago - namely the successful commercialisation of technology - is still a major issue today, especially with respect to the successful commercialisation of university research and development into industrial success.

¹ Porter, M.E. (1990) *The Competitive Advantage of Nations*, Free Press, New York

² Saxenian, A., (1994) *Regional advantage: culture and competition in Silicon valley and Route 128*, Harvard University Press, Cambridge, MA; Stankiewicz, R., (1986), *Academics and Entrepreneurs: Developing University-Industry Relations*, Frances Pinter Publishers, London

³ Jones-Evans, D. and Westhead, P. (1996) "High technology small firm sector in the United Kingdom", *International Journal of Entrepreneurial Behaviour and Research*, Vol. 2 No. 1, pp. 15-35.

⁴ European Commission (1993) *Growth, competitiveness, employment: the challenges and ways forward into the 21st Century*, Bulletin of the European Communities, Supplement 6/93.

This study examines the process of technology transfer from universities to industry within seven different regions of Europe namely Ireland, Sweden, Portugal, Northern Ireland, Wales, Spain and Finland. Through a multi-methodological approach, the research was undertaken in five distinct phases:

- the previous evidence and factors affecting the development of academic entrepreneurship in seven regions of the European Community (Northern Ireland, Wales, Portugal, Spain, Sweden, Finland and Ireland)
- a study of university policy and practice towards academic entrepreneurship. This includes the general role and function of the industrial liaison office; the involvement of the university in different types of industrial links; the main opportunities and barriers to the development of links between university and industry; the benefits to the university from industrial links and the perception of industry's assessment of the relationship with universities. This was achieved through interviews with key individuals in the processes of technology transfer between academia and industry, as well as secondary data
- the identification and analysis of specific cases of 'good institutional practice' of university initiatives, within each region, to develop closer links with industry. These cases were identified from the previous stage of the research
- a study of academic entrepreneurs in universities in different regions of Europe - this gives a the profile of academics in science and engineering departments; the degree to which they are involved in academic entrepreneurship; the type of entrepreneurial activities undertaken; and the influence of personal, occupational and university factors on this
- the description of specific cases of academics' entrepreneurial activities (where academic entrepreneurship includes contract research, technical consultancy, patenting and licensing activities, as well as the creation of spin-off firms, by university staff). This illustrates the operation of the principles and processes identified quantitatively in the previous work package

The research will examine the growth and development of the phenomenon of 'academic entrepreneurship' not only from the viewpoint of the institution (university), but also from the viewpoint of the individual (academic). Therefore, the main study will examine:

1. the role of academic entrepreneurship in the economic development of different types of regions in the European Community
2. the general policies for developing academic entrepreneurship in the peripheral regions of Europe
3. the processes by which university-industry relationships are formed and whether these vary by types of region, university and university-industry relationships
4. the university environment and overall strategy of the university and its effect on the development of academic entrepreneurship and university-industry relationships
5. the types of university programmes best suited for developing academic entrepreneurship within different types of regional settings
6. the existence of best practice models of university initiatives to develop academic entrepreneurship and their applicability elsewhere
7. the main issues facing academic entrepreneurs in the peripheral regions of Europe

It is worth noting that these objectives have not changed during the course of the project. In addition, the research is of both academic and practical significance, and contributes to the body of understanding on the processes of knowledge-based entrepreneurship in Europe, as well as developing specific policy measures to aid the technology transfer from universities to small technology-based firms. In particular, the report focuses on developing an understanding of:

- the role of universities in developing innovation and entrepreneurship. In particular, it examines whether the universities are undertaking a proactive role in encouraging the growth of academic entrepreneurship
- academic entrepreneurs within different regions of Europe, building on previous research carried out by the applicants in this area
- the different factors which lead to the success or failure of academic entrepreneurship, taking into account the different clashes that may exist between business and scientific cultures.

In particular, it is envisaged that the results from the project will lead to specific policy initiatives at regional national and European level. Indeed, in adopting a regional approach, this project may support some of the recent policy initiatives arising from DG XVI. These, as Landebaso⁵ indicates, should focus not only on the generation of the weaker regions' indigenous RTD activities, but on facilitating the identification, adaptation and adoption of technological developments in a specific regional setting. It also follows some of the guidelines of the recent Action Plan for Innovation⁶ which states quite clearly that whilst regions tend to look to their own solutions, there is also a need to use this wealth of experience to take a more consistent approach to efforts which hitherto have been too fragmented, in order to overcome the obstacles and handicaps which still hinder innovation in the European Union. There is therefore a need to draw on the successful experience of various regions and countries, exploiting accumulated knowledge and improving the dissemination of good practice.

Each individual country report is described in Appendix 1. In addition, the methodological instruments utilised during each stage are shown in Appendix 2.

⁵ Landebaso, M. (1996) *Towards a New Regional Policy for the promotion of Innovation*. Paper presented at the National Innovation Day Conference, Dublin, Ireland, Nov. 4th.

⁶ European Commission (1996) *The First Action Plan for Innovation in Europe - Innovation for Growth and Employment*, European Commission, Brussels.

3. SCIENTIFIC DESCRIPTION - PROJECT RESULTS & METHODOLOGY

3.1 Introduction

This section will describe the research investigations undertaken during the course of the project. First of all, it will provide the necessary background to the project, which has been gathered from a variety of secondary data analysis undertaken by the different partners. It will then focus on the four different empirical work packages, describing the methodology undertaken during each stage of the research, and the main results arising from the work. Where applicable, it will highlight the different countries' results, but only on a comparative basis. More detailed reports can be found in the Annex to this work.

3.2. AN EXAMINATION OF PREVIOUS RESEARCH

3.2.1 Introduction

In the medium to long term, sustained competitiveness in the global economy will depend on technological or innovation-based strengths. These include the ability to develop new products, to access successfully new markets, to apply new technology, to incorporate best practice in the management of enterprises and to develop skill levels across the full spectrum of the labour force⁷. These are all elements to which the university can make a substantial contribution. For example, the recent inquiry into Higher Education in the UK, carried out by Sir Ron Dearing, concluded that universities should no longer be seen as isolated islands of knowledge. Instead, higher education was to be seen as a significant force in regional economies, as a source of income and employment, as contributing to cultural life, and supporting regional and local economic development. However, there continues to be little co-operation in the exchange and absorption of knowledge between industry and third-level institutions such as universities⁸. As a result, if the situation does not improve, then the limited capacity of Europe's research and technology base to convert scientific breakthroughs and technological achievements into industrial and commercial success will continue.

The dependency on technological development for future national competitive advantage may be particularly pronounced on the periphery of Europe, in countries such as Greece, Ireland, Spain and Portugal. These nations need to have a much broader spectrum of R&D capabilities if they are to successfully exploit technologies in industry, even within medium technology sectors. Furthermore, the research has found that it is becoming generally accepted that small peripheral countries cannot sustain a development strategy based on relative factor costs (wages, labour, etc.). Instead, they must increasingly develop a comparative advantage based on the enhancement and exploitation of the national knowledge base, as in other developed, progressive countries, where science and technology is at the top of the national agenda. This increasing emphasis by economists and policy-makers on the importance of the generation and

⁷ Nijkamp, P., (1986), *Technological change, employment and spatial dynamics*, Berlin, Springer-Verlag; Smilor, R.W., Gibson, D.V. and Dietrich, G.B., (1990), "University spin out companies: technology start-ups from UT Austin", *Journal of Business Venturing*, Vol. 5 pp. 63-76; Amin, A. and Goddard, J.B., (1986), *Technological change, industrial restructuring and regional development*, London, Allen and Unwin; Aydalot, P. and Keeble, D., (1988), *High technology industry and innovative environments - the European experience*, Routledge, London; Cooke, P. (1985), "Regional Innovation Policy: problems and strategies in Britain and France", *Environment and Planning C: Government and Policy*, Vol. 3, pp. 253-267; Ewers, H-J and Wettmann, R.W., (1980), "Innovation-oriented regional policy", *Regional Studies*, Vol. 14, pp. 161-179.

⁸ National Committee of Inquiry into Higher Education (1997) *Higher Education in the Learning Society*, HMSO London

availability of new technologies has considerable implications for the promotion of economic growth within the peripheral regions of the European Community. The attractiveness of developing high technology industrial sectors has sparked a number of policies to create or generate innovativeness of peripheral regions, and to upgrade the technological capabilities of local firms through regional innovation centres. Despite this, past success in the development of innovation has eluded a number of peripheral regions, mainly because of their low innovation potential, which is an outcome of the relative scarcity of industrial R&D carried out there. Therefore, as European policy-makers have noted, there must be a large investment in strengthening the learning capability of those who are weakest, especially with regard to innovation. It is therefore not surprising that, as table 1 shows, there has been considerable growth in the expenditure on R&D by universities in peripheral regions. During the period 1985-1991, Ireland (102.4%), Greece (187.1%), Portugal (250%) and Spain (234.3%) have increased their R&D expenditure in higher education by a higher amount than the European Community (74.6%). This increase in expenditure is mainly due to the impact of European Commission Structural funds, whose aim is to strengthen European cohesion and further union by promoting more balanced economic and social development.

Table 1.
Research and development expenditure performed by higher education
(MECU - 1994 prices and exchange rates).

	1985	1986	1987	1988	1989	1990	1991	% Change 1985-1991
Belgium	333	353	386	382	608	-	696	109.0
Denmark	234	268	301	335	367	390	402	71.8
Germany	3008	3346	4025	4233	4457	4800	5734	90.6
Greece	31	29	34	40	81	86	89	187.1
France	2345	2505	2626	2739	3039	3313	3528	50.4
Ireland	41	50	52	52	62	72	83	102.4
Italy	1209	1371	1580	1756	1935	2317	2470	104.3
Netherlands	809	872	919	902	943	1061	1112	37.5
Portugal	34	41	50	60	83	104	119	250.0
Spain	248	268	307	402	531	671	829	234.3
UK	1987	1918	2072	2370	2509	2624	2882	45.0
EC	10276	11020	12352	13270	14615	-	17944	74.6

In addition, it has been suggested that an increase in R&D spending and the number of R&D personnel in universities within peripheral regions may be largely due to involvement in

European Commission RTD international-based programmes. These research links would be with either other universities and private/public research centres but not specifically with indigenous firms⁹. In the three less developed countries of the European Union, namely Ireland, Portugal and Greece, RTD funding from the EC accounts for between 10% and 35% of total civil R&D spending.

Despite the increase in spending on university R&D, there is little evidence from previous research into this area to suggest that there is substantial interaction with the local science and technology infrastructure (such as universities) within the different European peripheral regions in this study and the indigenous technology sector. Indeed, the role that a vibrant indigenous technology-based sector may play in the development of the economy has tended to be neglected by policy-makers within many European regions. This reflects much of recent innovation policy undertaken by a number of regions in the European Commission. This has been targeting the attraction of the R&D facilities of large firms, with the hope that there will be subsequent spin-off activity, rather than on the promotion, development and growth of a strong indigenous technological sector. The reasons for this 'link gap' between universities and the indigenous technological base are complex, although the evidence suggests that this is due to a clash of two quite different organisational cultures. On one hand, the traditional culture within many academic institutions does not encourage the development of links with small-scale industry. On the other hand, there is also evidence of reluctance by small technology-based firms within peripheral regions to become involved in relationships with their local universities¹⁰ although large companies regularly access universities for external sources of technological expertise¹¹. Whilst small firms were aware that university departments could provide advanced inputs in favourable conditions, it was generally considered that the knowledge generated by universities was less likely to be targeted to their needs. This is an issue that will be explored in some depth during this report

This general apathy - by universities and small firms alike - towards closer collaborative links may be one of the greatest weaknesses of Europe's research and technology base, which has resulted in a comparatively limited capacity to convert scientific breakthroughs and technological achievements (from university research) into industrial and commercial success¹². Despite this, it is evident that great potential does exist within many peripheral regions of Europe for increased university-industry collaboration. The reasons why this potential has not been fully realised needs to be examined more thoroughly. To date, there is little evidence to suggest that the university sector in many regions of Europe is a significant actor in the development of economic and technological potential of different regions. This is despite indications, from previous research studies in the US and Europe, that the university sector can undertake a variety of roles, especially with regard to the development of high technology small firms, which governments at national and European level view as essential actors in the future creation of quality employment, wealth-creation and technological innovation. The following section will examine some of these roles in detail.

3.2.1 Creating and enhancing employment opportunities.

⁹ European Commission, (1994) *The European Report on Science and Technology Indicators 1994*, European Commission, Luxembourg

¹⁰ Fontes, M., (1995) *New technology based firms and national technological capability: the case of Portugal*, Unpublished Ph.D thesis, University of Manchester Institute of Science & Technology.

¹¹ Chatterji, D. and Manuel, T.A., (1993) "Benefiting from external sources of technology", *Research-Technology Management*, Vol. 36, No. 6, pp. 21-26; Link, A.N. and Rees, J., (1990), "Firm size, university-based research and the returns to R&D", *Small Business Economics*, Vol. 2, No. 1, pp. 25-32.

¹² European Commission, (1993) *Growth, competitiveness, employment : the challenges and ways forward into the 21st Century - white paper*, European Commission, Luxembourg

Regional and national governments view the high technology sector as a source of direct and indirect employment opportunities, and universities are seen as crucial to facilitating the growth of the local high technology sector. Within any region, the development of a centre of academic excellence in a certain field can therefore create or enhance a favourable public image and reputation¹³. As a result, additional jobs can be created not only in a university, but also in the wider community surrounding the university, because of its enhanced economic and social status¹⁴. With evidence that the majority of jobs in high technology industries have been created by small firms¹⁵, there are also opportunities, if the right mechanisms are in place, for this sector to benefit directly from the research carried out within the academic institution.

Probably one of the most famous examples of this within Europe is to be found not within an industrial area, but in the largely rural area of East Anglia in the UK. Here, the University of Cambridge has been utilised as a catalyst in linking academic research, entrepreneurs and financial institutions to create a seedbed for new industry¹⁶. As a result, the region has experienced the fastest growth in employment within the UK in high technology manufacturing as well as other knowledge-based services activities such as R&D and computer services. Universities, as large locally based organisations can, through selective tendering, procedures also create numerous opportunities for smaller firms in the region to supply goods and services to the institution itself.

As well as creating employment, universities are also seen as important assets in retaining skilled graduates within a locality who might otherwise have been attracted away to the core regions. Trinity College Dublin in the Republic of Ireland (with the support of various government agencies) has initiated an innovative policy of hosting laboratories from a range of industries to retain postgraduate researchers and assists in providing funding and experience for further research¹⁷. This has begun to reduce the brain-drain of skilled young people away from Ireland, and reduced the “education for export” that was developing previously, particularly in science and technology areas.

Universities are also involved in training, in both requisite quantity and quality, of the labour force of scientists, engineers and technicians, who provide one of the key ingredients for the growth of technologically advanced industrial centres. By providing graduates with the skills required by knowledge-based industries, many of which are smaller firms, they affect the overall level and focus of educational attainment that, in turn, can affect a region’s ability to adopt and exploit new technologies successfully. This role is becoming increasingly important. Indeed, there are concerns that higher investment in technological R&D might not produce the expected economic benefits due to a lack of qualified people both to develop and exploit advanced and innovative products and processes.

The presence of a large research university with its thousands of potential highly educated technical personnel can also be a factor in attracting companies to a particular region, as firms can only easily recruit there if they are already located in an advanced urban-industrial area. Many regional development bodies are increasingly aware of the attractive powers of

¹³ Acs, Z.J., Fitzroy, F. and Smith, I. (1995) “High technology employment and university R&D spillovers: evidence from US cities”. In Bygrave, W.D., Bird, B.J., Birley, S., Churchill, N.C., Hay, M., Keeley, R.H. and Wetzel, W.E. (eds.) *Frontiers of Entrepreneurship Research 1995*, Babson College, Wellesley, MA, pp. 274-285.

¹⁴ Malecki, E.J. (1991) *Technology and regional development*, Harlow, Longman.

¹⁵ Jones-Evans, D. and Westhead, P., (1996), “High technology small firm sector in the United Kingdom”, *International Journal of Entrepreneurial Behaviour and Research*, Vol. 2 No. 1, pp.15-35

¹⁶ Segal, N. (1986), “Universities and technological entrepreneurship in Britain - some applications from the Cambridge Phenomenon”, *Technovation*, Vol. 4 pp. 189-204.

¹⁷ Jones-Evans, D. and Pandya, D. (1997) *Entrepreneurial universities - cases of good practice from the Republic of Ireland*, Technology Policy and Less Developed R&D Systems in Europe, Seville, 17th-18th October.

universities that have a good record of collaborative research and development with inward-investing firms. For all start-up technological centres, the ability to build a local labour market of good quality engineers and scientists is critical, and the university can play an important part in this through the supply of highly trained science and technology graduates. Moreover, students can also be used, through placements and assignments, by local small businesses to develop critical management and technical competences that they could not otherwise afford.

3.2.2 Creators of new technology-based firms

The university sector concentrates a large critical mass of scientifically sophisticated individuals who can generate new technologies. These, in turn, can lead to innovative ideas (and technological knowledge) which can be channelled and diffused by new ventures. Various studies have recognised that a significant number of new technology-based businesses in both the USA and Western Europe had been established by scientists emerging from different types of academic-based organisations, such as non-profit research institutes, government research centres and universities¹⁸. The role of universities in creating these milieus of innovative firms within different regions has led to a proactive approach by universities, usually supported by regional or national government, in adopting a direct entrepreneurial role¹⁹. This can range from the establishment of university-owned holding companies to promote fledgling academic entrepreneurs to the development specific centres of research and training that promote and assist the process of spin-off of academic research into a network of industrial firms and business ventures. Some of these issues are examined in more detail in this report.

3.2.3 Technology transfer for small firms.

Whilst the creation of spin-offs is one example of technology transfer into the small firm sector, universities can also play a valuable role in directly transferring both technological expertise and knowledge - through either consultancy activities or patenting - to existing local entrepreneurial ventures. Consulting by academic scientists and engineers can be the most versatile and cost-effective means of linking industry with the university sector²⁰. This is because it is a relatively inexpensive, rapid and selective means of transferring information with few institutional tensions and it rarely involves extensive demands on university personnel and material resources. It is therefore recognised as the most effective two-way channel between university and industry, often leading to other forms of co-operation. Academic scientists and engineers who engage in consulting acquire knowledge about the needs of industry and can therefore identify how these needs can be met by the university sector.

Another important means of technology transfer is the commercialisation of research results through patenting and licensing, and it has become recognised that patenting contributes to the effective utilisation of technology, in that a company is more likely to invest in new technology if a patent protects it. However, there is little evidence of the smaller firms benefiting, as yet, from patenting activities within many regions of Europe, and there is an urgent need to re-

¹⁸ Tesfaye, B. (1997) "Patterns of formation and development of high technology entrepreneurs". In Jones-Evans, D. and Klofsten, M. (eds.) *Technology, Innovation and Enterprise - the European experience*, Macmillan, London, pp. 61-106; Roberts, E.B., (1991), *Entrepreneurs in high technology, lessons from MIT and beyond*, Oxford University Press New York,

¹⁹ Kinsella, R. and McBrierty, V. (1997) "Campus companies and the techno-academic paradigm: the Irish Experience" *Technovation*, Vol. 17. No 5, pp. 245-252

²⁰ Mansfield, E., (1994), *The contributions of new technology to the economy*, Presented at the American Enterprise Institute Conference on the Contributions of Research to Economy and Society, Washington DC, October.

examine the policies and practice of this valuable source of knowledge for the small firm sector.

3.2.4 Provision of technical facilities for local small firms.

Another way in which universities can help small firms is by making technical equipment available within their laboratories for use by existing local businesses to solve production process problems and to supplement their commercial advantage. This can particularly benefit small firms, who usually cannot afford the relevant technical equipment. With universities having computing, testing and analysis and library facilities, these could act as an incentive for small firms to engage in an academic-industry based relationship. As a result, local firms can become more technologically sophisticated. This, in turn, enhances their competitive performance and, in some cases, their survival. For example, a Centre of Expertise programme has been established in Wales that identifies 35 specialist Research Centres. These are based at one of the 13 Higher Education Institutions in Wales, and conduct research of an excellent and highly specialist nature. These Centres are valued for their extensive interactions with industry and are encouraged to create close links with local indigenous firms.

3.2.5 Development of entrepreneurial graduates.

One of the more prominent success stories of interactions between universities and local industry has been the effort, within many institutions, to link small firms with their graduates. In previous years, the natural career path for any individual with a degree would be to go and work for a large organisation. However, with graduate unemployment increasing, there have been efforts by a number of universities in the UK to develop initiatives to encourage students to consider self-employment or working for a small business as a viable option to working for other organisations. This can be done through the introduction, at all levels of education and in all courses, of specific 'enterprise issues' such as the integration of entrepreneurial role models into educational programmes and the introduction of supervised work-placements in small firms as part of the educational process. This could emphasise the benefits of self-employment to graduates. Other methods could include greater guidance on self-employment and working in a small firm within careers' advice, and the encouragement of students to develop business ideas through courses on idea generation and marketing.

3.2.6. Summary

An examination of previous research in the area of academic entrepreneurship, both within the countries examined, and in the wider research sphere, has revealed that universities can play a variety of roles to encourage the development of technology transfer with firms at a local level. This could, if applied to many peripheral regions, overcome many of the problems faced in these regions in terms of access to technological resources, particularly by indigenous firms. Whilst this research has identified that universities can act a catalyst in developing linkages with industry, there is an obvious need for further research which should examine the mechanisms which exist for transferring technology between academic departments and industrial firms. In particular, a detailed exploration of the selected dimensions of university-industry relationships such as technology transfer and knowledge acquisitions is required.²¹

²¹ Geisler, E. and Furino, A., (1993), "University-industry-government co-operation: research horizons," *International Journal of Technology Management*, Vol. 8, Nos. 6/7/8. pp. 802-811.

3.3 The role of the industrial liaison function.

3.3.1 Introduction

As stated earlier, there is increasing evidence of a proactive approach being undertaken by academic institutions, a number of which are adopting a direct entrepreneurial role in collaborating with industry. These include the licensing of patents to industry²² and the creation of spin-offs that are based on technology developed within university laboratories²³.

However, much of the previous research on the technology transfer from university to industry has concentrated on discussing these processes from the viewpoint of the recipient organisation (particularly the technology-based spin-off firm)²⁴. There has been very little detailed examination of the proactive role that the university (at an institutional or individual level) can play in developing strong linkages with industry. Very few studies have examined the strategies and policies that are undertaken to increase the process of technology transfer from academia into local indigenous business, especially through internal mechanisms such as the industrial liaison office (ILO). As such, this research forms one of the first detailed studies of the role of the Industrial Liaison function within the university sector in Europe. In particular, it will give a direct insight into the processes by which universities develop a strategy for creating technology transfer interactions with industry.

One of the few previous studies of this phenomenon suggested that the industrial liaison office acts as a formal function of the university in managing the interface between academia and various external institutions, including industry, government and other research organisations²⁵. It can also be used as a signpost organisation offering switchboard services and directing industrialists who are seeking help to the most appropriate expertise within the university. However, this is a simplified definition as the function differs from university to university and from country to country²⁶. For example, recent research from Sweden²⁷ indicates that an industrial liaison function within the university, through creating important contacts with external actors, can

- provide insights into the direction that education and research should follow to address the specific needs of industry and society
- offer opportunities for the university's employees to gain direct industrial experience through taking part in a variety of external activities with firms
- attract external sources of funding which can then be allocated for the development of specific areas of industrial research.

²² Wallmark, J.T. (1997) "Inventions and patents at universities: the case of Chalmers University of Technology", *Technovation*, Vol. 17 No 3 pp. 129-142; Lindström, G. (1994) *Idéutveckling-produktutveckling - en studie av exploatering av oberoende uppfinningar* (Idea-based product development - a study of the exploitation of independent inventions), Linköping Studies in Management and Economics, Dissertation No 28.

²³ Jones-Evans, D. and Klofsten, M. (1997) "Universities and local economic development - the case of Linköping, Sweden", *European Planning Studies*, Vol. 5 No 1, pp. 77-94.

²⁴ Stankiewicz, R. (1986) *Academics and Entrepreneurs: Developing University-Industry Relations*, Frances Pinter Publishers, London.

²⁵ Schaettgen, M. and Werp. R. (1996) *Good practice in the transfer of university technology to industry*, European Commission DGXIII, EIMS Publication No 26.

²⁶ Kulmann, S. and van der Meijden, R. (1989) *University Industrial Liaison Services in Europe*, TII Conference.

²⁷ NUTEK (1995) "Innovative Activities in Swedish Firms", *NUTEK R*, Stockholm, 1995:18.

Therefore, through supporting the growth of such a function, an enterprising university could maximise its resources to develop an internal enterprise culture. Ideally, the ILO can help facilitate this process by providing opportunities for enterprising staff to develop ideas and contribute to the economy via knowledge transfer and spin-off companies. However, staff involved in the transfer of technology to industry will require a number of competences²⁸. These include a knowledge of the process of taking out patents and licence; expertise in legal agreements, such as research contracts; negotiation skills; database building skills; knowledge of grants and subsidies; marketing and business planning knowledge; and networking development skills.

There has been a growing amount of research undertaken during the last few years that has attempted to examine the relationship between academia and industry²⁹. These studies have failed to discuss, in any real depth, the important role that the industrial liaison office (or its equivalent function within the university system) can play in the technology transfer process. There is, therefore, very little information to suggest that universities, through the ILO, are undertaking a proactive role in bridging the gap between academia and industry and that, at most, industrial liaison offices at higher educational institutions are merely providing marketing services for their parent organisation. For example, it has been suggested that the majority of university R&D co-operation with industry be based on direct contact of researchers and their industrial counterparts³⁰. Therefore, whilst the ILO function may, in theory, be considered as essential, practice demonstrates that many industrialists tend to bypass these contact points, often because of unsatisfactory earlier experience with comparable institutions³¹.

3.3.2 Methodology

By specifically examining the industrial liaison function, this study will compare and contrast the general policies for developing academic entrepreneurship within a sample of universities in a number of European regions and small countries on the periphery - Ireland, Northern Ireland, Sweden, Finland, Wales, Spain and Portugal. The partners contacted a minimum of three universities in each country, each situated within different types of region (university in a rural region; university in traditional industrial region; university in 'growth' or economically prosperous region). These universities were also studied for the other stages of the research project. The universities were as follows:

- Finland - University of Oulu; University of Tampere; Tampere University of Technology; University of Turku; Åbo Akademi University; Turku School of Economics and Business Administration
- Ireland - University College Dublin; University of Limerick; University College Galway; University College Cork; Trinity College Dublin
- Northern Ireland - University of Ulster; Queen's University Belfast (only two universities in the region)

²⁸ Charles, D. and Howells, J. (1992) *Technology transfer in Europe: public and private networks*, Belhaven Press, London.

²⁹ Bower, D.J. (1992) *Company and campus partnership - supporting technology transfer*, Routledge, London; Charles, D. and Howells, J. (1992) *Technology transfer in Europe: public and private networks*, Belhaven Press, London; Schaettgen, M. and Werp. R. (1996) *Good practice in the transfer of university technology to industry*, European Commission DGXIII, EIMS Publication No 26.

³⁰ Kulmann, S. and van der Meijden, R. (1989) *University Industrial Liaison Services in Europe*, TII Conference.

³¹ Schaettgen, M. and Werp. R. (1996) *Good practice in the transfer of university technology to industry*, European Commission DGXIII, EIMS Publication No 26.

- Portugal - University of Aveiro, University of Porto and University of Trás-os-Montes e Alto Douro
- Spain - University of the Basque Country; UCM: University “Carlos III” of Madrid University of Santiago de Compostela
- Sweden - Linköping University; Umeå University; Luleå University; Chalmers University
- Wales - Cardiff University, Swansea University, Bangor University and the University of Wales College of Medicine

As previous studies have demonstrated, there have also been quite different approaches to the development of academic-industry collaboration in these countries and regions. The research will therefore illustrate whether there are significant differences and similarities in the approaches undertaken by the university sector in various European regions with regard to bridging the gap between academia and industry. The universities to be studied in each country were chosen to reflect the possible diversity of academic entrepreneurship that may exist within each country. However, this is not an issue within this comparative study and has been discussed in more detail in the individual reports.

The main method of gathering data during this study was to be face-to-face semi-structured interviews with individuals representing the industrial liaison function in both countries. Whilst interviews were carried out with five or six persons at each university in some countries (such as Sweden), only a couple of ILO representatives were interviewed in others (such as Ireland). As will be explained later, this reflects the structure of the ILO function in each country rather than any methodological considerations. Prior to the interview, all ILO representatives received a short description of the project together with a copy of the interview instrument for the questions. The interviews lasted between 40 minutes and two hours (depending on the persons' knowledge of the different issues) with the notes from the interviews have been sent to those who wished to check and complement them to guarantee the results. Four main areas of interest were discussed in the interview instrument, namely:

- the general role and function of the industrial liaison office and how has this changed
- direct involvement of the university with industry
- the main opportunities and barriers to the development of links between university and industry
- the benefits to the university from industrial links and the perception of industry's assessment of the relationship with universities.

The data gathered during the interviews was then analysed using a number of approaches to reduce, code and group the information³².

One of the main problems of the data collection, even using semi-structured interviews, is the implicit assumption that there is a deliberate, established and articulated policy towards academic entrepreneurship. It also assumes that there is a specific and deliberately designed organisational structure and that relevant databases are available. This is unlikely to be valid in a number of the regions examined, in particular Spain and Portugal. In both these countries, it was expected that only embryonic policy developments regarding academic entrepreneurship would be discovered. It was also expected that fragmented organisational structures, ambiguity of roles to be played and overlapping functions would be present. Consequently, some of the empirical results cannot be directly compared although some broad conclusions can be reached.

³² Miles, M.B. and Huberman, A.M. (1994) *Qualitative data analysis - an expanded sourcebook*, Sage Publications, London.

3.3.3. Results and Analysis

3.3.3a The Role of Industrial Liaison Offices

An examination of the countries involved in the study demonstrates a number of different models. Four of the partners - Northern Ireland, Wales, Sweden and the Republic of Ireland - reported that the universities had established a formal system with a full university administrative role for the Industrial Liaison Office. This office acts as the established link between academia and external organisations by acting as a 'gateway' to university departments³³.

Within Finland, Spain and Portugal, the university had yet to formally establish the ILO system. Instead, the function was carried out at a departmental level (as in Portugal and Finland), with some industrial liaison functions being undertaken by other units within the university or by external organisations (as in Spain). Therefore, the industrial liaison role across the peripheral regions of Europe did not have a common model. In addition, there were variations in the degree of centralisation of the function relative to the administration of the university.

Within the more proactive institutions - especially those found in the Scandinavian countries of Sweden - the system can be more decentralised, with the ILO being one of only a number of independent units (at departmental level) working in collaboration with industry. In Sweden, this is largely due to the evolution of the ILO function within the university over a considerable period of time - it had recognisable commonplace ILO functions within the university system during the 1970s. As a result, the role of the industrial liaison function is relatively more advanced, as a whole, than the other countries in the study.

Therefore, within most of the Swedish cases, universities have widened the industrial liaison operations to include units, independent of the ILO, with responsibility for new activities such as patenting, contract research, continuing education and the development of spin-off firms. Indeed, the success of such a system, especially at Linköping University where the ILO was directly involved in the development of spin-off firms³⁴ has resulted in this type of structure becoming accepted (within Sweden) as a more effective organisational form for managing the academic-industry links. Indeed, three of the four Swedish universities studied are in the process of re-evaluating and reorganising the role and structure of the ILO. As a result, there will be a move from a single contact point towards the creation of a number of independent units focusing on specific activities with external actors. Indeed, collaborative activities are becoming increasingly specialised, and more people becoming involved in the industrial liaison function³⁵. This is not surprising, as industrial co-operation is being seen increasingly as the 'anchor in reality' for many academic institutions³⁶.

In Finland, there has been a tendency for the individual academic departments to have direct control over their relationship with industry. In such cases, the industrial liaison function is to be a proactive 'animateur' that is not attached to any single department. The levels of involvement can vary - at both the University of Turku and the University of Tampere, the ILO function is more that of a Research Liaison Officer, being very much reactive with the

³³ Klingström, A. (1987) *Co-operation Between Higher Education and Industry*, Uppsala University, Uppsala.

³⁴ Jones-Evans, D. and Klofsten, M. (1997) "Universities and local economic development - the case of Linköping, Sweden", *European Planning Studies*, Vol. 5 No. 1, pp. 77-94

³⁵ NYFOR (1996) "Samverkan mellan högskolan och näringslivet", SOU, Stockholm, 1996:70.

³⁶ Buchberger, B. (1998) "University research vitalization and social contribution", *Technological Forecasting and Social Change*, Vol. 47 no 3, pp. 211-216.

departments initiating all the projects. However, at the Åbo Akademi University, the 'ILO function' has become one of wholly managing EU projects, identifying sources of finance and completing application forms. Therefore, with the globalisation and 'Europisation' of many research activities (and the subsequent complications in the administration of contracts and the apply procedure of external finance), this function acts increasingly as an advisor for the new contracts and evaluating the correct marketing strategy for the university. This is particularly advanced at the University of Oulu in Finland, where the Research Services Unit (acting effectively as the ILO) promotes research activities by obtaining and delivering information and creating contacts between researchers, financiers, and the end-users of the results. There, the emphasis is on the European Union co-operative research and development of financing, and users of the services offered by the Research Services Unit include not only the researchers of the University of Oulu, but also external enterprises and other organisations.

The model of departmental-led responsibility for direct contact with industry is also found in Portugal. The difference between the Portuguese and the Finnish approach is that the Portuguese model relies mainly on departmental or research unit led initiatives, supported by various interface organisations that can be either within the university or externally-based. As a result, the 'industrial liaison office' does not really exist. Within Portugal, the main difference between the universities studied in terms of their industrial liaison activities is related to the development of a coherent academic-industry strategy³⁷.

For example, at the University of Aveiro, the establishment of linkages with industry has one of the most influential driving forces behind the growth of institution since its creation in 1973. Indeed, the University of Aveiro is the only university within the Portuguese study where a written strategic policy of reinforcement of linkages with society has become available. The identification of existing barriers and opportunities for university-industry co-operation led to the recognition of the need for a coherent policy framework to foster the linkages with industry. However, this has tended to be largely departmental led (as in the majority of Finnish universities) with opportunities generated by the several interface institutions existing in UAV. The advantages of this model are that it is demand-led and has a direct link with the relevant suppliers of technology. The interface organisations can access the individual departments' expertise directly when required. In addition, there can also be wider scope for direct co-operation between departments, hence facilitating the development of a global and strategic approach on university-industry linkages.

Whilst there is evidence of university-industry linkages within the other two universities studied in Portugal - Trás-os-Montes e Alto Douro and Porto - the lack of any coherent strategy has led to industrial linkages being dominated largely by a variety interface organisations. For example, at the University of Porto, there is a long established practice of interaction with industry. However, the autonomy of a large number of interface and research units - over 50 - has led to serious difficulties to the development of a global policy towards co-operation with industry. Similarly, at the University of Trás-os-Montes e Alto Douro, there is a deliberate policy towards the promotion of linkages with society, although it should be considered as a statement of the willingness to co-operate rather than a strategic, organisational or practical guide. There is no industrial liaison office and as a result, there is no strategy to indicate how industrial linkages are developed. Therefore, at the moment, this is a task that is performed either by each department or, in some cases, by the individual initiative of its lecturers/researchers.

³⁷ Simão, J.V. (1994) *Universidade de Aveiro- Desafios e Sociedade*; Instituto De Investigação Da Universidade De Aveiro (1996) *Relatório de Actividades 1995 e Plano de Actividades e Orçamento 1996*

In Northern Ireland (at the time of the study), the ILO system was essentially in limbo, with the liaison function with Queen's University Belfast having been taken over by a private company - QUBIS - which was responsible for developing university spin-off activities. In Ulster University, the function was being completely reorganised and, as such had been left largely to the departments.

In Spain, the development of university-industry linkages has been driven by legislative changes that have enabled academics to work with industry. Currently, the Offices of Research Output Transfer (OTRI) undertake the promotion of contacts and relations between STI infrastructure and public/private organisations, and each university in Spain will have an OTRI attached to it. As such, the presence of a centrally planned liaison function has negated the drive for such a function to be created within individual institutions. However, whilst the specific activities of OTRI is linked to the Spanish National Plan of R&D, their functions can differ according to the university where they are located. Therefore, as with Portugal (and, to some extent, Finland), there is no actual industrial liaison office within the different universities, although some of the traditional functions of this organisation are carried out by OTRI and other bodies.

For example, in the University of the Basque Country, there are two organisations that could be considered as undertaking the role of the industrial liaison office - Euskoiker and the OTRI. Euskoiker was established in 1979 as an intermediary institution between the University of the Basque Country and Basque enterprises, with the sole aim of strengthening the relationship between academia and local industry. On the other hand, the OTRI was created in 1989, and belongs to the network of offices promoted by the National Plan of R&D. Its main function is the management of specific contracts that the university has with various enterprises, although it also acts as an information point for outside enquiries. It does not carry out a number of the other 'traditional' roles of the ILO function, such as making presentations, research marketing, publishing theses abstracts, science park management, facilitating spin-off firms or the administration of other ILO services. Similarly, the role of the OTRI in Galicia is that of administration rather than the promotion of collaboration with industry, with the provision of information on European funding being the most widely utilised instruments to build and establish relationships with the industry. As with the other two universities in Spain, the University Carlos III of Madrid does not have a specific policy towards university-industry relationships, with the OTRI being responsible for activities such as the management of research and funding opportunities, although it is aiming at increasing its links with industry.

Therefore, in all of the universities studied, the general mission of the ILO function within the university is broadly similar, namely to devise and increase the links between the university and external organisations. However the interviews revealed significant differences between the organisation of these functions within the various countries. Whilst the organisational forms differ across the countries, the main role of the ILO function in Northern Ireland, Ireland, Wales, Portugal, Spain and the majority of Finnish universities is contract management and the promotion and marketing of university expertise. As such, they were perceived as mostly reactive, administrative and, to a certain extent, undertaking promotional functions. On the other hand, the majority of the ILOs in Sweden (and the University of Oulu in Finland) were more proactive in working with industry to widen the scope of their research results and to create new businesses and employment. The evidence suggests that this difference tends to be dependent on the maturity of the individual university's stage of development in academic-industry relationships.

It must be emphasised, however, that nearly all of the universities in the study are in the process of, or are going through, a metamorphosis of slowly changing the role of the ILO from that of

an administrative officer within the university, to a more strategic position within the organisation. In particular, there is clear evidence that both Welsh and Irish universities are slowly moving towards a more proactive model. For example, the Programmes in Advanced Technologies in the Republic of Ireland are organisations within the ILO with their own administration and sectoral responsibilities. As a further result, there may be further delegation in the future to specialists within Irish universities. Similarly, Welsh academics reported that the last five years have shown improvement with respect to the efficiency and effectiveness of services on offer and there is an expectation of greater involvement in the proactive functions, such as research marketing, facilitating spin-off firms and building information systems in the near future.

However, at the moment, the tendency within the university sector in both Ireland and Wales is to have one central organisation that has responsibility for undertaking technology transfer activities, which can range from the provision of patenting advice to helping academics start up their own business. This is very different to the situation in Sweden, where the advanced nature of the technology transfer links has led to a decentralised structure. One central office acts as the referral point to other specialised technology transfer units (such as a patenting officer or spin-off unit) or directly to university departments. As a result, this office is not itself involved directly in any specific technology transfer tasks but acts as a facilitator for departments.

3.3.3b The functions of the industrial liaison office

As a result of the different organisational forms developed by the universities in various countries for industrial liaison, there were considerable differences in the actual technology transfer functions undertaken by these organisations, which reflected their perceived role within the academic institution. The evidence from the study suggests within countries such as Spain, Portugal and Finland, where the ILO is not formalised internally within the university, basic tasks such as responding to outside enquiries, acting as an information point and the administration of research contracts, tend to be the main functions undertaken. However, as the role becomes more formalised, such as in Oulu (Finland) and University Carlos III of Madrid (Spain) and the University of Aveiro (Portugal), then higher level tasks are undertaken. These include the marketing of the university and the industrial liaison function (both internally within the university and externally to companies and other interested partners); building information systems such as Internet home pages, and provision of EU grant information.

In countries such as Wales and Ireland, where the ILO function is an integral part of the university administrative system, there may be higher level tasks undertaken, as the ILO becomes essentially a stand-alone department. These include the development of directories of technological expertise and establishment of databases, and additional non-research activities, including continuing education, distance learning, co-operative education and work placements (including academics visiting industry), and international bench-marking. In some cases, the ILO may become involved in patenting advice (as experienced in the Universities of Cardiff and Limerick). However, paradoxically perhaps, the more advanced the ILO function becomes, as in a number of Swedish universities, the greater the delegation of these duties to individual departments or new specific units. For example, 'research marketing', which includes providing information about research projects, was undertaken in Sweden either at departmental level or, in some cases, by the university's central information department. This probably reflects the move from an 'entrepreneurial' style of university management to a more 'professional'

With regard to the facilitation of spin-off firms from the universities, the majority of the ILOs interviewed in Wales, Ireland, Northern Ireland and Sweden were involved with assisting

academics wishing to start-up businesses, although less so in Spain, Portugal and Finland, where external organisations were largely responsible for this work. This type of support was undertaken through innovation centres or provision of incubation units, although there is a higher degree of sophistication of such programmes in Sweden, which include growth-specific entrepreneurship programmes and finance/training packages tailored to the needs of technology-based small firms by the ILO offices. A number of industrial liaison functions were not carried out in the countries studied. These included the publishing of thesis abstracts, which tended to be left to individual departments. In addition, science parks near to university campuses tended to be managed by external organisations (although there were a couple of exceptions), which were usually responsible for contacts with Government, administration and financial support. However, it was common to have a well-developed structure of collaboration between the ILO and the management of the Science Park, especially with regard to support to spin-off companies and entrepreneurial programmes³⁸.

Given this, it is surprising to find that only a small number of the universities were working actively to develop links with local small firms. In Sweden and Finland, most of the funding for industrial research is generated from collaborative research with larger firms. However, the majority of universities also have a strategy of working closely with high technology SMEs. This is quite different to Northern Ireland, Wales and the Republic of Ireland, where technology transfer is undertaken predominantly with larger organisations.

In Wales, institutional links tend to be established with larger firms primarily based outside of Wales, whilst Irish universities tend to concentrate their activities in serving the branch plants of larger foreign companies (which generally do not have a facility for R&D within Ireland). In Northern Ireland, the universities are closely linked with large local firms such as Shorts Aerospace, DuPont (plastics), Seagate (electronics) and Nortel (telecommunications), which tend to provide funding for fundamental high-technology university research. However, smaller firms are linked with the universities via initiatives such as the Teaching Company Scheme (see later). In Spain and Portugal, both large and small firms are seen as potential partners for R&D and industrial collaboration

³⁸ Klofsten, M., Schärberg, C. and Jones-Evans, D. (1997) *Growing a technopole - a longitudinal study of entrepreneurship and industrial development*. Paper presented at the Regional Studies Association Conference, Frankfurt (Oder), September 20th-23rd.

3.3.3c Direct involvement of the university with industry

The main types of activities in which universities become directly involved are:

- Research funding
- Sponsorship or Endowment of chairs
- Sponsorship of research centres
- Sponsorship of researchers
- Training partnerships
- Technical services contracts

It is not surprising that links such as research funding and sponsorship of chairs, research centres and researchers are to be found in nearly of the universities studied. Such links are the traditional methods by which universities and industrial organisations have become involved in the development of co-operative research and development activities³⁹. Training partnerships with firms are also present in the majority of universities studied, which reflects the industrial content of many science and engineering courses within these institutions. Indeed, there is very little difference among the regions examined in terms of access to resources and relationship with industry. However, one notable exception is the with regard to the establishment of ‘industry clubs’ involving organised networking activities as well as a focus for management activities and support from the university to industry⁴⁰. This practice was most important within Swedish universities than any other country examined. However, this may be due to networking being an important part of business culture within Scandinavian countries⁴¹, with little evidence of such activities among firms in the Republic of Ireland⁴² and Wales. Other university links with industry included training programmes for companies, discussion seminars with entrepreneurs, co-operation with science parks and work placements.

3.3.3d Benefits to the university from industrial collaboration

The two main benefits perceived by the ILOs in working closely with industry were broadly similar in all the countries:

- it was accepted that an increase in collaboration activities would result in greater funding for research from industry. This, in turn, would lead to better teaching and research facilities, as well as access to new ideas, techniques and the development of specific research initiatives within industrial firms. In addition, it was believed that the widening of the scope of academic activities would result in the university being able to make a greater and more relevant contribution to the economic needs of the region.
- it was felt that closer collaboration with firms gave researchers the opportunity to focus on real-world problems and to broaden the researchers’ experience. In particular, close partnership with industry can also add to the quality of research, especially through feedback on the applicability of research results. This is because firms, as customers, play

³⁹ Bower, D.J. (1992) *Company and campus partnership - supporting technology transfer*, Routledge, London

⁴⁰ Klofsten, M. and Jones-Evans, D. (1996), “Stimulation of Technology-Based Small Firms - A Case Study of University-Industry Co-operation”, *Technovation*, Vol. 16, No. 4, pp. 187-193.

⁴¹ Johannisson, B. and Peterson, R. (1984) *The personal networks of entrepreneurs*. Paper presented at the Third Canadian Conference, International Council for Small Business, Toronto, 23rd-25th May.

⁴² O’Gorman, C. (1997) *The Irish Software Sector*, University College Dublin, Dublin; Jones-Evans, D. (1996) “Small firms, universities and technological development in a peripheral economy - the case of the Republic of Ireland”. In Fynes, B. and Ennis, S. (eds.), *Competing from the Periphery*, Oak Tree Press, Dublin, pp. 241-270.

the role of "efficient testing instruments", and can be used to reveal the relevant research areas that are of interest to the industry. These experiences can, in turn, be exploited for learning opportunities for both students and researchers.

Therefore, the main benefits of links with industry have been that an increase in funds has resulted in high-technology equipment, skilled teaching and top class training that is used to solve 'real' industrial problems.

3.3.3e Barriers to further collaboration with industry.

Overall, the general barriers for universities to develop increased collaborative links with industry were:

- lack of internal resources (especially time from normal academic duties)
- differences in culture between academia and industry
- lack of a reward system for academics involved in collaborative projects

The majority of universities considered that there were problems with resources at both an individual and institutional level. On an individual level, academic staff have increasingly less time to both establish and undertake collaborative projects with industry in addition to their teaching and administrative duties for the University. In addition, the continued emphasis on traditional outputs for academic work, such as publications, has meant that collaborative industrial R&D is not valued, except as a source of income. This is especially the case in the UK, where the Research Assessment Exercise - based on peer review via publications - does not currently place any significant importance on industrial research. As this assessment affects subsequent funding opportunities, pursuing industrial contracts could indirectly affect the funding received from the non-industrial sources. As a result, any additional entrepreneurial activities were not rewarded. Similarly in Spain, the priority within the university, especially in terms of promotion within the system, is related to excellence in basic research. Therefore, there is a distinct lack of motivation to undertake applied research or technology development activities related to firms. Indeed, the general lack of academic recognition for commercialisation and rewards for publications, as opposed to patents, had been a major barrier in many countries. As a result, many academics have been faced with the dilemma of either publishing their results for short-term revenue and academic recognition or withholding them until they are patented, with the risk of the technology becoming obsolete. In Sweden, the government has taken the previously unprecedented step of giving equal priority with teaching and research, within the university sector, to the 'third task' of commercialisation of R&D.

On an institutional level, it was considered that there was not enough emphasis, especially in terms of internal funding within the university, to sufficiently develop linkages with industry. For example, one of the factors constraining a Welsh university was the lack of resources available to help identify the needs of industrial opportunities and to promote both the funding of these opportunities and of University expertise to local SMEs. In Spain and Portugal, there was a considerable lack of any finance to promote the development of new entrepreneurial initiatives linked to the university's R&D results. This was especially in relation to the lack of a proper infrastructure for developing academic-industry collaborative activities, especially in the marketing of research expertise. It was felt that universities were not, in general, proactive enough, and there were not enough promotional activities to ensure businesses' awareness of the expertise available.

In Ireland, the lack of financial resources and property for expansion was a major barrier to the development of industrial liaison activities. This is despite recommendations in the Science Technology and Innovation Advisory Council report⁴³, which proposed that all state sector and third level institutions involved in research or technological development should devote sufficient resources to a specific function for technology transfer. In particular, this should be aimed at identifying those firms that can benefit from currently available technology. Similarly in Spain, the OTRI network was established to encourage the transfer of technology to industry although there were still considerable problems with this system, despite being a national initiative. One of the solutions to the problems of lack of resources would be a programme of action, and not rhetoric, that would provide guidelines for industry to work with universities i.e. more of a stated policy as opposed to the current ethos of endorsement without incentives.

Another major problem in increasing the collaboration between academia and industry, in all countries, was the difference in the organisational and institutional cultures of universities and industrial firms. In many cases, this was due a lack of appreciation of the differences, by universities in the development of academic research as opposed to industrial research, especially in terms of time conception, priorities and bureaucracy. Industrial firms need to ensure that any R&D project is disseminated from the laboratory to reach the market place quickly. Therefore, when collaboration takes place with the university sector, firms require academic researchers who are able to work to commercial timescales. In many cases, this is an irreconcilable obstacle, because academics are not used to work under pressure and to specific timescales. Many firms also expect a particular R&D problem to be solved quickly, whereas many academic institutions would take a considerable period, as in a research project, to examine the problem and come up with a range of solutions. Therefore, universities tend to follow a model of action which is directed from supply to demand side whilst many enterprises, on the contrary, function according to a model directed from demand to supply side. This contradiction can prevent the improvement and reinforcement of co-operation between industry and academia.

There can also be a gap in the priorities of each partner relative to the research results produced from collaborative projects. Whilst firms require research results either to be patented or, in some cases, to be kept confidential, the career structure of academia, based on published works, requires that the collaborative R&D is placed within a scientific journal. Therefore, links with industry can, in some cases, restrict the free flow of information between academics and institutions⁴⁴. As a result, the impression existed, within both countries, that the lack of academic recognition for commercialisation, and rewards for publications as opposed to patents, was a major barrier. Finally, universities, are, by their nature as large public-sector organisations, are bureaucratic. As a result, many smaller firms can have problems in dealing with the labyrinthine procedures of the academic institution.

There can also be a problem with academics themselves, according to the ILOs questioned. Many suggested that universities are not traditionally viewed as leaders in entrepreneurship⁴⁵. Indeed, it has been indicated that many academics are concerned that research collaboration with industry is against the central ethics of universities, which should concentrate on fundamental research and the education of students. This seems to be particularly pronounced, according to the interviews, within Portugal and Spain. For example, it was felt perceived,

⁴³ STIAC (1995) *Making Knowledge Work for us - a strategic view of science, technology and innovation in Ireland*, Stationery Office, Dublin.

⁴⁴ Charles, D. and Howells, J. (1992) *Technology transfer in Europe: public and private networks*, Belhaven Press, London

⁴⁵ Louis, K.S., Blumenthal, D., Gluck, M.E. and Stoto, M.A. (1989) "Entrepreneurs in Academe - an exploration of behaviours among life scientists," *Administrative Science Quarterly*, Vol. 34, pp. 110-131.

within a number of the Spanish institutions, that it was not the responsibility of the university to answer to the short time problems of the firms, with academics concentrating mainly on teaching, with only some research undertaken.

There was also some concern that the future direction of university research could be controlled directly by industry. This would diminish the ethos of a freethinking university and undermine the importance of basic research and under-graduate teaching. There was also worry that the end result of collaboration could be short-term contracts in which industry would require 'quick and dirty' solutions to problems, with the result that any collaborative work would lack depth, lessens staff motivation and restricts the development of new ideas. In effect, university departments would merely be acting as extensions to the research activities of firms. Indeed, a number of ILOs indicated that future policies might be required to avoid such exploitation. However, overall, it was generally accepted that there would be more benefits than disadvantages from this relationship.

Universities were not always the problem in developing a collaborative culture with industry. There was an underlying theme, throughout the interviews, that the clash of different cultures was also due, in part, to the attitude of business (especially smaller firms) towards academic institutions. Whilst the universities had an open door policy to co-operate and work with all types of industry, industry's perception was rather dependent on the type of industry and the nature of the link with the university. In particular, the 'ivory tower' stereotype of academics - as inefficient, out of touch with the real world and impractical - was found by the ILOs to exist in many firms. This was particularly the case in low technology SMEs, where the owner-managers tended not to have any previous experience of academia. This tended to lead to a lack of trust in the ability of academics to perform tasks efficiently and to a pre-determined time-schedule.

Within some of the rural universities, it was suggested that the low activity within the immediate locality could result in considerable problems in developing funding opportunities for collaborative research. This applied not only to Spain and Portugal but also to more developed universities in Wales and Ireland. In some of the more remote rural areas, the existing infrastructure does not encourage the development of co-operation between researchers and firms.

In the more advanced system of academic-industry collaboration in Sweden, it was considered that the main barriers to working with industry within Swedish universities were related to improving the efficiency of the existing system of collaboration. For example, it was indicated that industries were generally unable to provide problems that were of direct interest to many academic departments. Some firms also did not understand the services that were offered by the university. However, as in the less sophisticated systems in Spain and Portugal (and, indeed, elsewhere) universities could, and must, market their services better, and be more sympathetic towards the potential clients. Even within this system, it was felt that incentives for working with industry had been poor compared with incentives for research or teaching activities.

3.4. CASES OF UNIVERSITY GOOD PRACTICE.

3.4.1 Introduction

The previous section examined the strategy of the university, through the industrial liaison function, in developing academic-industry linkages. This section will deal with implementation of such linkages, and describe a series of 'good practice' cases, identified by the ILO in each

university, which illustrate the successful development of university-industry linkages through the intervention of the ILO.

3.4.2 Methodology

Semi-structured interviews were conducted with individuals directly responsible for each of the initiatives in order to obtain up-to-date, accurate information. In some cases, the interviews included not only those individuals involved in the management of the initiative, but also those participating. This data was supported by the collection of a wide variety of documents (many of which were provided by the interviewees) illustrating more general information about each initiative, such as brochures, pamphlets, circulars and reports. Attendance at some of the initiatives' activities was also possible and was considered a valuable insight into the working of those initiatives.

The interview instrument for gathering information drew upon Yin⁴⁶ as the main guide for developing a case study history for each of the initiatives. The main themes concentrated on the background to the development of the initiative, the current situation, links existing with industry, the structure of the initiative, and plans for the future. The interview was supported by secondary data, provided by the interviewees, which gave further details of the initiatives.

As table 2 shows, twenty four different 'good practice' initiatives, developed by the university to strengthen academic-industry relationships, were identified. Some of them have similar characteristics. Hence they can be regarded as reflecting eight different approaches which will be outlined in this report. In addition, the nature of those initiatives is strongly linked with the national and/or regional institutional context, the profile of the regional economic fabric and the role that individual agency or higher education institutions (HEI) organisational culture plays in stimulating their emergence and design. The structure of this section of the report will closely follow the ideas expressed above. So, for each country there will be a synthesis focused on the contextual circumstances and on institutional or individual agency followed by a brief characterisation of the initiatives surveyed.

⁴⁶ Yin, R.K (1994) *Case Study Research*, Sage Publications, California

Table No 2.
Classification of university initiatives to encourage academic entrepreneurship.

	Finland	Ireland	Northern Ireland	Portugal	Spain	Sweden	Wales
Innovation Networks	X					X	X
Campus Companies		X	X	X	X	X	X
Enterprise training		X			X	X	
Research contracts							X
Patenting/licensing		X				X	
Career services/Training			X		X		X
Service provision			X	X			
Industrial professorships	X						

3.4.3. An overview of university initiatives

3.4.3a Finland.

The Finnish report includes three different initiatives, one of them promoted by the national government and the other two developed by Universities.

The **WELFARE CLUSTER OF OULU** is a national initiative co-ordinated by the central government. Its general aim is the improvement of the competitiveness of industries, products and services operating in the health and welfare markets, through the set up of a network bringing together the regional welfare system, particularly welfare services providers, research and education institutions and industrial firms. It gathers an interest group involving local universities and research institutes, the Oulu's municipality and several national welfare related organisations. The peripherality of Oulu, combined with its higher than average level of social and health problems, was the main reason behind the direct intervention of the Finnish government.

The **ADJUNCT PROFESSOR INITIATIVE** is one of the methods utilised by the University of Tampere to maintain and deepen its already high level of collaboration with industry (particularly with large firms). It involves the hiring of part-time professors whose main activity is carried out within industries that have an active field of co-operation with the University. There are significant mutual benefits associated with this initiative, since, on the one hand, University profits, in pedagogical terms, of the adjunct professor's experience within industry and, on the other hand, industry has a more effective access to technology developed by University researchers. These benefits can be extended to students' employment (either

during or after the studies), who may profit from the established connections. The adjunct professor initiative is mostly financed by public funding, namely by central government and by the municipality of a coastal city (Pori) located about 150 km from Tampere. Nevertheless, a number of chairs are financed by regional private (large) enterprises.

The **TURKU TECHNOLOGY CENTRE** was established in 1985 to aid the commercialisation of academic research results carried out in three local universities. The strong industrial research tradition existing in Turku area has been the main motivating force for the creation of the Technology Centre. Its construction was financed by private funds and public funding covers its operational costs. Presently, the organisation is a major centre of technology transfer, resulting from R&D activities carried out by about 30 institutes, departments and laboratories of the Universities and by 140 SMEs, some of which are subsidiary companies of larger international firms. The Technology Centre facilitates multidisciplinary work and makes available venture capital, providing also technology transfer support services and microenvironments for large co-operative projects between academic and industrial researchers. One should stress that academic entrepreneurship is still taking the first steps in Turku mainly due to restrictive administrative features.

The initiatives surveyed in Finland are rather different in terms of aims, organisation and functioning. However, they reveal some similar features that should be considered as key issues of their success. On the one hand, the existing tradition of multidisciplinary and co-operative work (i.e. of networking) facilitates the establishment of a favourable environment to develop collaboration between institutional and productive fabrics. On the other hand, the creation of networks is strongly encouraged by public authorities, as shown by the high level of intervention of public powers (both central and local governments) in the studied initiatives. Moreover, these initiatives can be regarded, to a large extent, as a result of public policy, institutional and financial support aimed at the strengthening of linkages between higher education and industry.

3.4.3b The Republic of Ireland

The Irish report outlines four different initiatives, three of which promoted by Universities and the fourth established by a State development agency.

The Trinity College of Dublin (TCD) set up in 1986 what would become an emblematic initiative, the **TCD INNOVATION CENTRE**. The emergence and consolidation of this initiative owes much both to the initial support of the Irish Development Agency and to the individual commitment of three members of University's staff with high administrative responsibilities. In short, the Innovation Centre accommodated campus companies providing logistic support, accessibility to both information and research available in TCD and entrepreneurship training.

The **CAMPUS COMPANY DEVELOPMENT PROGRAMME (CCDP)** was established in 1996 jointly by the University College Dublin (UCD) and the Dublin Business Innovation Centre (DBIC), as a means to reinforce the relationships that the two institutions had been developing for some time. It is basically an entrepreneurship training programme directed to what is regarded as a small but strategically relevant number of (knowledge-intensive) firms with specific technological and business requirements.

The **PATENTS AND LICENSING POLICY** developed by the University College of Cork (UCC) was an attempt to encourage academic to commercialise their R&D results. This

initiative was began by an industrial liaison office (ILO) with very little support from University or individual partners. According to information available, the lack of resources as well as of sensitivity from the University to academic entrepreneurship prevented a more ambitious approach to foster University-Industry links. Despite the relative success of the programme in financial terms, its future seems jeopardised by a certain degree of ambiguity associated with the role of ILO.

A university did not establish the fourth initiative, **THE CAMPUS COMPANIES PROGRAMME**. Instead, it was developed instead by a State development organisation - FORBAIRT. Nevertheless, it aims to support academics and entrepreneurs in college campus by providing advice and, mainly, financial support to the commercialisation of R&D results. Apart from the latter activity, few co-operation links are established with Universities' policies.

The most successful initiatives surveyed in Ireland are rooted in the recognition of the need to stimulate the emergence of locally based firms to retain qualified labour force together with the belief that HEI can play a decisive role to attain such objective by means of their R&D activities, human resources and educational programmes. These initiatives illustrate how the existence of a diversified institutional fabric, having a shared perception of development problems and resources to support initiatives, often combined with individual agency, can lead to success stories of attitudinal change within organisations with long established cultural patterns. This contextual situation cannot be extrapolated to all the HEI as shown by the Patent Programme of UCC. Furthermore, the FORBAIRT Programme indicates that there is still room for improvement in building up institutional capacity.

3.4.3c Northern Ireland

Two initiatives were analysed in Northern Ireland, one of them promoted by a University and the other by a national government scheme.

QUBIS LTD. is a private company set up in 1984 at Queen's University Belfast to exploit commercially the R&D activity carried out by university staff. Its main aim is to provide venture capital to high quality projects endowed with a clear commercialisation potential. The initiative helps the creation of new firms whose ownership is shared with established private companies, in order to complement academic technical and innovative capacity with commercial and marketing skills. The University and local business agents share company management. The high level of success achieved, expressed by the fact that none of the companies has failed so far, is regarded as closely linked to the involvement of local experienced industrialists in Qubis Ltd. management board. The initiative is considered as a good investment for the University namely in what concerns its prestige and public visibility inherent to the acknowledgement of the contribution given to local economic development. One should stress that conversely to other high-tech small firms in Northern Ireland, the turnover of the fourteen companies created in the framework of Qubis is sourced almost totally (90%) from outside the region. More than a half of the partners of those companies are based outside Northern Ireland.

The **TEACHING COMPANY SCHEME (TCS)** - is a national government initiative to support partnerships between companies and the science, engineering and technology base (mainly Universities), which enables firms to improve their innovative and competitive capacity. The scheme supports industry-based training, supervised jointly by academic and industrial staff, for young graduates, and academic research and training in industry relevant domains. In Northern Ireland, TCS is developed in association with the Queen's University of

Belfast and University of Ulster. The initiative in the region has been more successful than the rest of the United Kingdom, partly because the regional government has allocated additional funds to it. The recent developments in TCS strategies, focusing support schemes on firms with less than 200 employees, are regarded as a potential benefit for the region, in which SMEs are predominant.

The initiatives surveyed in Northern Ireland result mainly from the combination of a long established practice in universities of working with industry and an effective translation of national designed policies encouraging co-operative activities to regional reality. This may be illustrated by the purposeful and efficient use of a national scheme (TCS) aimed at the consolidation of co-operative dynamics between academic and productive spheres.

3.4.3d Portugal

The university sector developed all the initiatives surveyed in Portugal. The **INCUBATOR** created by the University of Aveiro in 1997, is a campus company development scheme that is regarded as a means to promote self-employment of recent graduates and to bring university resources closer to the regional productive fabric. It includes a previous entrepreneurship training action after selection of applicants, and provides shared facilities. The establishment of this initiative is closely linked with the policy developed by University of Aveiro towards the reinforcement of linkages with society in general and with the productive fabric in particular.

IDAD (Instituto do Ambiente e Desenvolvimento/Institute of Environment and Development) is a non-profit interface institution established in the University of Aveiro in 1993. It is aimed at the provision of consultancy and services to private and public organisations within the environmental, natural resources and spatial planning domains. One can argue that the creation of IDAD was, to a large extent, a result of the high sensitivity of teaching staff of University's Department of Environment and Planning in relation to co-operation with external agents. In addition, the significant growth of the demand for environmental service provision and the established policy in the University to promote the links with industry were important factors. The initiative benefits from a deep-rooted tradition of multidisciplinary work existing in University of Aveiro.

INEGI (Instituto de Engenharia Mecânica e Gestão Industrial/Institute of Mechanical Engineering and Industrial Management) is an interface institution established in University of Porto (UP) in 1986. Its general aim is to strengthen the linkages between UP (mechanics area) and industry, developing three different types of activities: service and consultancy provision, training programmes and technology transfer. As the majority of similar initiatives in UP, INEGI has a high level of autonomy both in terms of financing and management. One can argue that the involvement of several members of Faculty of Engineering's teaching staff in INEGI's activities may be regarded as being the most evident link with UP.

THE VETERINARY CLINIC of the University of Trás-os-Montes e Alto Douro (UTAD) was established in 1992 as a means to provide the veterinary students with effective practical training. There is a clear relationship between educational/pedagogical activities and the veterinary services provided, since students participate directly in almost all the clinical operations. Farmers and indeed any member of the community can resort to the services of the Clinic almost free of charge. Co-operation with firms producing pharmaceutical and animal-feeding products is a new field of co-operation that is starting to be exploited.

ITIDAI (Instituto de Trás-os-Montes para a Investigação e Desenvolvimento Industrial/Institute of Trás-os-Montes for Agro-Industrial Research and Development) is a non-profit association which assumes the role of an interface institution between UTAD and the regional social and economic fabric. Among its general objectives, technology and knowledge transfer and training provision are the main focus. Established in 1989, the initiative has not yet achieve its main objectives. This may result, to a significant extent, from the weakness of the regional productive fabric. Currently, it develops its activity under a research contract framework in the fields of energy and natural resources management, having as main partners regional and local public institutions.

The case studies carried out in Portugal reinforce the perception that regional characteristics combined with historical, cultural and organisational aspects of the universities strongly affect the developed forms of interaction between academia and society. Within a common framework that makes evident the willingness to foster co-operation with society, the Portuguese “good practice” initiatives surveyed are very different in terms of objectives and functioning. The initiatives can be divided into those which are and are not partially or fully integrated in deliberate policies. They therefore give strategic and practical guidance or state only a general willingness for interactions. One should stress that in Portugal, conversely to what happens in the other studied countries, the level of intervention of public authorities is rather low. Portuguese universities, in what concerns the development of initiatives to foster linkages between higher education and society, are acting alone.

3.4.3e Spain

The Spanish report includes three initiatives, a first one promoted by a private higher education institution, a second one by a public University and, finally, a third one developed by an University in collaboration with a manufacturing association.

SAIOLAN was created by the Polytechnic School of Mondragon in 1985, in collaboration with the Basque government and the provincial delegation of Guipuzcoa. Its main aim is the creation of new entrepreneurial activities, through information, formation, R&D and advise provision, and its target groups are potential entrepreneurs working within the University and SMEs (mainly firms belonging to the Mondragon Co-operative Corporation- MCC) willing to extend or diversify their activities. The creation, development and success of SAIOLAN are closely linked to the particular environment provided by the synergy build on the MCC. In 1992, SAIOLAN obtained its own legal entity, functioning as an autonomous unit within MCC. The main impact of SAIOLAN is connected with the diversification of business activities rather than with the set up of new firms. The importance of the role played by SAIOLAN is recognised by both the regional and provincial governments, which still are its main financing source. The relatively large dependence upon governmental funding is regarded as a potential factor of change in what concerns aims and strategies, as a decrease in public financial support may imply an increased focus on service provision to Mondragon co-operative firms.

THE PEDRO JUAN DE LASTANOSA INSTITUTE was established in 1995 by a group of researchers of the University Carlos III, Madrid, aiming to contribute to improve the social and economic environment of a declining industrial area. It provides innovation support to firms and training to unemployed people. The initiative was gradually developed according to a well-structured path: acknowledgement of potential demand, awareness increase and action definition. Despite the full integration within the university structure, the main financial resources are due to external sources (training courses and technological services). The Institute has a close relationship with the university's ILO. However, this relationship is focused on

information and legal/financial advice provision rather than on the barriers that are raised by the target firms' low innovative culture and technological level.

THE INSTITUTE OF CERAMICS was created in 1990 and is based on a partnership between the University of Santiago de Compostela and a ceramic manufacturers association (AFICEGA), supported by the Galician regional government. It is the outcome of a combination between the high level of expertise available in the university and the willingness of firms towards the improvement of their innovative capacity. This kind of initiative, revealing a strong institutional co-operative effort of public and private spheres, is rather unique in Spain. The Institute develops R&D projects and educational and training actions and provides direct services to firms. It should be noticed that the whole activities are promoted according to explicitly stated industry needs.

The initiatives studied in Spain are very different in what concerns their aims, functioning and, mainly, their reasons for establishment. These differences are rooted in particular regional economic, social, cultural and organisational contexts. Two of the surveyed initiatives clearly illustrate the strength and pro-activity of the regional level of government in Spain. The role of higher education as an agent of social and economic development seems to be fully acknowledged both by regional public authorities and academia.

3.4.3f Sweden

The Swedish report presents three initiatives, one of which resulting from a partnership between industry and an university, another one from individual agency and the third one promoted by a partnership between university, public authorities and industry.

The first initiative analyses the relationships established between the **CENTRE FOR INNOVATION AND ENTREPRENEURSHIP (CIE)** of the University of Linköping and **SMIL**, a local association of small technology-based firms. It reflects the recognition of the need for stimulating both creation and growth of knowledge-intensive type of firms as an essential factor to foster an effective and mutually benefiting connection between universities and industry. The main activities developed by CIE/SMIL may be divided into the promotion of new businesses establishment, the updating of business expertise of already established firms and the promotion of social networking activities and exchange of information between firms belonging to SMIL. The success attained by the CIE-SMIL initiative, particularly in what concerns spin-off based firm birth and development and networking promotion, can be regarded as strongly connected with the innovation supportive environment existing in Linköping region. The favourable environment stems, on the one hand, from the existence of a number of high-technology large firms and, on the other hand, from the synergies which have been developed within local University between business stimulation, R&D and educational activities.

The **FORSKARPATENT** is a patent and licensing service provision firm created in 1994. Its aim is to bring structure and time-effectiveness to the commercialisation of R&D results obtained in University of Linköping, exploiting new knowledge in the form of patents, know-how and other intellectual property rights for trade and industry commercially. An important feature of Forskarpatent concerns the support that it gives to University researchers (generally lacking of business experience) in terms of legal and commercial procedures. The launching of this initiative was closely related with the individual commitment of a local inventor and entrepreneur and of a University professor. Moreover, its development may be related to the nationwide favourable environment fostered by central government in the 90's, namely by the

legal framework recognising the importance of higher education-industry co-operation (e.g. giving to Universities the right to own holding-companies for research). The holding company of the University of Linköping and a Technology Bridge Foundation share equally the proprietorship of Forskarpatent.

The **UNITEK** project is promoted by Uminova Centre (the industrial liaison office of Umeå University), an interface institution promoted by the university, regional and local public authorities and by the chamber of commerce. The initiative aims to facilitate contacts between industry and local academia, diminishing the cultural gap existing between academics and industrialists in a peripheral area of Sweden characterised by a predominance of low-technology based small dimensioned firms. Its general goal is pursued through three different activities: the placement of under and post-graduate students in regional firms, the development of information networks and the promotion of marketing. Ten municipalities of the region are actively involved in the initiative, both in terms of management and financing, as well as in terms of selection of potential firms to participate in the project.

The initiatives studied in Sweden are aimed at the technology and knowledge transfer and at industrial development on a basis of a close co-operation between universities and industry. On the one hand, regional social and economic characteristics favour the development of co-operation activities between academia and industry and, on the other hand, are considered as an essential basis to define the conceptual and organisational framework which guides those activities. The Swedish cases reveal a supportive attitude of central government, both in terms of policy and financing, and, particularly in one of the studied cases, of local authorities, which are directly involved in co-operation activities.

3.4.3g Wales

The Welsh survey includes five initiatives, three of which developed either alone or in partnership with other institutions by the University of Wales, Cardiff, one by the University of Wales, Bangor, and the fifth initiative, targeted to Welsh HEIs, promoted by a state funded organisation.

The **CARDIFF UNIVERSITY INNOVATION NETWORK (CUIN)** was created in 1996. It aimed at establishing links between the increasingly important SME sector in Wales and the University of Wales, Cardiff. A Welsh Office report produced in 1995 provides the backcloth to the initiative which also lived from the influence of a newly appointment of a Vice-chancellor. In addition to a gateway role to University resources, the network main activity relies on the organisation of meetings between University staff and firm's owners or managers. These meetings are held informally on topics jointly defined by the University and the networked firms. As a result, they are not only informative but also provide the opportunity to set in motion a process of acquaintance and shared perceptions of opportunities, constraints and professional requirements of both academic and entrepreneurial worlds. i.e. contributing to bridge a cultural gap which is seen as hampering a more effective economic development in Wales.

The **CARDIFF UNIVERSITY CAREERS SERVICE** is a set of initiatives through which University interacts with Welsh based firms. These aim, on the one hand, to make firms more aware of the potential that can be gained by recruiting a graduate from the University and, on the other hand, to prepare graduates to work effectively on the small firms environment. The perception of the need to pursue these objectives was reinforced by a study prepared by the Welsh Development Agency which highlighted the fact that SMEs tend not to recruit graduates

and, simultaneously, that graduates are often unaware of the opportunities offered by SMEs. As a follow-up of this study a special programme was created for Wales, in addition to which Cardiff University also develops its own initiatives. The joint funding of short-term placements and the organisation of specific training programmes, as well as information management, are among the main activities within the scope of these initiatives.

The **CARDIFF MEDICENTRE** is basically a campus company programme jointly developed by the University of Wales College of Medicine and several other national and local institutions. The firms located in this centre benefit from an easier access to the expertise available at the University, providing at the same time an opportunity for academics to commercially explore their work. The recent growth in the number of companies in the healthcare sector and the recognition of the benefits that could accrue to the Welsh economy from establishing Cardiff as a prestigious location for high-technology firms in this sector underpins the emergence of this multi-institutional joint-venture.

Established in 1989, the **BIOCOMPOSITES CENTRE** is a self-financing contract research centre on the processing of wood and plant materials affiliated to the University of Wales, Bangor. The Centre, developed by high-qualified scientists, is located on the University College campus, having internal access to University facilities and specialist knowledge/expertise. It enjoys a high degree of financial and managerial autonomy which avoids bureaucratic and cumbersome administrative procedures and facilitates timely and efficient response to the industry needs. The contract research projects developed in this Centre are primarily the result of Centre's pro-activity. There is a recognition that although the Welsh Development Agency financed its creation, multinational companies based outside Wales dominate current portfolio. As a result, efforts are being developed to increase the links with the Welsh economy.

The recent developments in the Welsh economy are encompassing the initiatives aimed at the reinforcement of higher education- industry linkages, namely in what concerns the increasing importance of SME sector. The need for institutional networking development is recognised both by universities and by public institutions as a means to foster Welsh based firms' competitiveness, either in terms of technology or of qualified workforce transfer. One can argue that the surveyed initiatives result to a large extent from a combined effect of an overall favourable policy framework providing funding schemes and of a pro-active university environment (institutional and, in some cases, based on individual agency).

3.5. A SURVEY OF ACADEMIC ENTREPRENEURSHIP

3.5.1 Introduction

To date, the focus of the project has concentrate on examining describing the infrastructural reforms and institutional innovations that promote a culture of entrepreneurship within the institution. As we have seen these can include industrial liaison offices to support linkages between academia and industry, other initiatives such as science parks and technopoles⁴⁷ and specific university organisations to develop the growth of technology-based spin-off firms⁴⁸.

There has been very little examination of the individual academic and the different types of entrepreneurial activities s/he can undertake to develop linkages with industry. Indeed, previous research into academic entrepreneurship has tended to equate such an activity with the creation and development of a new organisation, commonly known as the academic or technology-based spin-off⁴⁹. However, the spin-off phenomenon may be only one type of academic entrepreneurship. For example, some US researchers did suggest that in addition to spin-off firms, there are differing degrees of academic entrepreneurship, which are distinguished by the amount of external contact with industry⁵⁰. From previous research and the literature, we have identified eight specific types of academic entrepreneurship (table 3).

Such activities are outside the normally accepted duties of academics, which are recognised by educational establishments in many countries as teaching and personal research. As such, any activity outside of these two areas of academic work could be termed as 'entrepreneurial'. However, as stated earlier, it is worth noting that the Swedish Government has recently declared that the activity of collaborative research with industry should be classed as having equal status with teaching and basic research.

3.5.2. Methodology

A questionnaire survey was administered during the Summer and early Autumn of 1997 to all researchers and teachers at the faculties of Science, Engineering and Medicine in three regions in each country. In Wales, Ireland and Northern Ireland, the questionnaire (see appendix) was mailed. In the case of Finland and Sweden and partly in Spain, the questionnaire was sent by e-mail, or by post where the e-mail systems were insufficient. The team in Portugal made their study by phone, as it was difficult to get people to answer the questionnaire. Due to lack of

⁴⁷ Saxenian, A. (1994) *Regional Advantage - culture and competition in Silicon valley and Route 128*, Harvard University Press, London.; Segal, N. (1986), "Universities and technological entrepreneurship in Britain - some applications from the Cambridge Phenomenon", *Technovation*, Vol. 4 pp. 189-204;

⁴⁸ Tödtling, F. (1994), "Regional networks of high-technology firms – the case of the Greater Boston region", *Technovation*, Vol. 14, No. 5, pp. 323-343; Smilor, R.W., Kozmetsky, G. and Gibson, D.V. (1988) *Creating the technopolis - linking technology commercialization and economic development*, Ballinger Publishing Company, Cambridge, Massachusetts.

⁴⁹ Autio, E. (1997) New technology-based firms in innovation networks. In D. Jones-Evans and M. Klofsten (eds.) *Technology, Innovation and Enterprise - The European Experience*, London: MacMillan, pp. 209-235; Samson, K.J. and Gurdon M.A. (1993). "University scientists as entrepreneurs - a special case of technology transfer and high tech venturing," *Technovation*, 13 (2), 63-71; Doutriaux, J. (1991) University culture, spin-off strategy and success of academic entrepreneurs at Canadian universities. In N.C. Churchill, W.D. Bygrave, J.G. Covin, D.L. Sexton, D.P. Slevin, K.H. Vesper, and W.E. Wetzel (eds.), *Frontiers of Entrepreneurship Research*, Wellesley, MA: Babson College, pp. 406-421.

⁵⁰ Louis, K.S., Blumenthal, D., Gluck, M.E. and Stoto, M.A., (1989) Entrepreneurs in Academe - an exploration of behaviours among life scientists *Administrative Science Quarterly*, Vol. 34, pp. 110-131.

time, the data from Spain represented by three universities instead of the four that normally have been included in earlier research.

Table No 3.
Academic Entrepreneurship Activities

<i>Activity</i>	<i>Description</i>
Large scale science projects	Obtaining large externally funded research projects, either through public grants or through industrial sources
Contracted research	Undertaking specific research projects within the university system for external organisations
Consulting	The sale of personal scientific or technological expertise to solve a specific problem
Patenting/licensing	The exploitation of patents or licenses by industry from research results
Spin off firms	The formation of a new firm or organisation to exploit the results of the university research
External teaching	Provision of short courses to non-university personnel/ students and external organisations
Sales	Commercial selling of products developed within the university
Testing	Provision of testing and calibration facilities to non university individuals and external organisations

The list of academics that comprised the sample was obtained from university administration, homepages, or IT-support departments. The main advantages of using e-mail as a distribution channel was the quick response and low cost. However, problems in finding the right addresses, as well as technical problems with different computer systems, were some negative aspects to the e-mail approach.

The returned questionnaires were entered on to an SPSS database for each country respectively. Thereafter the data was aggregated and, for discrete variables in cross-tabulation, the chi-square test of independence to analyse significant differences was used. The ANOVA (analysis of variance) test has been used for continuous variables. As table 4 demonstrates, a total of 4,672 respondents answered the questionnaires giving a response rate of 38%. This section will describe the background of the respondents on an aggregated level such as dispersion between countries, sex, age, job classification, academic qualifications and previous employment outside the university sector. It also presents results about the number of persons having direct contact with industry and the kind of academic entrepreneurship activities being pursued in the universities. In addition, the support of the university environment towards industry collaboration is of particular interest as well as the academics attitudes about the industrial liaison services. Note that the significance levels will not be stated in this short report. However, where the finding is stated to be significant, this has been statistically confirmed.

Table 4

Overall response rate

Countries	No of questionnaires send out	No questionnaires received	Response rate
Sweden	3481	1194	34%
Spain	1625	504	31%
Portugal	1360	313	23%
Finland	1616	582	36%
Northern Ireland	1200	538	45%
Ireland	1542	663	43%
Wales	1514	878	58%
In total	12 338	4 672	38%

Six hypotheses are then tested from the aggregated data. These hypotheses examine whether:

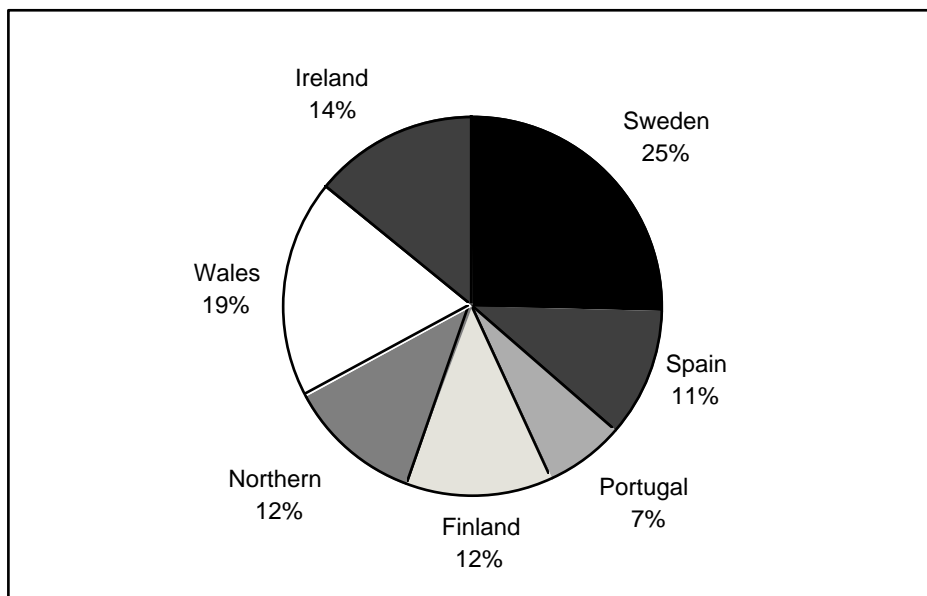
- there is a connection between earlier working experience outside the university sector and external contacts in the academic role
- the link between experience from industrial contacts and the awareness of any supportive environment for academic entrepreneurship within the universities
- previous employment outside the university sector has an influence on the perceptions about universities support of academic entrepreneurship,
- previous small business experience influence academics perceptions about the universities support of academic entrepreneurship
- there is a connection between the use of ILOs and the positive perception about a supportive environment for academic entrepreneurship
- there is a connection between a high academic degree and the involvement in academic entrepreneurship activities.

These different hypotheses mainly test several factors that might influence the perception about the environment within the universities towards academic entrepreneurship being supportive or not. The hypotheses have been formulated from an examination of the previous literature on academic entrepreneurship as well as the basic analysis of the original questionnaire. The analysis of the responses intends to reveal whether any associations exist between the various features of the questionnaire, thus either proving or disproving the hypotheses formulated. The report is ended by general conclusions built on the findings in this report as well as previous results in the research project.

3.5.3. Sample Characteristics and Results

This study includes 4,672 respondents from seven countries/regions in Europe; Sweden, Spain, Portugal, Finland, Northern Ireland, Wales and Ireland (Figure 1). As is demonstrated, Sweden and Wales have the largest shares of respondents (25% and 19%) and Portugal the smallest (7%). The respondents from Spain, Finland and Northern Ireland have an equal share of the total number of respondents. Table 5 presents the data for each participating country regarding the dispersion according to gender and age. Thus, the table shows that 77% of the respondents are male - this may reflect the faculties targeted for the study - Science, Engineering and Medicine.

Figure 1
Participant dispersion



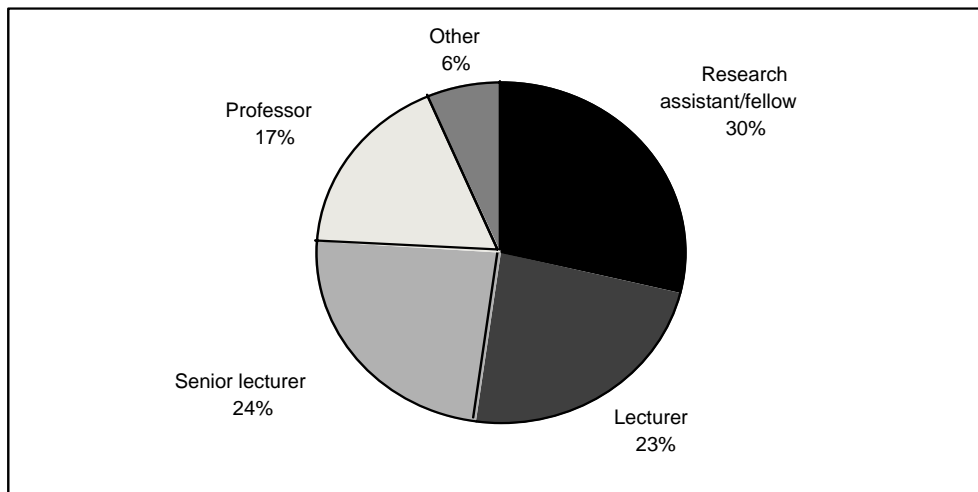
The age of the average respondent is 41 years old, which is higher than the average age of other entrepreneurial types (usually mid 30s). This is to be expected, given the additional postgraduate education undertaken by many of the respondents early in their careers. Respondents from Ireland have the significantly highest average age - 45. Indeed, the differences in average age divides the participating regions in two groups; The first group - Ireland, Wales and Northern Ireland - have an average age of 44 while the second group - Sweden, Spain, Portugal and Finland - have an average age of 39. There are also significant differences in share of female respondents. The samples from Spain, Portugal and Finland have significantly more female respondents (an average of 27%) while Wales has less (19%).

Table 5
Some facts about the participating countries/regions

Country/region	No of responses	Men	Women	Average age
Finland	582	73%	28%	37
Ireland	663	78%	22%	45
Northern Ireland	538	78%	22%	42
Portugal	313	72%	28%	39
Spain	504	73%	27%	37
Sweden	1194	79%	21%	40
Wales	878	81%	19%	44

In terms of academic job classifications, approximately a quarter of the respondents are lecturer/senior lecturers, with about a third working as research assistants/fellows, and 17% having a professorial appointment. As table 6 shows, when the data is separated by country, there are quite a few differences between the countries concerning job classification.

Figure 3
The respondents' current job classification



By country, the obvious difference is that Portugal and Ireland have proportionately few research assistants in the study, whilst Sweden and Finland have a higher proportion. On the other hand, Portugal has the largest share of lecturers (including senior lecturers) of all participating countries whereas Finland has the smallest share of lecturers.

Table 6
Job classification between the participating countries/regions (%)

Country/region	Professor	Senior lecturer	Lecturer	Researcher	Other
Finland	19	7	5	61	7
Ireland	22	22	43	3	10
Northern Ireland	13	22	30	28	8
Portugal	9	54	37	0	1
Spain	21	36	20	17	6
Sweden	15	24	11	45	5
Wales	18	21	30	24	7

In terms of the highest academic degree achieved, it is not surprising to find that the majority of the academics have Ph.Ds. The second largest category is postgraduates followed by 13% graduates. In each of the countries studied, it can be seen that the majority of the respondents are also qualified to the level of PhD, except for Finland, which has 43% qualified to Ph.D level. On the other hand, Finland has a greater proportion of postgraduate respondents in their study compared to the other countries (38% compared to an overall average of 21%). Wales has the largest proportion of respondents with Ph.Ds (79%).

Figure 5.
Highest academic degree achieved

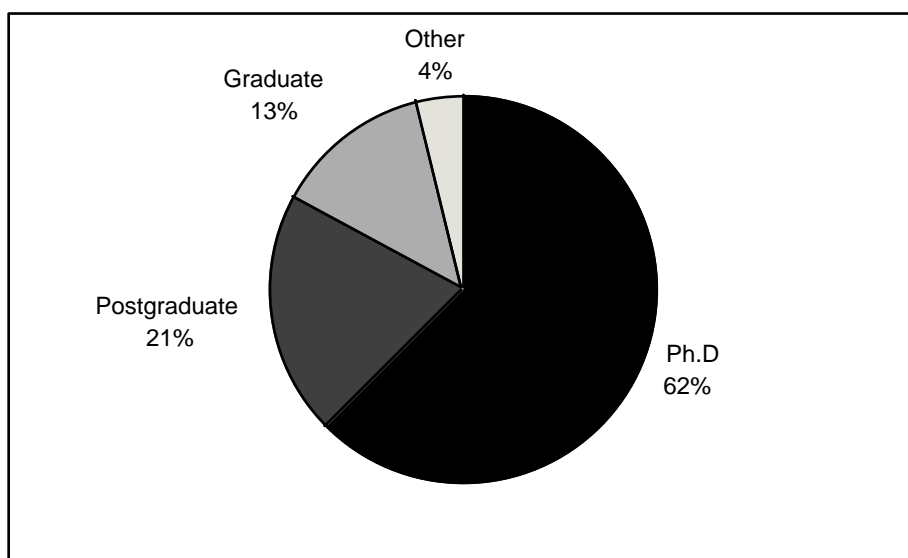


Table 7
Differences in highest academic degree achieved

Country/region	Ph.D. (%)	Postgraduate (%)	Graduate (%)	Other (%)
Finland	43	38	16	3
Ireland	57	27	3	13
Northern Ireland	68	20	8	5
Portugal	63	23	13	2
Spain	70	14	15	1
Sweden	58	18	23	2
Wales	79	13	7	2

In terms of previous industrial experience, 50% of all respondents have been employed, prior to their academic appointment, in a full-time position outside the university sector - figure 7 shows the sectors in which those 2,336 persons are from. Overall, the most common sector in which academics have previously been based is the public sector - this is also true for all individual countries. This is followed, perhaps surprisingly, by manufacturing sector, and then services. Only a small share of the survey - 3% - have worked in more than one sector. Table 8 shows that Ireland has the largest share of respondents with previous industrial experience with Spain and Portugal having the smallest number of respondents with external work experienced.

Figure 7
Earlier employment outside the university sector.

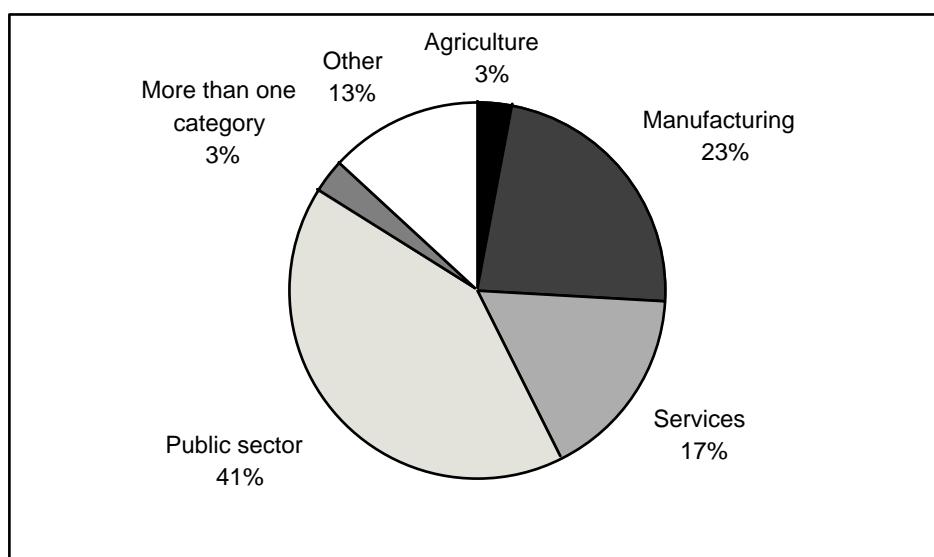


Table 8
Differences in earlier industrial experience

Country/region	Have earlier been employed in a full-time position outside the university sector
Finland	46%
Ireland	63%
Northern Ireland	57%
Portugal	41%
Spain	41%
Sweden	50%
Wales	48%

3.5.4. Main results of survey

This section will describe the results for all countries together as well as significant disparities between the countries. Four overall themes are addressed, namely:

- previous entrepreneurial experience
- possible direct contacts towards industry
- academic entrepreneurship activities
- attitudes among the respondents about the university environment, supporting external activities or not.

3.5.4a Previous entrepreneurial experience

Much of the early research examining entrepreneurial behaviour has indicated that owner-managers tended to have fathers who were themselves entrepreneurs⁵¹, and that this was a major factor in influencing the decision to establish a new venture. A number of studies of technical entrepreneurs have found similar results. For example, in an examination of previous research into technical entrepreneurship, it was found that across five different studies, 38% of technical entrepreneurs were from families in which one of the parents was self-employed⁵². A detailed study of technology-based entrepreneurs in the USA also discovered that the majority of his sample had fathers who had been self-employed⁵³. In addition, it is expected that academics who have had exposure to small business management through self-employment or a

⁵¹ Collins, O.F., Moore, D.G. and Unwalla, D.B. (1964) *The Enterprising Man*, East Lansing, Michigan: Bureau of Business and Economic Research, Michigan State University.

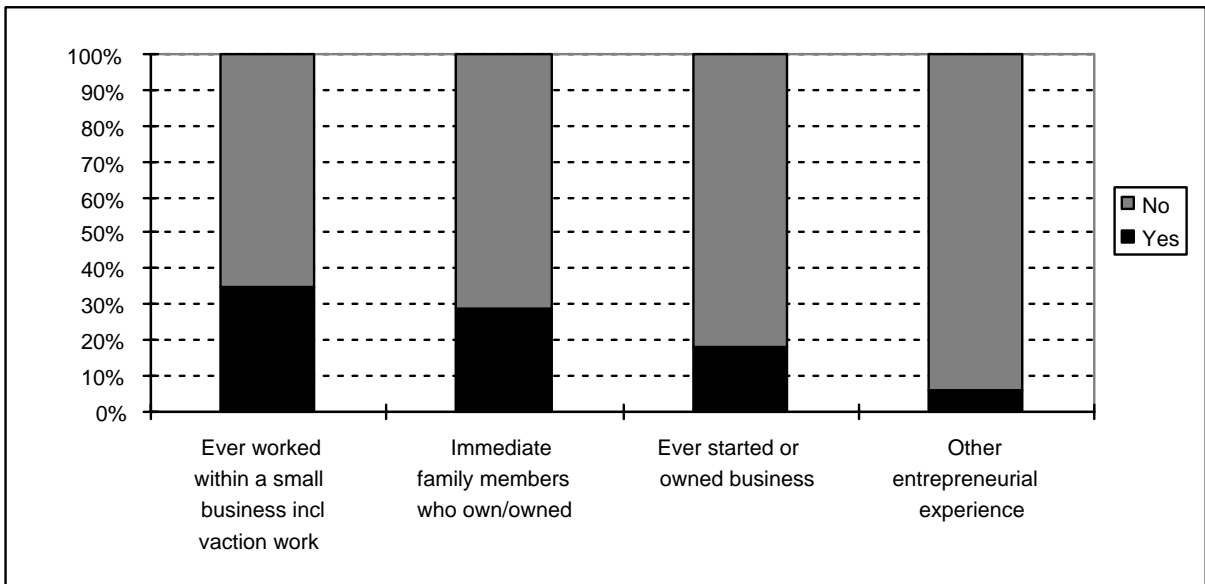
⁵² Cooper, A.C. and Dunkelburg, W.C. (1986) Entrepreneurship and paths to business ownership', *Strategic Management Journal*, Vol. 7, pp. 53-68.

⁵³ Roberts, E.B. (1991) *Entrepreneurs in high technology - lessons from MIT and beyond*, Oxford University Press, New York

prior occupational position might find this an influential factor in initiating their own entrepreneurial⁵⁴.

Despite this, it is still surprising to find that overall, 56% of the respondents have had some kind of previous small business or entrepreneurial experience. Such a large degree of previous entrepreneurial experience has not been noted in other studies. In terms of the type of prior entrepreneurial experience, there were almost as many of the respondents who had worked in a small business - 35% - as those with immediate family members who are owner-managers. However, the most surprising finding is 18% of all the academics questioned having either started or owned their own business. Whilst it is probable that many of these businesses are 'convenience' consultancy firms for channelling external income earned through various activities, they do, nevertheless, constitute an act of organisational creation. This was a completely unexpected finding.

Figure 8
Small business experience



In Table 9 we can see the differences in small business experience between the participating countries. Portugal, Sweden and Ireland have a comparatively larger share of respondents with previous small business experience compared to the rest of the countries. Sweden has the significantly largest share of respondents that previously worked in a small business and Portugal has the significantly largest share of respondents with immediate family members who own/owned business. Wales has the overall smallest share of respondents with previous small business experience. To a large extent, this finding probably reflects the industrial structure of the region studied.

Table 9
Differences in earlier industrial experience.

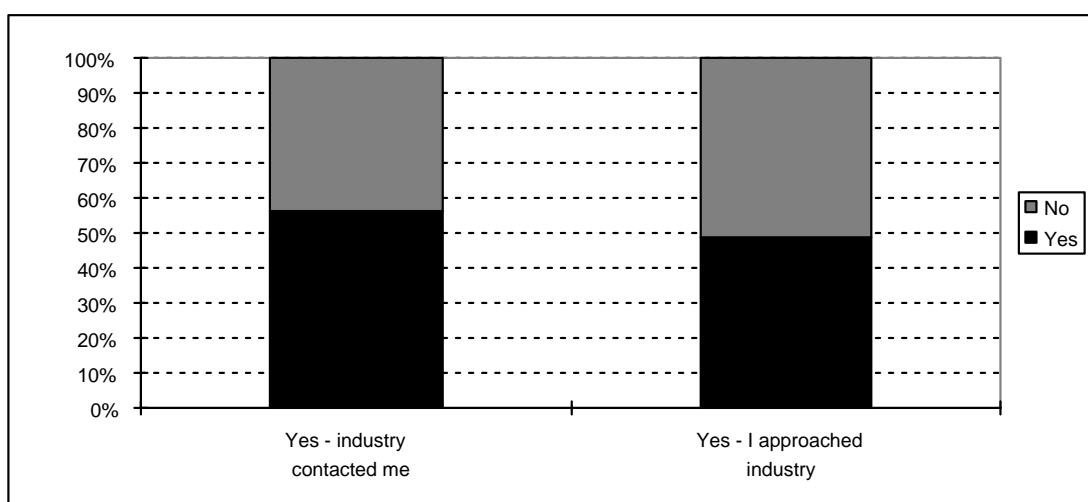
⁵⁴ Jones-Evans, D. (1992) *Technical entrepreneurship in the UK - an examination of the relationship between the previous occupational background of the technical entrepreneur and the management of the small technology-based venture*, Aston University, Birmingham: Ph.D dissertation

	Finland	Ireland	Northern Ireland	Portugal	Spain	Sweden	Wales
Previous small business experience	56%	63%	58%	64%	N/A	62%	47%
Ever worked within a small business	36%	35%	36%	28%	56%	42%	26%
Immediate family members who own/have owned a small business	21%	36%	31%	48%	36%	28%	22%
Ever started or owned business	20%	15%	9%	18%	18%	26%	14%
Other entrepreneurial experience	5%	9%	4%	1%	16%	7%	5%

3.5.4b Direct contact with the industry during the last five years

Overall, approximately 70% of the respondents have had some type of contact with industry during the last five years, with nearly a third of those questioned concentrating solely on either their teaching or basic research activities. In terms of the type of contact, the number of academics who were proactive (i.e. approached industry looking for work) was slightly less than those who were reactive to the needs of industry. However, this figure is still quite high for a sector that has been accused of being passive in forming linkages with industrial partners. However, as collaboration is built up on mutual contacts it is not surprising that the number of initiatives is quite equal among the two parties, university and industry.

Figure 9
Initiatives towards industry- industry collaboration



When studying how the respondents came into contact with industry, we see that there are quite substantial differences between the participating countries (table 10). Ireland has comparatively

the largest share of respondents who have had direct industrial contact during the last five years. Spain has the smallest share but the observed value is not significantly different from the expected one i.e. the general average for all countries. Wales has the highest share of both contact patterns, which implies that their respondents that have had industrial contact during the last five years have been equally reactive and proactive in developing links with industry. It is also noticeable that in Portugal, it is more than twice as common to be approached by an industrial organisation than to take the initiative oneself (23% vs. 57%). For all other participators, the two possible contact patterns are approximately the same.

Table 10
Differences in industrial experience during the last five years

Country/region	No direct industry contact during the last 5 years	Yes - approach to industrial organisation	Yes - approach by industrial organisation
Finland	38%	42%	48%
Ireland	28%	52%	56%
Northern Ireland	32%	46%	50%
Portugal	38%	23%	57%
Spain	44%	35%	42%
Sweden	33%	58%	61%
Wales	36%	70%	78%

3.5.4c Academic entrepreneurship activities

The types of activities that the respondents have undertaken in collaboration with industrial organisation are described in Figure 10 below. An overall average of 70% of the respondents has answered the questions. The different types of academic entrepreneurship activities that can be undertaken are described in Table 1. Overall, the main types of activities undertaken by academics in both countries were (in order of popularity) contract research, consulting, large-scale science projects and external teaching. The less popular activities were those of testing, patenting/licensing, spin-offs and sales. The fact that consultancy is one of the most popular form of activities is not surprising, as it has been recognised as an effective method in linking universities with industry⁵⁵. However, it is surprising, given the importance that policy-makers place on patenting and spin-off developing, that the incidence of these activities in both countries is relatively low. Those academic scientists and engineers who engage in consulting acquire knowledge about the needs of industry and can therefore identify how these needs can be met by industry. The extent of different academic entrepreneurship activities, i.e. external linkages towards industry, for each country is further described in Table 11.

⁵⁵ Mansfield, E., (1994), *The contributions of new technology to the economy*, Presented at the American Enterprise Institute Conference on the Contributions of Research to Economy and Society, Washington DC, October.

Figure 10
Different academic entrepreneurship activities

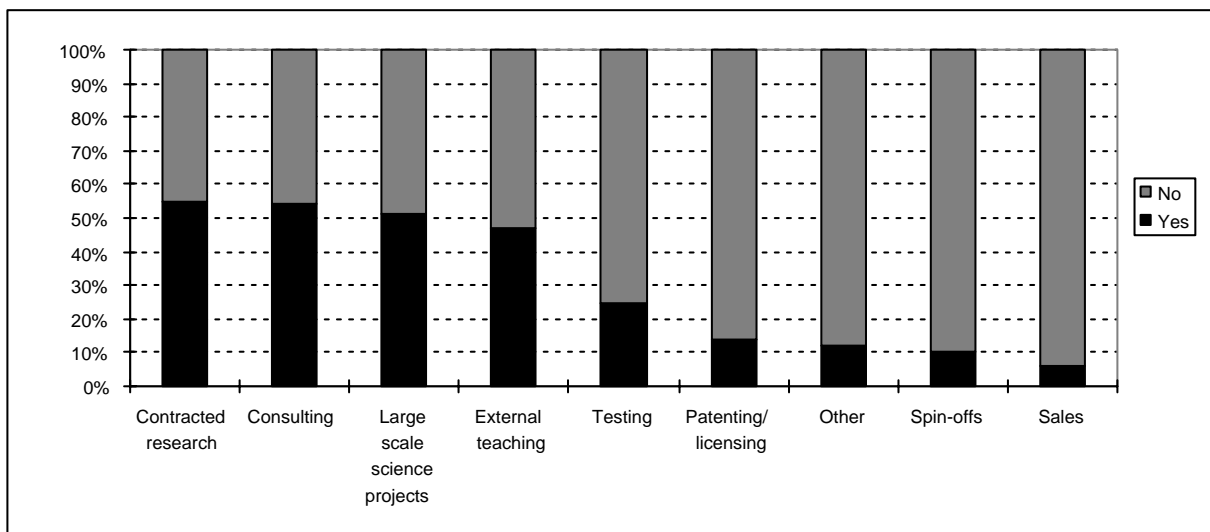


Table 11
Different academic entrepreneurship activities (%)

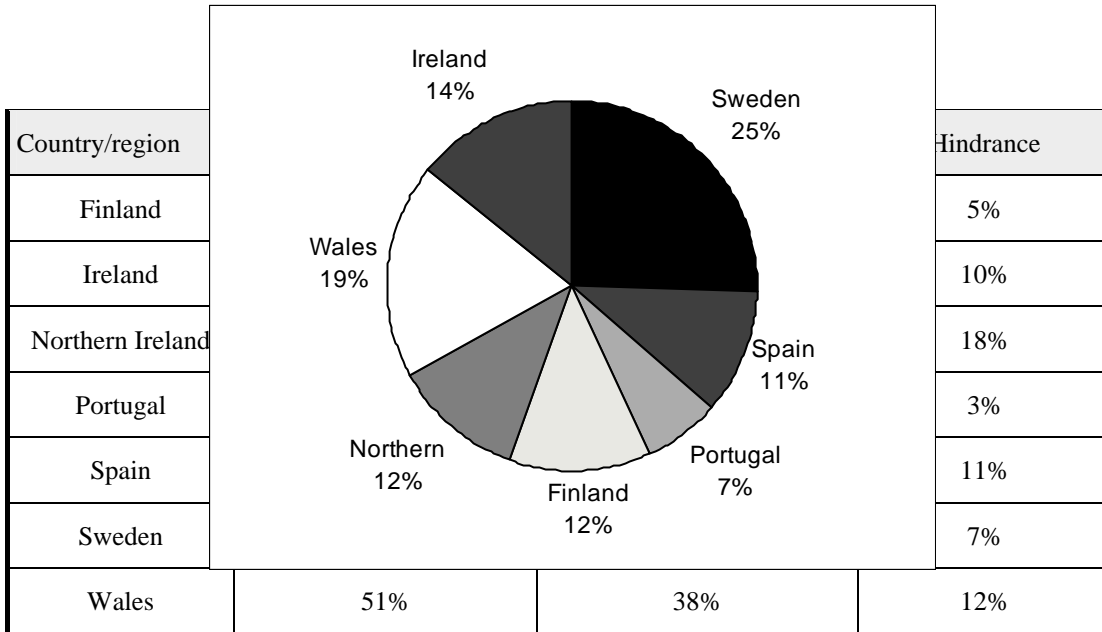
Academic entrepreneurship activities	Finland	Ireland	Northern Ireland	Portugal	Spain	Sweden	Wales
Contracted research	39%	51%	39%	43%	52%	45%	58%
Consulting	30%	49%	33%	54%	46%	51%	54%
Large scale science projects	28%	46%	32%	36%	54%	44%	45%
External teaching	23%	48%	23%	60%	45%	40%	29%
Testing	12%	19%	17%	29%	9%	15%	24%
Patenting/licensing	10%	10%	7%	2%	2%	12%	14%
Spin-offs	5%	7%	5%	4%	3%	12%	7%
Sales	3%	2%	6%	6%	2%	6%	6%

The table shows that several of the respondents are involved in more than one activity. Wales is most active in terms of contract research and consulting, whereas Spain is involved in more large-scale science projects than other countries. Portugal is the most active in external teaching, whilst Sweden has the highest incidence of spin-off activity. Sweden has the greatest involvement in spin-off activity, as would be expected given the dedicated support in this area.

3.5.4d Supporting environment

94% of the respondents had an opinion about their university environment towards academic entrepreneurship activities such as described in chapter one. Figure 11 demonstrates that 51% of the respondents describe their university environment towards academic entrepreneurship activities as supportive. 39% feel that the environment has no effect on entrepreneurial activities whereas 10% experience the university as preventing such activities.

Figure 11
The respondents description of the university environment towards academic entrepreneurship activities.



More than half of the respondent group, 61%, are aware of the industrial liaison office, (or equivalent external oriented contact organisation) within their university. Of these, 26% have used the industrial liaison office's services in developing external links. Thus, only about 740 persons of a total of 4,672 respondents have ever used the ILO services.

The university environment towards academic entrepreneurship activities varies between the different participants as it is shown in table 12. The respondents from Portugal are the most positive towards the university environment as they have the highest level for perceiving the university environment as supportive. Sweden has the least, even though the respondents seeing the university environment, as hindrance is relative low, compared to the other countries. Among the countries studied, it is the respondents from Northern Ireland that experience the university environment as the largest hindrance effect. Each country's awareness and usage of their university's industrial liaison function is described in Table 13.

Table 13
Differences in awareness and experience of the local ILO.

Country/region	Awareness of industrial liaison office (ILO)	Have used the ILO in developing external links
Finland	29%	4%

Ireland	71%	22%
Northern Ireland	62%	33%
Portugal	74%	26%
Spain	83%	45%
Sweden	57%	12%
Wales	61%	17%

The majority of respondents are aware of their industrial liaison office (with the exception of Finland) within their university. In Finland, only 30% were aware of the ILO, but the nature of the IL function in this country, this is not surprising, and probably reflects either the nature of services provided and the support provided by the offices. However, it is noticeable that the ILO is only utilised by a small proportion of academics in developing external links. This absence of contact between the academics and the ILO could be due to a lack of internal marketing, as suggested earlier, about the exact role and function of the ILO within the university. On the other hand, it suggests that many academics may prefer to work directly with industry, thus circumventing the bridging function altogether. In terms of regional differences, although it is difficult to find any significant differences, it seems clear that those Finnish respondents have used their ILOs the least and Spain among the most.

3.5.4e. Testing of Hypothesis

In the following chapter, six different hypotheses have been tested based on the initial aggregated data from all the countries, as well as previous research within the area. The overall perspective for the hypotheses concern the different factors influencing the academics' perceptions about the university climate, and whether this climate supports external collaboration and facilitates contacts towards industry.

Hypothesis One, the first hypothesis that can be drawn from the questionnaire, is:

“Previous employment outside the university sector or previous small business experience has a positive effect on the likelihood of academics engaging in contact with industry”

This hypothesis is based on the following assumptions: previous outside employment gives academics a deeper understanding of industry's commercial needs and thus makes them less daunted by the prospect of liaising and collaborating with industry. Similarly, previous small business experience enables academics to realise the benefits and opportunities which arise from the commercial exploitation of their university work and also gives them the basic knowledge of how to initiate and develop entrepreneurial activities. There is considerable previous research that demonstrates that work experience, particularly within the small firm sector, can influence an individual's propensity towards enterprise⁵⁶.

As expected, analysis of the data showed this hypothesis to be true, as it is significant. This is despite the tendency not being too strong. In other words even though the hypothesis correspond, it is not valid for many of the respondents. Nearly the same level is valid for the persons with previous small business experience, where 9%, (1333 instead of 1225 persons) more than expected also had been in direct contact with an industrial organisation since joining the university.

Hypothesis 2 - The second hypothesis focuses more on the academics opinions about the university environment for supporting external linkages or not. In this case it was interesting to see if direct contact with industry makes researchers and teachers more aware of the characteristics of the university environment. The hypothesis was stated as follows:

“Having direct contacts with industry enables academic to make informed opinions about their university's supporting environment towards academic entrepreneurship activities.”

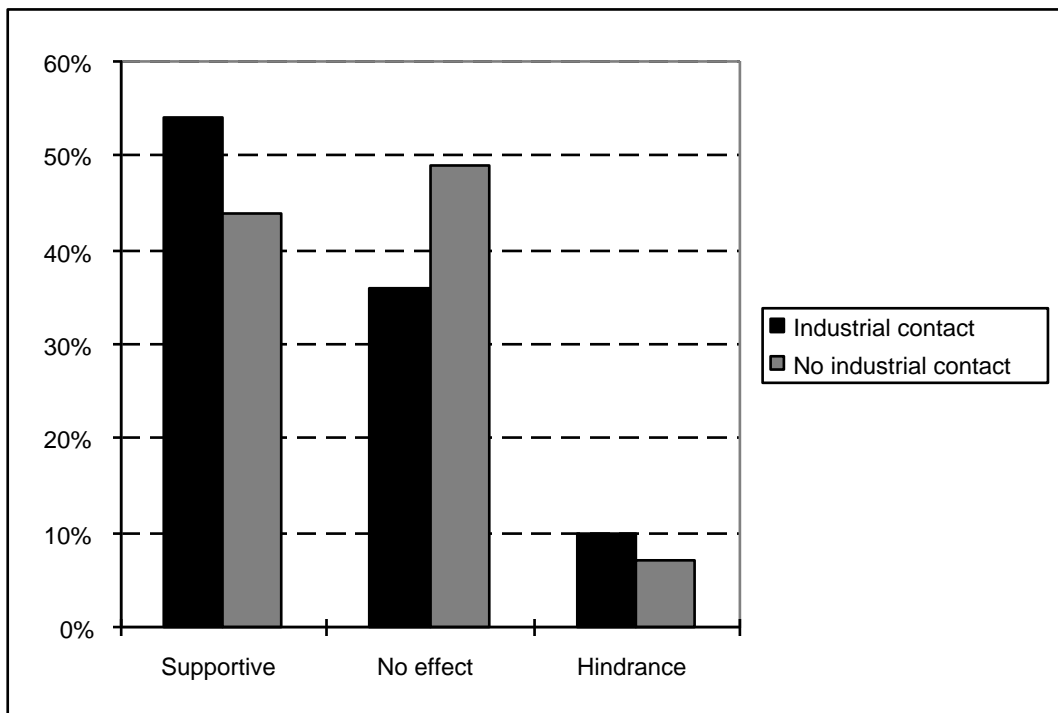
The assumption behind this hypothesis is that having contact with industry within their role as an academic at a university, enables academics to experience the university procedures established for such activities and thus deepens their awareness and judgements about the university environment towards academic entrepreneurship.

⁵⁶ Jones-Evans, D. (1996) "Experience and entrepreneurship - technology-based owner-managers in the UK", *New Technology Work and Employment*, Vol. 11, No. 1, pp.39-54; Mayer, M., Heinzl, W. and Muller, R., (1990) "Performance of new technology-based firms in the federal Republic of Germany at the stage of market entry", *Entrepreneurship and Regional Development*, Vol. 2, pp. 125-138; Roure, J.B. and Mardique, M.A., (1986) "Linking pre-funding factors and high technology venture success: an exploratory study", *Journal of Business Venturing*, Vol. 2, No. 1, pp. 5-28; Litvak, I.A. and Maule, C.J. (1972) "Managing the entrepreneurial enterprise", *Business Quarterly*, Vol. 37, No. 2, p. 43; Cooper, A.C. (1971) *The Founding of Technologically-based Firms*, Center for Venture Management, Milwaukee.

It could not be proved that respondents that have not had any direct contact with industry have no opinion about university's supporting environment. Consequently there were no difference in whether or not respondents had direct contacts towards industry and their ability or willingness to make opinions about the support of the university environment. Thus, the respondents have opinions irrespectively of direct contacts with industry. However, relating the same hypothesis to knowledge and use of the ILO function, it was found that respondents which had direct contacts with industry tended to be more aware of the ILO, (which is the formal subject for external linkages) - 13% more than expected. Further, there is also a connection between those who have used the ILO function - 36% more than expected also have opinions about the university environment.

To summarise this hypothesis, it can be stated that the respondents who have had direct contact with industry seem to have more reflections over the university environment than the others. This conclusion is based on the fact that respondents with external linkages tend to classify their university environment as either 'supportive' (about 8% more than expected or 83 persons) or 'hindrance' (about 14% more than expected or 27 persons). As shown in figure 12, a lower number of respondents with experience of external linkages tended to classify the environment as having 'no effect' - less than 13% compared to the overall average. In other words, respondents that have had direct contact with industry tend to have a stronger opinion of the university environment.

Figure 12
Respondents opinions about their university's supporting environment



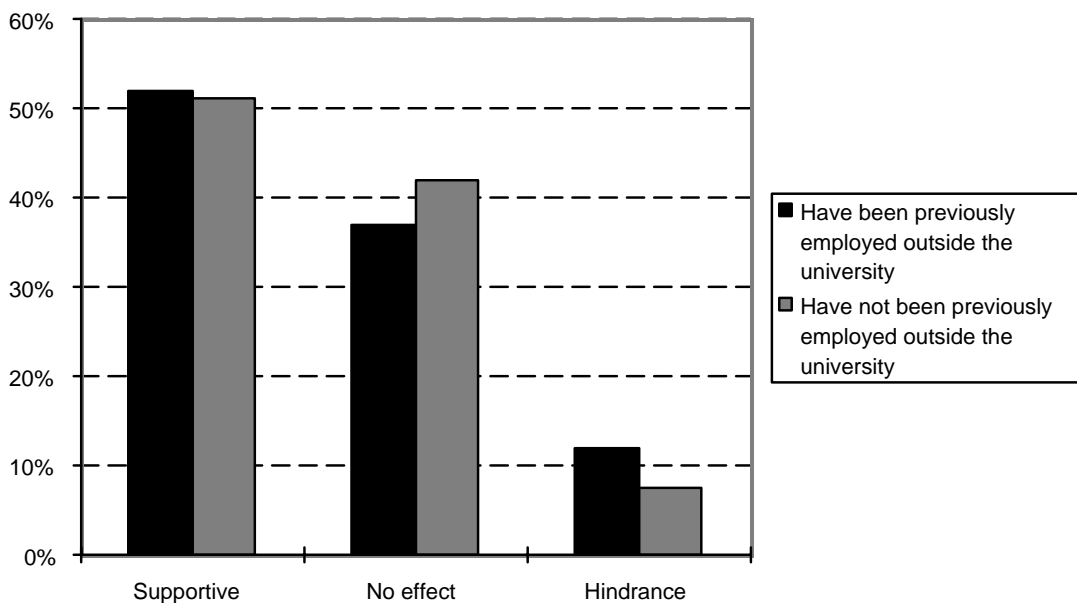
The second hypothesis with regard to academics' perceptions about their university's supporting environment is **Hypothesis Three**:

“Previous employment outside the university sector has a direct influence on academics' perceptions about their university's supporting environment towards academic entrepreneurship activities”

This hypothesis stresses the possible importance of earlier experience from employment outside the university sector and how that could influence the academics opinions about the university environment, being supportive or not concerning external collaboration. It is based on the assumption that previous outside employment broadens academics' experiences and raises their expectations with regard to both the supportiveness and efficiency of the university towards academic entrepreneurship.

The results show that respondents that have had previous employment outside the university sector tend to be less positive about their university environment towards academic entrepreneurship activities i.e. there are more respondents than expected who experience the university environment as 'Hindrance' (about 22% more than the overall average, 251 persons instead of 206). On the other hand, there are not significantly fewer respondents with previous employment outside the university that considers the university environment as being supportive. Therefore the result of the hypothesis is that there are significantly more people with an earlier employment outside the university sector that find the university climate as a hindrance to the development of academic entrepreneurship. The number of these individuals is not large, and the differences in expected and observed values are also small. In addition, it must be noted that the majority of the total number of respondents with previous industrial experience considers their university environment as supportive (Figure 13).

Figure 13
Respondents' opinions about university's supporting environment towards academic entrepreneurship activities by previous employment outside the university sector.



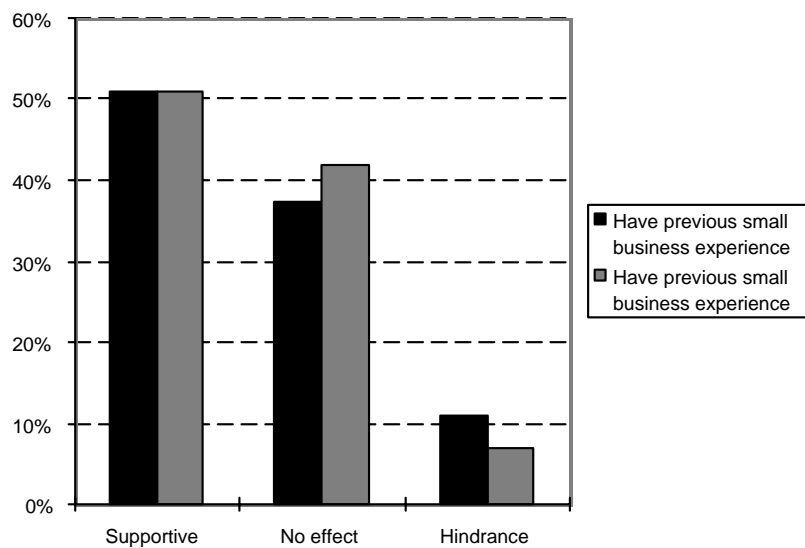
The next hypothesis is **Hypothesis Four**:

“Previous small business experience has a direct influence on academics’ perceptions about their university’s supporting environment towards academic entrepreneurship activities”

This hypothesis, which is very similar to hypothesis three, makes the assumption that previous entrepreneurial experience enables academics to become more aware of the benefits of exploiting research results and, in turn, raises their expectations as to the level of supportiveness and efficiency their university should provide. In addition, this previous experience could also encourage academics to actively initiate liaisons with industry themselves as opposed to using the ILO function to develop any external linkages.

The results indicate that this hypothesis is true. However, there is only a vague tendency. Respondents with previous small business experience tend to classify the university environment as a 'hindrance' to a larger extent than expected - about 17% more than the overall average i.e. 277 persons instead of 236). However, the major part of the respondents with previous small business experience still tends to classify the university environment as 'supportive' (figure 14).

Figure 14
Respondents' opinions about their university’s supporting environment towards academic entrepreneurship activities by previous small business



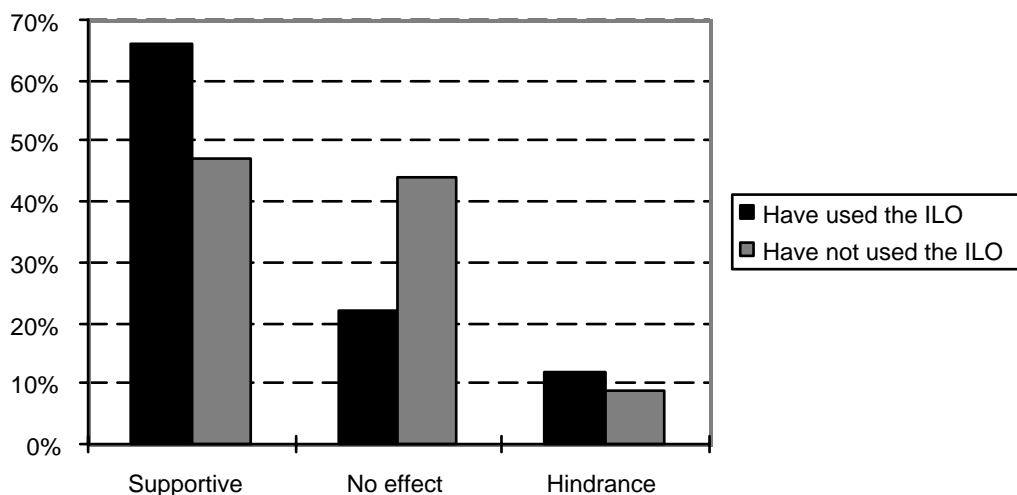
One result, valid for both hypotheses three and four, is that respondents who have earlier experience from either employment outside the university (irrespective of sector), and respondents with small business experience, are more critical to the university environment for supporting external linkages. However, it is important to remember that there are not too many of these respondents (compared to all respondents), with the majority finding the environment as supportive. It could also be said that respondents with such experience (as described in these two last hypotheses) take, in general, a position on the issue, positive or not, than the remaining group of respondents.

Hypothesis 5 - The fifth hypothesis relates to that the use of ILO services i.e. external oriented contact organisation would have impact on the academics opinions about the university environment towards entrepreneurial activities. The thesis was stated as follows:

”Use of their university’s ILO has a direct influence on academics’ perceptions about the supporting environment towards academic entrepreneurship activities.”

This hypothesis assumes that having used the ILO function in developing external linkages, academics can make more informed judgements about the university environment towards such activities, thus revealing more realistic perceptions as to the supportiveness of their university environment towards academic entrepreneurship. The hypothesis is shown to be true, with respondents that have used their university’s ILO considering the university environment as more supportive than expected. As Figure 15 shows, about 23% more respondents than the general average find that the university environment is positive for entrepreneurial activities, i.e. different activities in collaboration with industry.

Figure 15
Respondents that have used their university’s ILO’s perception of the university environment for external activities



However, as table 13 shows, about 65% of the respondents are aware of the ILO (Finland is an exception with a level of about 29% being aware of the ILO). Of these, there was a wide span of respondents, between 4% (Finland) and 45%, (Spain) who had used the ILO services. This means that the utilisation of the ILO function differs between the countries and consequently, this hypothesis is more relevant for some of the countries. In Spain, for example, the ILO could be a useful means for developing an entrepreneurial climate within the university whereas its role is less important in Finland.

Hypothesis 6 - The last hypothesis concerns the fact that the level of academic degree influences academic entrepreneurship activities and was stated as follows:

”Does the academics’ job and degree have any influence in the number and type of entrepreneurial activities that they develop.”

There is no question in the survey about the number of entrepreneurial activities that a respondent have been involved in even though it was possible for the respondents to indicate which kind of academic entrepreneurship activities they had previous experience of. However, regarding the different types of entrepreneurial activity, the hypothesis is true. Job and highest qualification gained influences all types of academic entrepreneurship activities except sales. Senior fellows at universities with at least a PhD (i.e. Professors and senior lecturers) tend to have the most industrial contacts concerning all different types of activities. This is not surprising as professorial staff should have relatively more freedom to make their own choices and act as leaders for others as for graduates or postgraduates.

3.6. Cases of academic entrepreneurship

3.6.1 Introduction.

The objective of this final part of the research study was to build on the quantitative data presented in the previous section and present examples of good practice of academic entrepreneurship activities. However, unlike the previous case studies, these would examples of individual initiatives to develop academic entrepreneurship, rather than institutional programmes. The academic entrepreneurs were identified from previous stages of the research as commercially exploiting their research work through the gaining industrial contracts. This type of interaction has become increasingly important to all institutions, as academic-industry interaction provides universities with a potential source of funding and increases the legitimacy of universities within the national education system. On an individual level, the benefits for academics are the ability to earn additional personal income and/or research funding and the academic prestige that may be associated with the commercial exploitation of research. The wider community also gains due to an increase in commercial activity and the exploitation of leading edge knowledge.

3.6.2 Methodology.

The cases would be based on the different types of entrepreneurial activities identified earlier in the study - large scale science projects, contracted research, consulting, patenting/licensing, spin-offs, external teaching, testing and sales. The cases have been chosen through recommendations from the ILO officer or equivalent individuals within the university to exemplify 'good practice'. In some countries (due mainly to timescale of the project) it was not possible to identify all the different types of entrepreneurial activities. Semi-structured interviews lasting approximately one and a half-hour were conducted with, where possible, the academic/s who initiated the activity. The interviews collected information on

- **the “entrepreneurial” activity** - detailed description; origin of idea; development of activity; organisation of activity; origin of technology utilised in activity; problems encountered in development of this activity within the university/department and how these were overcome
- **the academic participant** - description of career to date; industrial contacts throughout career; previous entrepreneurial experience; motivation for entrepreneurial activities

- **relationship with the university** - institutional framework for such activities; support of university; role of the Industry Liaison Office; encouragement of university for entrepreneurial activity
- **relationship with industry** - perception of university's relationship with industry; perception of department's relationship with industry; individual academic's relationship with industry; balance of academic work with industrial activity; initial barriers to establishing this activity and subsequent problems; lessons from relationship with industry

The academic representatives were also to recommend an external customer or partner who would characterise the external parties and be willing to take part in an interview and give needed information. Information was therefore gathered from these relevant industrial partners/clients through telephone interviews and/or e-mail exchanges.

This section will deal only with cases from six countries. The Northern Ireland study examined the cases through a series of comparative semi-structured interviews with twenty academic entrepreneurs. Details of this report are contained in the annex.

3.6.3 Cases of good practice

3.6.3a Finland

SPACE RESEARCH LABORATORY - THE UNIVERSITY OF TURKU. The Space Research Laboratory has developed ERNE (Energetic and Relativistic Nuclei and Electrons), which is an analysis equipment measuring quality and energy for the relativistic nuclei and electrons in space. The ERNE-project represents a typical large-scale science project, where technology transfer is conducted by internationally acknowledged research group, with large collaboration network, focusing on scientific solutions without commercialisation goals involved. The project expanded, when all the participants were in full motion, but as soon as the project is over, the network collapses and very little spillovers are left over. The technology development takes place in several companies, while the university is merely co-ordinating the project and conducting scientific test simulations. Well- co-ordinated projects can yield more projects later, but no commercial goals are involved in this kind of science projects. This is mainly because of attitude and mental model of the role of the academic. The project manager saw the contradiction between the academics work and the entrepreneurial activities and did not encourage anyone to establish spin-offs.

LARGE SCALE SCIENCE PROJECT - THE TAMPERE UNIVERSITY OF TECHNOLOGY. The Semiconductor Laboratory (SemiLab), promoted as a Centre of Excellence in Research by the Ministry of Education, develops epitaxial semiconductor materials and devices in co-operation with industry and universities worldwide. SemiLab has about US\$ 2 million dollar portfolio per year of collaborative R & D grants and contracts, mainly acquired from outside the university budget, to support its activities. The R & D activities fall into two broadly defined areas. Materials: physics, design, growth, and characterization of semi-conductors. Devices: design, fabrication, and characterization of optoelectronic devices, in particular, laser diodes, LED's, and solar cells. This is also a large-scale science project with the distinction that the university takes actively part in technology development process and actually produces components and devices themselves. As a starting point for the positive development is seen a European high standard technology programme, which in the first part focuses on theory and then starts to develop technology upon the theory.

Commercialising the research results is an essential part of the case and very promising results have been received.

PATENTING (THE TAMPERE UNIVERSITY OF TECHNOLOGY). Professor Pertti Törmälä, Director of the Biomaterial Institute formed a research group in 1982 that established a firm, called BIOCON, which business idea was to do patenting for the results of biomaterial research. He considers entrepreneurship as one way to transfer technical / scientific research results into practise in such research areas, where the domestic and international industry is not willing to take the necessary risk. The patenting activity discussed here is about basic patent of materials, on which several products and product families have been built on. In 1987 the BIOCON applied for a patent of 'new surgical materials and devices'. The idea of the patent is that the biomaterial, surgical implant, dissolves in the human body, thus minimising the operation costs and risks. The new technology was international and the patent for it was applied only 3 to 6 months earlier than its American and Japanese rivals. The reason for patenting in this occasion was market's demand for better surgical implants in order to replace steel as a surgical material.

Industry's role in the patenting process is normally the finance and the practical implementation. The main problem in commercialisation is the shift from laboratory scale to the full industrial scale production. When patenting, it should be stressed out that that the product can be produced with the present technology and with relatively low costs.

In Scandinavia, patenting rights belong to the inventors, which gives the researcher rights for exploitation. If the property rights belonged to the university, it could be possible that the university would be too slow to utilise the patent or it would be utilised in way contrary to the wishes of the academic. However, patenting as a way to transfer research results into practise is relatively rarely used in Finnish universities. The fact that inventors are controlling the patent rights has not affected to the popularity of its use. The case study presented above gives no reasons why patenting should not be used more frequently. First, when promising research results emerge, academics should be taught how to proceed in patenting process. Secondly, a patenting firm should be established in order to be able to protect the patent internationally. The patenting firm helps in gathering finance for international patenting, which would be very difficult, if not impossible for a individual researcher. Thirdly, the period of time between the patent application and the moment, when the researcher receives royalties from the patent, can easily be 15 to 20 years. This last feature can be interpreted as in favour of the Scandinavian immaterial property rights legislation, since no university or other institution would wait for such a long time for the profit, that could also not come at all. Finally, as in other types of entrepreneurship, it is necessary to make a decision in patenting whether to stay as an inventor (license the patent rights) or to proceed further and commercialise the patented product. In the Tampere University of Technology a strong industrial tradition and clear 'playing rules' of patenting seem to play the role of a substitute for the previous entrepreneurial experience, which was needed when taking actively part in entrepreneurial activities.

SPIN-OFF ACTIVITIES (THE UNIVERSITY OF OULU). Dr Juha Risteli studied fibrosis phenomenon on rats for his doctoral research, and how collagen synthesis was applicable for the research of the fibrosis. In 1977-1980 he worked and studied for the Max Planck Institute of Biochemistry in Germany for 30 months. In this institute he received an expertise in the field of collagen protein chemistry, which is still rare knowledge in the medical sciences in Oulu. In 1984 he became a specialised doctor in clinical chemistry. At this time he started to do his own research and developed a diagnostic method in collaboration with industry. He has problems with his peers in academia, although this, he argues, has resulted in better opportunities to enter the markets and the product development co-operation than co-operate with the university. This

case is clearly a critical example of a negative university environment, and its effect on academic entrepreneurship. In 1985, the collaboration with the Farnos-Diagnostica (today Orion-Diagnostica) started, at the time a clinical useful method was emerged. He wanted to learn the technology transfer process and the first method was build up in 1987, next method was ready in 1993 and the last one in 1996. The fact that he had a permanent position at the university, did make it easier for the process of creating new methods. Collaboration with industry has been long and the knowledge and technology are Mr Risteli's expertise alone. When the method was discovered, he wanted to give it as soon as possible for the use of the firm for the production and sales. Mr Risteli benefited from the collaboration also by receiving the new products for free in order to use them in the research again. By these free industrially manufactured reagents, a lot of work, time and money were saved. One of the main problems is that some researchers seem to think that lower quality research is good enough for industry. However, long lasting co-operation is based on an open and honest interaction with industry. When problems emerge in the product development, it should be immediately informed for the firm. Researchers should understand that firms are not interested in the academic status of the person, but how the product operates in practise.

3.6.3b Ireland

LARGE SCALE SCIENCE PROJECT: THE NATIONAL MICROELECTRONICS APPLICATIONS CENTRE, UNIVERSITY OF LIMERICK. The National Microelectronics Centre (MAC) was set-up in 1981 as a commercial State-sponsored company to actively improve the competitiveness and more rapid development of Irish industry through the application of electronic and information technology. MAC operates as a private limited company and currently employs fifteen staff, all of whom are graduates, and has a turnover of approximately IR£1 million. The mission of MAC is to work with customers and partners in the profitable application and productisation of advanced electronics and information technology. MAC essentially delivers contract development of new and improved electronic products and processes for Irish entrepreneurs and industry. It also engages in project and technology management, and in consultancy and feasibility studies to solve electronic, technical software, advanced telecommunications services and information management needs.

MAC has a number of key activities that essentially relate to the areas of information technology, telecommunications, software and electronics. A significant area of activity is working on European projects. MAC was developed as a joint partnership between the then National Institute for Higher Education (NIHE) in Limerick (now University of Limerick), the Shannon Development Company (SFADCo) and the Industrial Development Authority (IDA). MAC was started at a time when the huge importance and impact of microelectronics was beginning to be understood by some key individuals in Ireland. The main players involved in the establishment of MAC were Professor Grant Anderson, Dean of Engineering & Science at the NIHE in Limerick, Dr. Ed Walsh, president of the NIHE in Limerick, Mr. Padraig White of the Industrial Development Authority and Mr. Paul Quigley of the Shannon Development Company. This group had a vision relating to the impact that microelectronics would have on industry and believed that it was essential that Ireland develop a competence in microelectronics. They believed that it was essential for some state body be involved in ensuring that industry was aware of these developments and exploited them

One initial problem in establishing MAC was the reaction from established universities to the creation of a competing engineering centre. Those involved in the NIHE in Limerick believe that at the time the established universities did not appreciate the significance that microelectronics would have on industry and academia. There was also resistance within the

NIHE in Limerick to the establishment of MAC. At the time the Engineering department were driving the move to MAC. Those involved met with the usual resistance to change from other departments. This included a fear that the Engineering department might grow too fast, become disproportionately large and increase costs for the whole college. However this resistance was overcome due to the involvement and leadership of the president of the college Dr. Ed. Walsh. The other important factor that facilitated the development of MAC was that the NIHE was structured on a US model of a university with power and budgets belonging with Deans and not with individual departments within the college as is typical in Ireland. This meant it was easier for senior staff in the NIHE to make the organisation adapt to the development of MAC.

PATENTING & LICENSING: THE LICENSING OF PATENTS DEVELOPED BY PROFESSOR GER FITZGERALD, UNIVERSITY COLLEGE CORK. Professor Ger Fitzgerald developed a patent for the transfer of DNA from virus resistant cultures to non-resistant cultures used in the manufacture of cheese. Cultures are essential to the development of acid and flavour in the manufacture of cheese. Prior to Ger Fitzgerald's discovery cheese manufactures were dependent on cultures that were naturally resistant to viruses. Professor Fitzgerald discovered the genetic basis for the natural resistance of some of these cultures. Fortunately the resistant DNA was on a plasmid and could therefore be transferred to other cultures. Cheese manufacturers could now make their existing cultures, which might have desirable properties such as a good taste or smell, virus resistant.

Professor Fitzgerald recognised the commercial potential of his discovery. In conjunction with a colleague and a patents lawyer he wrote a patent and registered the patent to University College Cork (UCC) in 1987. UCC then licensed the patent exclusively to Christan Hansen Ltd. This is a Danish multi-national with a significant involvement in the manufacture of Food Ingredients. They were licensed the technology on the condition that they manufactured the cultures in Ireland. This company began operations in Ireland in 1985 and supplied the cultures to all Irish cheese manufacturers. There were few operational problems in establishing the link with UCC. Hurley attributed the success of the link to the strong trust that developed between the head of Christan Hansen's UK operations and Professor Daly and the relationship that developed between the research staff at Hansen and the staff at UCC. The benefit to Christan Hansen has been that their R & D staff learnt of developments in culture research. Significantly the company was able to commercially exploit the research work from UCC. The on-going links with UCC have been maintained through research funding and staff exchanges between R & D in Denmark and UCC

In general UCC is very supportive of commercially exploiting the outputs of research. The president of the university believes that UCC must exploit its research output, to develop external funding for research and to develop research that is of relevance to the local and wider community. UCC has developed a patenting and licensing framework and procedures. The ILO provides a framework for developing and exploiting patents. Employment contracts specify that staff may engage in external activities and may earn income from such activities. The ILO played an important part in helping the academics secure and exploit the patent. Initially he put Professor Fitzgerald in contact with a patent lawyer. He then accompanied Professor Fitzgerald and his colleagues on their meetings with industrial partner, Christan Hansen Ltd. He provided an important business input to this negotiation process. There were no significant problems experienced in the development of this activity within the university or the department. Professor Fitzgerald's department, the Department of Microbiology provides the resources necessary for staff to pursue their research interests. The majority of the staff in this small department has strong links with industry.

SPIN-OFFS: IONA TECHNOLOGIES, TRINITY COLLEGE DUBLIN. IONA Technologies was founded in March of 1991 by three academics, Dr. Chris Horn, Anraí O'Toole and Dr. Sean Baker of the Computer Science Department Trinity College, Dublin. IONA Technologies develops markets and supports distributed component software that enables the development, integration and management of network-based applications in multi-platform network environments. IONA also provides professional services, including consulting and training and, to a lesser extent, product customisation and enhancement, as well as customer technical support. IONA Technologies has grown rapidly since launching its main product, Orbix, in 1993. Its worldwide market share is sixty percent and total revenues for the company have grown significantly. Revenues were US\$21.2 million in 1996. Reflecting this significant market success the company has been profitable since the launch of its key product, Orbix. In February 1997 IONA went public on the US NASDAQ market and the Initial Public Offering raised over US\$50 million for IONA.

The idea for the firm came from research work undertaken for the ESPRIT programme, which exposed Horn and his colleagues to the emerging technologies in the software industry. IONA Technologies was set up to take advantage of these technologies. Chris Horn, Sean Baker and Anraí O'Toole set out to develop the software to implement the CORBA standard. The trio established IONA Technologies as a campus company, which enabled them to commercially exploit their research while retaining their positions as university staff members. Although the number directly involved in IONA was small, other academics and researchers were indirectly involved in the early stages providing welcome support when necessary. The founding academics had extensive industry linkages from 1984 onwards. They worked on research based projects for companies such as Bull, Olivetti, Siemens, CAP and ICL. Their initial activity was focused on research but gradually the company began to focus on product development in 1991.

The development of IONA was funded from the founders' own resources after attempts to raise outside finance received little interest from banks, venture capitalists and investors. In the early days Horn recalls that "we were greeted with a degree of scepticism and it was difficult when it came to raising the necessary finance". Initial funding came from their own resources. Like many software companies, IONA Technologies had to become involved in consultancy and specialist computer training to fund the research and development of its software product. IONA developed specialist training packages for other providers of computer training with the profits from consultancy and training supplementing the wages of those who were developing Orbix. Training and consultancy services still account for about twenty five percent of IONA's business today. They would have preferred to concentrate solely on product development but according to Horn this was not possible. Most of this training work was done under contract for other training companies.

The company launched their first product in June 1993. However IONA technologies could not secure equity investment despite continued attempts. IONA linked up with SunSoft, the software division of the workstation manufacturer Sun Microsystems at the launch of their product. Sun Microsystems was also developing an object software product. IONA co-operated with SunSoft to promote its product and SunSoft operated as a reference seller of IONA's product. When selling its computer system Sun Microsystems would tell customers that Orbix software worked on Sun systems. In January of 1994 IONA sold twenty five percent of the company to Sun Microsystems for US\$0.6 million. Sun Microsystems sold this stake in 1997 for US\$67 million.

EXTERNAL TEACHING ACTIVITY: THE CENTRE FOR HEALTH AND SAFETY AT WORK, UNIVERSITY COLLEGE DUBLIN. The CHSW is an academic centre within

the University Industry Programme (UIP) at University College Dublin (UCD). The centre was established with the aim of providing continuing education and advanced training programmes and to co-ordinate health and safety research within University College Dublin. Its functions are to administer Continuing Education and Advanced Training Courses in Safety and Health; to provide a framework for research in related areas; and to offer advice and consultancy services to industry. The centre offers UCD accredited courses at Certificate, Diploma and Masters level in Occupational Health and Safety. These multi-disciplinary courses are intended for managers, supervisors, safety representatives and others with an interest in safety and health in the work place. The courses are delivered on a part-time basis. In delivering the courses the CHSW makes extensive use of outside experts. The centre has grown significantly since its establishment in 1991. In its first year the centre had twenty five students. In the academic year 1997/1998 the centre will deliver the Certificate course to 285 students, the Diploma course to 92 first year students and 74 second year students, and the Masters course to 10 students. The centre accounts for a significant proportion of the continuing education activities of the UIP. As an indication of the success of the CHSW, the diploma course have been introduced by competing universities such as the University of Limerick, University College Galway and University College Cork.

The initial problems experienced in starting the CHSW were the securing of university approval for the courses and acquiring the resources to deliver the Diploma course. Initially some academics were sceptical about the appropriateness of this “vocational” type course to a university. The most significant problem relating to the delivery of the course was securing accommodation on the UCD campus to deliver the lectures. This problem was finally overcome by offering the course at the University Industry Centre, the home of the UIP. Another problem was the lack of funding for developing and promoting the course since the UIP, which funds the development of its courses, was in its infancy. A final problem was securing expert staff in each of the areas necessary for the courses.

A number of factors were central to the success of the CHSW. Students surveyed following completion of the certificate course have indicated that the high quality of support materials and the employment of local tutors are essential to the success of the courses. More generally the development of partnerships with RTC’s and industry and the use of new educational delivery technology have increased the accessibility of UIP courses to course participants. The involvement of the UIP was essential to facilitate the development of what is essentially a multi-disciplinary based course. Of critical importance to the continued operation of the CHSW has been the development of a management and administration structure within the UIP. This has allowed the CHSW to continue to develop despite a reduction in the day to day input of the two initial founding academics.

DEVELOPING RESEARCH & EXTERNAL CONSULTING ACTIVITY: THE ENVIRONMENTAL INSTITUTE, UNIVERSITY COLLEGE DUBLIN. The Environmental Institute was established in 1989 to develop the research capacity in environmental studies within the university. The Institute also promotes and supports teaching in the area of environmental studies. The principle activities of the Institute include workshops, conferences and publications which develop the reputation of the University and the profile of individuals working within the disperse area of environmental studies. These workshops, conferences, and publications are directed at participants from industry and from the policy making sector. Most of the consulting work and research work occurs at a department or personal level. The Institute facilitates interdisciplinary work by supporting contact between the diverse groups. The Institute places the talents of a multi-disciplinary group of experts (from across the faculties in UCD) at the disposal of a wide range of clients in the State, semi-State and private sectors.

There is an in built tension between academic work and industry consulting and research. There is an in built tension between academic freedom and rigorous research work on environmental policies and the short-term interests of industry. This tension has been managed in two ways. First, the Institute has emphasised projects and research that adds new knowledge to the university. This is partly achieved by publishing the output of some research projects. The overall thrust at a university level for increased research activity and publications has motivated individual academics to engage in research-related work rather than pure consultancy work. Second, the Institute has secured external European Union funding for projects. This has meant that it is not solely dependent on funds from “interested” parties. At an individual level academics involve themselves in consulting projects which often have no added value to the university or academic knowledge and which are funded by an industrial client. However sometimes this initial confidential consultancy work has 'opened doors' for larger research projects. Central to the success of the Institute has been a clear understanding of its objectives. The objective of promoting and disseminating research work, rather than just consultancy, received support within the university from both individual academics and from the university management. The decentralised nature of the Institute has allowed it to effectively achieve this objective. A second important factor to the success of the Institute was the depth of expertise that had developed in the fields of environmental studies within the university. The Institute sought to act as an umbrella group for these activities and facilitated the development of research and consultancy by individuals and departments rather than trying to set the research/consultancy agenda and to control these activities. The Institute has heightened the awareness of industry and government of the activities in UCD and this has enabled departments, individuals and interdisciplinary teams to access research funds and to increase their profile in the commercial scene.

CONTRACTED RESEARCH: PROFESSOR JOHN HEGARTY, TRINITY COLLEGE DUBLIN. Professor John Hegarty is Professor of Laser Physics in the Department of Physics in Trinity College, University of Dublin. He is actively involved in securing research contracts for his own research activities. The motivation for securing these external funds is his own personal desire to be at the “leading edge” of his research area. He says he is motivated by “new ideas”. He has research projects funded from three different sources- the Irish Government, the European Union and Industry. One of his major research contracts is with the Hitachi Dublin Laboratory (HDL), which was established at Trinity College Dublin in 1989. Hitachi leases the laboratories from TCD and is responsible for managing the laboratory. The space for the laboratories was provided by TCD. Hitachi refurbished the buildings and equipped the laboratory. The Irish Industrial Development Authority provided a grant for forty percent of the cost of the refurbishment. The laboratory employs fifteen researchers that are paid for by Hitachi. There were very few problems at a University level and a Department level during the negotiations for the establishment of the HDL. In addition to carrying out their own research project in the laboratory, Hitachi collaborates with academics within the university on research projects. This collaboration with other researchers takes the form of direct sponsoring of research projects and providing access to equipment that is available in the Hitachi Laboratory. Hitachi funds research activities that Professor Hegarty described as “lose research briefs”. Academics such as Professor Hegarty who receive direct research funding from Hitachi are required to make an annual presentation of their research findings to Hitachi.

The “pay-offs” for individual academics in securing outside funded research contracts are several. First, the interaction with industry provides the academic with a broader perspective of how university research addresses the needs of industry and how it fits into the world of business. Second, research contracts with industry help graduates and researchers to get jobs with industry. Third, outside research contracts involving other universities, as is typical with

European funded research projects, provide both senior and junior researchers with a richer learning experience. One disadvantage of funded research projects is that the individual academic loses control over his personal research agenda. This happens because both government and industry partners may set the project brief for funded research. The contract research projects that Professor Hegarty has secured includes both applied and basic research projects.

3.6.3c Portugal.

Nine interviews were conducted with academics involved in entrepreneurial activities and representatives of external partners. The interviews illustrated the diversity of entrepreneurship types and co-operation practices, as well as of perspectives on the barriers which are raised to university-industry linkages in Portugal.

Oswaldo Pacheco is a senior lecturer at the UAV's Department of Electronics and Telecommunications. His research work, focused on bioengineering, industrial electronics and digital signal processing, is encompassed by the achievement of new products and technologies that can be used as industrial applications. One of the most successful co-operation initiatives in which Oswaldo Pacheco is involved concerns the on-going relationship with the neurophysiology service of the Hospital de Santo António (in Porto). This linkage gave rise to several technology transfer actions, namely digital signal processing systems which are being applied in sleep related studies. According to the interviewee, personal contacts are essential to develop the trustful basis needed to reinforce the linkages between academic and industrial spheres. Besides the communication difficulties, Oswaldo Pacheco states that the lack of financing sources to support technology transfer and the lack of public policies providing an effective framework for co-operation activities emerge as additional barriers to university-industry linkages.

António Martins da Silva is the head of the neurophysiology service of the Hospital de Santo António. The close personal relationship with a group of UAV's engineers developed after a first co-operation action in 1979, gave rise to a large set of joint successful R&D projects. Some of the products developed, considered as useful means to support medical decision, were placed in the market (e.g. the video-analogic signal integrated system which provides time counting during encephalographic analysis). According to Martins da Silva, the informal basis that is sustaining the co-operation activities is an important means to achieve success. He states that personal trust was and is crucial to remove the barriers which are raised to interaction activities.

Fernando Monteiro is a full professor of the UP's Department of Mechanical Engineering. His research is mainly developed within a large interface institution and it is focused on surface coatings for biomaterials and implant monitoring. The scientific expertise achieved gave rise to the creation of a spin-off company developing and selling biomedical products. Fernando Monteiro and two colleagues share 60% of firm's capital, being the remaining 40% divided among the Business Innovation Centre of Porto (30%) and a UP Foundation (10%). According to the interviewee, this business activity has not yet been very compensatory in pecuniary terms, mainly due to the long period of experimentation which the products require before their launching in the market. Spin-off based firms, according to Fernando Monteiro, are not being properly addressed in Portugal, as shown, for instance, by the lack of risk or seed capital and by the lack of protection provided by national product patents. In addition, besides the participation in firm's capital (10%), the UP did not give other support to the entrepreneurial activity. The firm's short term objective is to reinforce its position in international markets. The

first step to achieve this goal is to develop a partnership with a large Portuguese economic group in order to create the needed critical mass.

Manuel de Oliveira Duarte is associate professor at the UAV's Department of Electronic and Telecommunications. He is the head of a research group working on broadband systems which is developing a large set of national and European funded R&D projects. Oliveira Duarte created in 1990 a small firm aimed at the provision of consultancy services within electronics and telecommunications domains. The pool of consultants which was gathered gave rise to a number of other small firms, some of them participated by large economic groups, as well as to the extension of commercial activities (e.g. supply of telecommunication physical infrastructures, commercialisation of computers, software and other related equipments, etc.). The interviewee regards this entrepreneurial activity with mixed feelings. As positive aspects, he stresses both the opportunities open to his research collaborators in what concerns employment and the partial achievement of the initial expectations on personal pecuniary benefits. As negative aspects, he mentions the time and energy spent in disfavour of academic career and the general negative perception of academia in relation to his private activity. According to Oliveira Duarte, the success of university extension activities depends upon the exploitation of product markets rather than the search for service provision market niches.

Fernando Ramos is a senior lecturer at the UAV's Department of Electronics and Telecommunications. His research activity is carried out mainly within an interface institution and it is focused on multimedia communication based on advanced telecommunication networks. Fernando Ramos is working on the creation of a firm participated by the UAV which is going to launch multimedia based learning systems. The firm will be located in the university campus and will have as main product the provision of remote teaching of Portuguese language to foreign people. The creation of this firm, according to the interviewee, reflects the favourable environment existing in the UAV for the development of academic entrepreneurship. He highlights the importance of the recent policy framework to encompass and clarify the linkages between academia and society, stressing that a clear policy prevents business activities promoted by academics to collide with university interest. Fernando Ramos considers that universities should be endowed with people specially prepared to interact with industrial agents, providing thus the basis for a balanced relationship between high quality R&D and time response to firm's needs.

João Labrincha Baptista is associate professor of the UAV's Department of Ceramics and Glass Engineering. His research work is divided into two different areas, a first one concerning energy conversion systems, a second one exploring the use of traditional ceramic products in environmental applications. The first area gave rise to several joint R&D projects with large multinationals whose results are not interesting to Portuguese industry. Conversely, the second area, being endowed with large potentialities to be rapidly put in practice anywhere, originated already two national patents, concerning the development of water filtration beds with atomised clay and the re-utilisation of atomised clay used in water filtration to produce ceramic tiles. João Labrincha Baptista argues that the industrial production of these products is cheap and simple. However, until now there was no industrial demand for them. The eventual creation of a spin-off firm is dependent upon a deeper perception of potential markets and range of applications.

Arlete Faia is a full professor at UTAD's Oenology sector. Her research work is focused on wine microbiology and it is carried out within several national and international R&D partnerships. The basis of this research was her PhD work on the isolation of lactic bacteria from the wine to be used as starters. Industry has shown a large interest in the work developed by Arlete Faia since its very beginning has been one of the financing sources of the research. A

Portuguese supplier of oenology related products has already started the commercialisation of the product developed by Arlete Faia, having ensured its international dissemination. The product is going to be patented in the short term.

Rui Guimarães is associate professor at the UP's Faculty of Engineering. He works with a large interface institution, mainly in the field of operations research and optimisation. He is the responsible for the development of co-operation activities with a producer of gasheaters located in the region of Aveiro. According to the interviewee, the main driven force of this co-operation was the analysis of priority technological areas on which the firm's development strategy should lie on. Under the scope of the analysis several additional agreements of co-operation were signed giving rise to a number of technology transfer actions (e.g. polymer and steel plate components to be applied in gas-heaters) which assumed an important role in the firm's innovative effort. Rui Guimarães argues that the successful relationship with the firm was due, on the one hand, to significant mutual benefits achieved and, on the other hand, to the purposeful conjugation of scientific expertise with firm's innovative behaviour. The interviewee states that in Portugal there are not many firms presenting such innovation-prone attitude, which prevents a closer relationship between universities and industry. However, Rui Guimarães has an optimistic view on the development of linkages stemming from the change process which is taken place both in industry and in universities.

Artur Martins is the manager of a supplier of electric and electronic equipment for industry, mainly automation equipment. He has a close relationship with some members of UAV's Department of Electronics and Telecommunications (where he has got his degree) resulting from the perception of a growing demand for high skilled labour in the field of automation. This relationship has acquired visibility in 1995 with the agreement of co-operation signed between a large multinational (of which the firm is the local representative) and an interface institution of the university department above mentioned. The main goals of the co-operation action was to set up the infrastructures necessary to prepare skilled engineers and technicians in the field of programmable controllers and to develop a competence centre to provide education inside academic institutions and/or industries. According to the interviewee, the actions foreseen in the agreement were not yet fully accomplished. He argues that this delay is mainly related with problems arising from the relationship with the UAV, namely the lack of availability of its teaching staff to meet the deadlines initially defined. Artur Martins argues that the linkages between industry and universities result mainly from individual initiatives, being necessary to ensure a higher level of institutional involvement.

3.6.3d Spain

SPIN-OFF FIRM - Marian Martinez is a senior lecturer of the Department of Biology (Faculty of Medicine) of the University of the Basque Country (UBC). She has recently developed a spin-off activity in conjunction with two post-doctorate researchers. The three of them have established an enterprise dedicated to genetic diagnostics. She is currently works within the firm as well as holding a senior lecturer position at the UBC, although she is planning to leave the firm to avoid any conflict of interest in gaining R&D projects from the university. During her university studies she did not have any contact with industry and did not participate in any Research Project. Once she finished her Science Degree (Biology Area), she started her doctoral thesis in the University of the Basque Country as a Lecturer and at the same time participated in the design and experimental development of research lines related with genetic-biochemical polymorphism. When she finished her doctoral thesis, she realised that there was a very strong demand for paternity tests in the market. The Courts of Law used to make contact with the University in order to demand the required tests by law. At that period, the testing was

not made by the analysis of DNA, but by means of the proteins study. To make these tests, it was necessary to carry out very complex statistical analysis. Due to this need, computing 'spin-offs' were born from the University in order to make those probability calculations. These enterprises used to call this academic to realise common projects. In conjunction with her research team, they started to develop the entrepreneurial idea to create a service that would consist on realising paternity test inside the university (as they wished to also continue with their academic careers).

Having taken this decision of working within the University, they consulted the Basque ILO (OTRI) for support, in order to examine how to develop the service inside the University. In addition to the ILO showing no interest in the work, other obstacles were in place, including the primacy of teaching in the institution, the high cost of paternity testing, and the bureaucracy of the university. As a result of these initial problems they decided to leave the UBC and set up their own enterprise. Nowadays, the paternity tests ordered by the Courts of Law are made in University, and they are financed by some Research Projects, while the private tests are made in the enterprise created by this academic with her research team. They were fortunate to work with an organisation called BEAZ, who were impressed with innovative and mature nature of the project. As a result, support was offered to the spin-out team, including management advice, grants for technology and premises. The main constraint they faced was the lack of knowledge about entrepreneurial management. The primary motivation of the academic was the commitment to her research team to develop this idea. In terms of the relationship with the university, it is remarkable that the department of the university does not know anything about the enterprise, due to the independence of the firm. As a result, there is very little formal relationship with university. Although she had no previous relationship with industry, she has learnt from her own experience that the entrepreneurial world is much more 'real', as the enterprise is nearer to reality than university. In particular, industry knows what is demanded by society and also who the main competitors are. She also appreciates that the co-operation tendencies are stronger among enterprises than inside UBC.

CONTRACT RESEARCH - The second of the interviewed academics is a professor of the Department of Mechanics of the High Technical Engineering School of the UBC. During the last few years, he has taken part in several research projects with different enterprises and with the public institutions of the Basque Country, developing considerable experience in the relationship between the UBC and the industry. The principal aim of these contracted research projects is the improvement of machine processes. According to the academic, such activities have been difficult due to a number of constraints found in the university system. These include the lack of a University policy aimed at encouraging the development of industrially relevant technologies; the lack of appreciation that firms, as well as students, are potential clients of the university; the lack of importance in creating linkages between the university and local enterprises; the ILO (OTRI) at the university is bureaucratic and inefficient. The Director of the R&D department of ONA- Electroerosion S.A firm (which the academic is collaborating with), was interviewed. The relationship that ONA has developed with the University is fully supported by the management, and considers this relationship to be important for the future of the firm. The main obstacle found in their relationship with the UBC is the slowness in the mediation performed by the Basque ILO (OTRI) and the aim shown by this organisation to impose very strict conditions on the contracts signed by the enterprises with the UBC.

CONTRACT RESEARCH. The academic interviewed is a Professor of Computation and Artificial Intelligence in the Faculty of Physics of USC since 1995. He considers that the University has to be closer to society, to lend a service with social repercussions and with a socio-economic impact in Galicia. He is determined to create university structures which facilitate the connection between university research and industry, and which allow the

employment of researchers of R&D without the need to be devoted to teaching. He also thinks that the University is a good way to relate with industries because of its flexible structure, as the University has more freedom and lower operating costs than industry. He is involved in a number of contract researches with various enterprises. The factors which have influenced the academic's relationships with industry have been, on the one hand, the necessity of obtaining financial resources and, on the other hand, for the personal dissatisfaction of being exclusively devoted to the educational and strictly academic aspects. The major problem that he has found in the university structure is the strong rejection of the system towards the academics who stand out from the average, in terms of contacts with the industry, at least at the beginning of a research career. The negative image of the University is the academics in their ivory tower, without communicating their knowledge to the managerial world. According to him, there is too much bureaucratisation to apply for R&D projects. As for his relationship with the CTT, he finds the industries to work with because of his personal relationship with the director of CTT. With regard to the industrial point of view, working with university research groups has the advantage of being more competitive in the market due to lesser costs in the procurement of technology.

LARGE SCALE SCIENCE PROJECT. This is a European project in which there are a number of partners involved. In addition, research objectives - the development of a terminal able to meet the telecommunications needs of the future European Capital Market - are quite important. This project has a European dimension, but the respective firm contacted is located in Madrid. The main problem is the lack of institutional support for what ILO is now promoting, in means of economic and human resources limitations. On the other side, there is a lack among the academic staff of an entrepreneurial culture. From the point of view of the company, the vision again is absolutely different. If the firm is involved in a project, the support must be complete from the beginning, because if it is not, the project will not be successful, and the firm pursues the success in every activity in which takes part. The university's relationship with industry (as the firm's relationship with academia) in general is perceived as being sound and growing stronger. The main obstacles found in the beginning of this project, for the professor, were to find out the specific support required and how to organise his research team, because normally a professor directs or is involved in several projects at the same time.

CONSULTING. The second one is a consulting project on tensions over a vehicles transporting wagon, very specific R&D tasks for a firm located also in Madrid. This case has been chosen because the academic responsible carries out a great number of *ad hoc* consulting projects and the firms contacted by him usually come back again. So the main reason is certain success rate of this professor in this kind of activity. There were not significant problems in the development of this activity. The only problems raised have to do with the first steps of the project, that is, the establishment of the technical specifications and the price. But after a process of negotiation these difficulties were overcome. The institutional framework for this activity is neither a formal relationship nor an informal relationship. The main obstacles found in the beginning of this project, for both the professor and the individual partner, were to agree the technical specifications of the project, the time and the price. A process of negotiation solved these problems. There have not been subsequent problems.

LARGE SCALE R&D PROJECTS. Based at the University of Santiago de Compostela (USC), the academic interviewed in the Department of Biochemistry has carried out mostly R&D projects (financed by EU and Xunta of Galicia) in which industries are interested in participate in order to test their products. There did not exist any significant problems in the development of this activity on behalf of the University or the industry. There were more general problems in developing academic-enterprise such as a problem of space for such

activities within the department. The project examined in this research concerned work with INSUIÑA S.A., which is a medium size enterprise devoted to fish-farming. It is the first company in Spain (in 1982) that was dedicated to the breeding of turbot. At the moment, INSUIÑA S.A. accounts for 5% of the production of turbot in Galicia. The interviewed person in the firm is the responsible for production and he is the mediator between INSUIÑA S.A. and the University. This company is characterised for its strong linkages to the research carried out in USC, as it does not have neither a laboratory (space) nor specialised researchers in bacteriological analysis (technology) applied to turbot. As a result, the university research carried out plays a complementary role to the competitiveness of the enterprise in the market

3.6.3e Sweden

LARGE SCALE SCIENCE PROJECT - In 1992, the Swedish National Board for Industrial and Technical Development - NUTEK - took initiatives to establish 28 competence centres related to the universities/institutes of technology. The aim was to build up strong research groups in the country with an interdisciplinary approach in close collaboration with industry. One of these competence centres is the Centre of Excellence in Non-Invasive MEDical measurement (NIMED) at Linköping University. The Centre works closely with Astra Pain Control, which is one of the external partners to NIMED and is one of five research companies in the Astra group, specialising in pain control and is a world leader in local anaesthesia.

CONTRACT RESEARCH - In 1994, the International School of Management and Industrial Engineering, (IMIE) was established. This school was involved in three main activities: The Graduate Programme, The Interdisciplinary Research Programme and the Executive Master Programme in Project Management (PMEX). As the last programme is totally sponsored by industry, the case focuses mainly on that activity. Nine large multinational enterprises are funding the programme and also actively part on the board of PMEX.

CONSULTING - The Centre for Industrial Technology and Work Organisation, ITA established in 1984 is working on commission based development projects in, mainly, manufacturing industry, to jointly develop efficiency and work content. One customer from the beginning of ITA's activity is Finess AB a soft paper-mill active in a small community outside Linköping. This description is mainly based on interviews with one of the initiators for ITA Roger Andersson and Lars Ole Hansen staff manager besides board member for Finess AB.

PATENTING AND LICENSING - The initiator of Forskarpatent is both a business man and an inventor leading his own firm but on the same time well known within the university sector and among inventors and industrialists in Sweden. He has been the manager of Forskarpatent from the start in 1994 until the autumn 1997. Even though he is the enthusiast starting the business the interview is based on the patent-attorney mainly responsible for the patent-application process, involved and employed at the organisation since it was started. He is, in contrast to the initiator still working at Forskarpatent.

SPIN-OFF - This case is based on an interview with one of the earliest "spin-off entrepreneurs" from Linköping university, Per Rowa. He was one of four owner managers of Innovativ Vision emerged as early as in 1983. At that time there were no specific activities facilitating spin-off activities going on at the university. On the contrary, it was the entrepreneurs themselves that initiated some of the support activities that later became SMIL; Business Development in Linköping. Dr Magnus Klofsten, one of the university persons directly involved in the establishment of SMIL and moreover manager for CIE; Centre for

Innovation and Entrepreneurship, established in 1994, represents the academic view of these spin-off activities.

SERVICES IN GENERAL - Linköping University is the only university in Sweden that offers distance education by means of the terrestrial television broadcasting network. The Centre for Continuing and Distance Education, U-link, which was established in the beginning of the 90's allocated at Mjärdevi Science Park a close neighbour to the university is responsible for these. The case is based on interviews with the initiator and executive manager for U-link between 1989-1997, a project manager at U-link and the informant at the Regional Social Insurance office (which has been a major customer to U-Link).

3.6.3f Wales

Six different types of academic entrepreneur were identified in Wales. Three different types of spin-off activity were examined - the 'individual' spin-off entrepreneur, the 'campus company' entrepreneur and the 'department-led' spin-off entrepreneur. The other three types were the consultant entrepreneur, the contract research entrepreneur and the medical entrepreneur (who was involved in a number of entrepreneurial activities).

'INDIVIDUAL' SPIN-OFF ENTREPRENEUR - This electronic and materials engineering professor was previously employed (i.e. pre-academic career) in a public research establishment and for a time in a small technology-based firm. As well as starting-up his own spin-off company during his academic career, he has also been involved in large scale science projects (having been directly approached by industrial organisations), contract research, consultancy, and external teaching. From the time of his PhD onwards he has always had contacts with industry and perceives the applied side of his research to be by far the most interesting - finding purely academic work 'boring'. His specialist field is magnetic materials, and he is involved in fundamental research that underpins applications (believing strongly that university research should support industry in developing their R&D).

The entrepreneur's spin-off company is a small specialist chemical firm with 2 full-time and 3 part-time employees, plus himself (furthermore, 3 new full-time employees are due to start shortly). The spin-off was set-up via a Teaching Company and is located on a university science park, producing materials for instruments in the oil industry and competing mainly with similar companies in the United States. Indeed, the market is so competitive that the company has steered clear of patenting activities as it would involve publishing research that could then be exploited by these competitors. The entrepreneur believes that, in any case, patenting is not viable for small companies and should be left to large concerns. In this example, the spin-off has a patent contract with a larger company that passes down royalties. According to entrepreneur, patenting is less important than know-how, particularly with regard to manufacturing processes, and it is this knowledge that must be developed and kept-in-house. He also suggested universities should not be involved in patenting and licensing as they are not really aware of what is involved.

THE 'CAMPUS COMPANY' ENTREPRENEUR - This example is that of a geologist who has not been employed outside of the university sector. Previous entrepreneurial experience has involved contract consultancy on an ad hoc basis as a subcontractor for a number of electricity and water authorities, as well as sponsored research from industry and the defence sector. This experience resulted in the setting-up of a campus-based commercial exploitation unit. The entrepreneur's early academic career involved a large amount of field-based projects and short-term contracts for specific projects that grew out of PhD research. Investigations later

shifted to the laboratory and in-house facilities of the university in a bid to generate larger and longer-term research grants and as teaching and publishing pressures mitigated against short-term contract work. The university did not support any of the patent opportunities that the entrepreneur felt arose from research work (yet which were felt could generate substantial royalties for the university). This factor, as well as the personal choice to take advantage of opportunities to translate laboratory research into the commercial world, led to the creation of the commercial unit. It acts as a conduit for expertise within the field of geotechnics, with the profits being channelled back into the unit and the wider academic group for the purchase of equipment and other resources. The unit further provides a good learning experience for students (particularly of case studies and site investigations); supports the funding of PhD students; and helps to bridge gaps for research assistance between contracts. The unit has operated with tremendous success and regularly produces such substantial surpluses that the entrepreneur is currently considering the scope for a stand-alone spin-off company.

THE 'DEPARTMENT-LED' SPIN-OFF ENTREPRENEUR - In this study the entrepreneur has not acted as individualistically as other entrepreneurs, but has formed part of a university-department led team that initiated a spin-off company. The entrepreneur is an engineering professor and the head of faculty within engineering in his university, and has a wide-range of contract research and consultancy experience, in particular with the aerospace and nuclear industries. The spin-off company emerged as a result of industry requiring a modelling and simulation service that was not being met elsewhere, and with the department being repeatedly asked to simulate various situations. During this period the university set up an incubator to facilitate spin-off activities, and in this context the entrepreneur and two other department members created their own company and located it within the incubator. The activities of the company have focused on computer modelling for various industries concerning compressible flow, and have included the development of a collection of software modules, which although were not patented are now used on a worldwide basis. According to the entrepreneur, the motivation for starting the company was to enable himself and his colleagues to stay at the heart and forefront of a rapidly moving field. The company provided the flexibility and manpower that the university environment could not support, and allow the directors to 'put-into-practice' their own experience, and employ research staff on longer contracts than that associated with the department and the university as a whole. Although the spin-off originated because of a gap in the market, finance was still a problem during the setting-up phase. The entrepreneur indicated that during this period banks were reluctant to support three academics with no business track record. Thus, the company was financed purely via its initial contracts that then generated the income to formalise the spin-off and purchase the necessary equipment. The biggest overhead was the company's computer system and this was eventually sponsored by an industrial organisation.

THE CONSULTANT ENTREPRENEUR - Consultancy, along with contract research, has been by far the most common and lucrative area of entrepreneurial activity among academics. In this example an experimental psychology professor has used his knowledge of a number of different subjects in order to act as a consultant to industry on a number of large-scale projects. Although, by his own estimation, he has been criticised by other academics for being a 'jack of all trades and master of none', he has been able to use the earnings from a number of disparate contracts to fund theoretical research in his specialist field. The entrepreneur states that gaining further research money as the main motivation for carrying out consultancy work. Recent projects include: research for a large industrial client on automatic speech recognition for office application; co-ordinating a supplier-chain development programme, bringing together a range of industrial projects; large-scale contract work with the post office on how people learn to type; two current projects with the Defence Evaluation Research Agency (DERA) involved in setting-up of models to examine the performance and control of remotely operated vehicles

such as undersea operations and aircraft control; production design for a number of SMEs. The entrepreneur has also set-up three companies. Two of the companies have subsequently faltered (although purchasers for both were found), while the third was taken over by a venture capitalist, with the entrepreneur being 'edged-out' being edged out of its activities.

THE CONTRACT RESEARCH ENTREPRENEUR - An example of academic involved in large-scale contract research for a number of multi-national companies is that of biology research professor who has maintained and collaborated with a series of industrial partners since first undertaking a research fellowship. This has now extended to position where she collaborates with all the multi-national involved in her field in the UK. Indeed, her initial motivation to undertake commercial and industrial work was prompted by a market opportunity that appeared when a number of 'old' university associates decided to 'go-it-alone' (having previously been employed by multi-nationals) and invited her to become involved in gaining industrial contracts. She now considers her contract research work to be of primary importance in funding new equipment within her department and to leverage further academic research council funding, as well as being a valuable secondary source of income for herself. The entrepreneur considers that she is highly opportunistic, and although her first contracts came from a Japanese company that actively approached her, she admits to spending a significant proportion of her time during the early years of commercial work 'knocking-on-the-door of industry'. She is now in a position where she only takes on contract research for which she considers the results can be academically published, and at present her funding is approximately evenly split between industrial and research council funding. The level of funding is now such that she has a considerable team of university researchers contracted solely to her projects. Therefore, although the activities started out as very much as a venture that revolved around her individual ambitions, it quickly evolved into a team approach.

In recent years the entrepreneur has concentrated on contract research projects involving multiple industrial partners, with herself having a key role in their overall co-ordination. The largest project at present involves ten industrial partners, and the entrepreneur has taken a large degree of responsibility for agreeing: timetables; budgets; and the publication of results. The project is operating over four years and, according to the entrepreneur, has estimated revenue of seven hundred and fifty thousand US dollars per annum. The operation is being carried out on various international sites and this has enabled the entrepreneur to assemble a 'workforce' at her own particular institution that is distinctively international in its make-up. The entrepreneur was of the opinion that the results of projects were such that it is highly likely that her contract will be renewed for a further considerable period.

THE MEDICAL ENTREPRENEUR - This study concerns a clinical trials professor, who while on sabbatical in North America came across the concept of setting-up a centre specialising in wound healing. Before becoming involved in academia the entrepreneur had ten years experience working in a clinic and general practice, and it was in this arena that he first undertook a degree of entrepreneurship by putting in place procedures to stimulate significant growth both in the number of patients and income. During his early academic career he instigated a lecture and seminar series for 'external' doctors for which he managed to gain commercial sponsorship. These contacts resulted in the development of small-scale research studies, and subsequently larger projects. It was such commercial support that was the key to developing the centre, which is now the largest in the world (with more than 40 members of staff). As well as being primarily a 'testing' establishment, the centre also undertakes other postgraduate and franchised research, and has significantly contributed to developing the credibility of research in the field of wound healing. The current work of the centre and the entrepreneur involves 'double-blind' controlled drug trials and the development of a swallowing test for a multi-national pharmaceutical company.

The relationship between the entrepreneur and the university has been fairly mixed, with the university agreeing to the centre being set-up on its property (on a no-fee basis) as long it was otherwise self-funding. However, the centre now operates on three sites (one of which has particularly high rental costs), as well as giving practical experience to a significant number of research students. During the time the centre was being set-up no ILO or equivalent existed within the entrepreneur's establishment, a role which he considered to be of particular importance to gaining commercial and industrial funding. In response to this, the entrepreneur actually took on the role of part-time manager with regard to the university's commercial affairs. This position has evolved, particularly due to the success of the centre, into two full-time jobs. Despite the entrepreneur's involvement in the university's institutional framework the centre has remained as its own cost centre, operating as a division of the department.

3.7 Summary

This section has examined the main results of the project, describing the different methodologies utilised during the research. The research undertaken during the four stages has broken new ground in terms of the phenomena examined. The study of the industrial liaison function within different regional and institutional settings is one of the most detailed examinations of institutional policy and practice towards academic-industry relationships. It is certainly one of the first studies of the function and role of the industrial liaison office in developing university linkages with industrial firms. The survey of 4672 academics is probably the most comprehensive survey of the phenomenon of academic entrepreneurship undertaken within Europe. The results demonstrate that academics have more entrepreneurial experience and are more entrepreneurial than previously thought. It has also widened the concept of academic entrepreneurship away from spin-off firms to all types of technology transfer activities. With regard to the wealth of case study material generated, both types of cases - individual and institutional - provide valuable data on the proactive role that universities and academics can play in the development of further links with industry.

4. CONCLUSIONS AND POLICY IMPLICATIONS

4.1 Introduction

This section of the report will examine the main implications of the results of the study. Where appropriate, implications for policy initiatives at an institutional, local, regional and European level will be determined. An agenda for the development of future research studies to build on this programme of research will also be considered.

4.2 The role of the industrial liaison function.

The study has indicated that there are a number of different models of organising the industrial liaison function within different regions of Europe. Within countries such as Spain, Portugal and Finland, only the most basic tasks are undertaken by the ILO function, whilst in countries such as Wales and Ireland, where the ILO function is an integral part of the university administrative system, there may be higher level tasks undertaken.

However, it is clear that these particular models have not been deliberately chosen as part of a definitive strategy, by the institution, to develop linkages with industrial firms. Rather, the process has been largely reactive, reflecting current administrative models or, in some cases, being driven by European funding initiatives to work with industry. The ILOs also undertake a number of functions, which also tend to vary across institutions. Again, many of these technology transfer functions tend to be developed reactively rather than proactively as part of a coherent strategic aim of the university to match its particular institutional strengths to the needs of the firms.

At an institutional level, this reflects, to some extent, the haphazard organisation of innovation at a regional level before the arrival of programmes such as RITTS and RIS. Whilst there are successful models of a strong ILO structure, particularly in Sweden, there is no guarantee that such a model could be transferred successfully to a rural region or a smaller, less technologically-oriented university, as the local needs for technology transfer differ widely across regions. In addition, the ability (and structure) of institutions to provide technology transfer capabilities to local firms can also vary.

To this extent, one policy proposal, which arises from this study, is that the European Commission should authorise research to examine the feasibility of establishing a new policy support programme - UNITTS (University Technology Transfer Strategy). Based on the same structure as the RITTS programme (albeit on an institutional and not regional level), this initiative would enable universities to develop a specific technology transfer strategy that would be relevant to the needs of local firms, as well as international organisations. This approach may benefit the heterogeneous nature of the university sector in relation to its local industrial environment (witness the success of Cambridge and the many failed attempts to re-create the ‘phenomenon’). This could lead to a review of a number of important issues at an institutional level, including:

- **the most relevant organisational form for the industrial liaison function. This could range from a full integration into the administrative system of the university, to complete decentralisation to departments.**
- **the resources required to establish such a system, and to manage issues such as lack of funding and of staff time to foster industrial linkages**

- **the development of an adequate reward system which reflects the income generating activities of academics involved with industry**
- **a strategy for outlining universities' expertise and relevance to small firms and how this can be incorporated into a mutually beneficial partnership between the SME and the academic researcher**

It is unlikely that any of these issues could be resolved at a regional or national level. Instead, they must reflect institutional and local conditions. The development of such a programme may also be able to contribute to solving some of the main cultural problems inherent in many academic-industry relationships, and would address the low incidence of collaboration with local small firms. It would also complement the activities of one of the main RITTS strands, namely the support for technology parks and local technological resource centres.

Given the lack of funding and support for such activities, it is evident that within many institutions, the industrial liaison function is not seen as an important part of the overall administration of many universities. This is despite the ILO function being the primary official route by which links between the academic institution and external organisations are formed. Indeed, within some universities, the linkages with industrial firms are driven at the departmental level, often because of an absence of any substantial administrative support by the core. In many instances, this is due to a lack of resources being made available to support the industrial liaison function.

Internal marketing procedures were also considered to be inadequate in the majority of universities examined. The minimum degree of internal effort towards this process should ensure the university should be geared towards further integration between the industrial liaison function and academic departments so as to encourage a two-way process of communication. Whilst ILOs need to be informed of academics' specific expertise and requirements, academics must also be aware of the full range of facilities and services offered at their institution to help them in their industry-related activities. One option is for an accreditation system, administered from the Commission, which would deliver the minimum standards for the role of industrial liaison function within European universities.

In the absence of any professional body for ILOs, the Commission could also encourage the formation of such an organisation, which would take responsibility for the accreditation process and disseminate 'good practice' of different initiatives throughout EC institutions. This would, eventually, result in a more structured support system whereby all academics are made aware and are constantly informed of new developments regarding support services on commercial issues and are provided with encouragement and active support when efforts are made to forge links with potential industrial partners.

On an institutional level, it was considered that there was not enough emphasis, especially in terms of internal funding within the university, to sufficiently develop linkages with industry. As stated earlier, it was considered that, overall, there was a lack of a proper infrastructure for developing academic-industry collaborative activities, especially in the marketing of research expertise. It was felt that universities were not, in general, proactive enough, and there were not enough promotional activities to ensure businesses' awareness of the expertise available.

Another finding, which reflects previous research in the area of university-industry links, is the gap of knowledge, by researchers and industrialists, about each other's organisational cultures. These cultural differences are mainly down to a lack of communication by both researchers and industrialists about the advantages (and disadvantages) of collaborative activities. It was

therefore evident that there was a need to set up guidelines as part of a policy for industry working with a university, with a particular need to increase awareness, and to market the university in a more professional light. Great potential does exist within many countries for increased university-industry collaboration⁵⁷. The reasons why this potential has not been fully realised include a lack of information about these activities, coupled with the fact that such arrangements have never been previously considered by university authorities. This is clearly one area where policy makers can influence further developments by providing more information on the potential benefits of such relationships. For example, one clear benefit for industry from universities is the provision of highly trained and technologically literate graduates who will become the labour force of scientists, engineers and technicians, and provide the key ingredient for the growth of technologically advanced industrial centres⁵⁸.

At a national (or international level), the European Commission could take the lead on recognising the importance of industrial research for assessment or promotion exercises, giving it at least equal weight with teaching and basic research activities. More importantly, through the various Innovation programmes, it could help and encourage the spirit of entrepreneurship within the academic sector. However, one also needs to take into account (as will be discussed later) that not all academics may be suited to working with industry, as not all academics are suited to undertaking both teaching and research activities. Universities must respect the position of individuals who have become lecturers or researchers in order to create or disseminate knowledge to the student or academic population. However, for those who wish to develop linkages with industrial firms, the university must give as much support to the pursuit of this 'third function' as it would to the other two roles of the university. In particular, incentives for working with industry must, at least at an institutional level, be equivalent to incentives for teaching and basic research. Therefore, on an individual level, academic staff currently undertaking substantial teaching and administrative duties for the university need more time released to assume projects with industrial partners.

4.3. Cases of university good practice

The twenty four cases described have demonstrated that, given the right environment and support, the university sector can become more entrepreneurial, especially if they can exploit internal resources to their optimum advantage. As a result, indigenous research capabilities can be enhanced through initiatives such as attraction of industrial laboratories, networking activities, patenting incentives and the formation of campus companies, which keep researchers in science and technology within the region. In return, the universities can become more innovative, through adopting more practical techniques in teaching and gaining access to high technology industrial laboratory equipment.

One of the key contributory factors contributing to the success of the different initiatives examined appears to be the acknowledgement and incorporation of mutually beneficial activities for all partners involved and an awareness of the economy in which they participate. It is important to note that such initiatives have not been developed on an ad-hoc basis. They have been carefully planned to take advantage of the particular strengths of each university, and a system of procedures, programmes, incentives and policies are necessary to form a successful

⁵⁷ Rees, J. (1991) "State technology programs and industry experience in the United States", *Review of Urban and Regional Development Studies*, Vol. 3, pp. 39-59.

⁵⁸ Gibson, D.V. and Smilor, R.W. (1991) "The role of the research university in creating and sustaining the US Technopolis." In Brett, A.M., Gibson, D.V. and Smilor, R.W. (eds.), *University spin-off companies - economic development, faculty entrepreneurs and technology transfer*, Rowman and Littlefield Publishers, Savage, Maryland, pp. 31-70.

technology transfer mechanism between universities and businesses. As a result, if any single initiative is to succeed, it must fully acknowledge the economic implications for all parties and the kinds of approaches that would be most beneficial to all partners in view of their position and role within the economy. The keyword for success seems to be mutual benefit'. The various university initiatives all illustrate this in practice as they all addressed the problem in a different way in relation to their specific needs, specialisms and resources. This is naturally a practical technique that could be transferred elsewhere, as innovation is evidently the key in responding successfully to a lack of resources (especially within the university sector). This conclusion reinforces the development of a specific policy instrument that will aid universities in determining a specific strategy towards the development of academic-industry linkages within their own locality.

Therefore, it is imperative that there is both an awareness of the structure of the local and national economy and of mutually beneficial activities for all partners within any initiative aimed at further developing universities' collaboration with industry. As stated earlier, however, there can be considerable cultural problems in developing such relationships. However, as some of the cases demonstrate, whilst industry's confidentiality and ownership requirements need to be respected, compromises should be sought wherever possible.

It can be argued that many successful initiatives require originality if they are to be interesting and attractive to potential participants. Despite this, the study indicates that there are common 'types' of initiative, all of which have been developed independently of each other. Many of these initiatives could have learnt from each other's development - for example, campus companies development programmes usually have very much the same content, although the context is adjusted to local or regional circumstances. As suggested in section 4.2, a membership organisation of ILOs could be one policy instrument in ensuring that universities can learn from each other's initiatives.

The research suggests that on the whole, policy-makers at European and national levels have tended not to focus on developing mechanisms or instruments to strengthen the links between academic institutions and other actors in the innovation system, leaving much of the activity to individual universities. As a result, not only has there been a considerable 're-inventing of the wheel' in the development of various initiatives by universities working independently of each other. In addition, there has also been an opportunity lost in the dissemination of 'good practice' of technology transfer initiatives, a technique that is strongly supported by the European Commission's Action Plan for Innovation⁵⁹.

Therefore, another policy suggestion for the European Commission would be to establish a databank of 'good practice' academic-industry initiatives (not only from Europe, but also globally). Higher educational institutions could then access this following a full strategic review of their links with local industry (as implied earlier) This would avoid duplication of effort in the initial development of many initiatives. Such an approach would follow the philosophy of ADOPT, ADAPT and IMPLEMENT. As a result, the relevance of the different activities to both academic and industrial partners would be considered. The European Commission could also be used to monitor the outcomes of any future initiative. Whilst the stimulation of interaction between academia and industry is interesting, more concrete outcomes, such as increased employment opportunities, collaborative research contracts or funding for consultancy work are all potential

⁵⁹ European Commission (1996) *The First Action Plan for Innovation in Europe - Innovation for Growth and Employment*, European Commission, Brussels.

outcomes realised by the case studies of university-led initiatives discussed in this research.

The various university initiatives examined during this stage of the research also reveal a diversity of mechanisms to reinforce linkages with industry. As the results have shown, these can be grouped according to the different types of initiative developed. Although not possible during this research project, further research needs to be undertaken to examine the characteristics of each type of technology transfer mechanisms, and concentrating on similarities and differences in each scheme. This may lead to a 'best practice' guide for each particular type of initiative, especially if this is best on case study material of 'good practice' from different institutional settings. However, as will be discussed later, this institutional (as well as regional) context needs to be taken into account when developing a new initiative.

The detailed analysis (at both regional and comparative levels) also suggests that three main 'customer groups' can be identified in relation to develop closer academic-industry links:

- students and graduates (training/career services; graduate enterprise programmes)
- academics (campus companies, entrepreneurship training, patenting/licensing).
- firms (firm birth, networking and technology transfer, research contract service provision and training)

Two of these markets, students/graduates and academics, are essentially internal. As a result, these are probably the types of initiative that many universities would be most comfortable in establishing, assuming that some of the barriers to technology transfer, as discussed earlier, are overcome. The third market - industrial firms - is probably where the university can have the most problems in developing different initiatives, mainly due to the clash in institutional and organisational cultures which exists. This could indicate that the industrial liaison function within the university sector should concentrate on the two 'markets' with which it has direct contact.

Liaison activities with firms should be left to an external organisation that acts as a true bridge between the two institutions. However, given the plethora of such organisations already in existence, then this could lead to further confusion among potential customers for university services. Indeed, as the Action Plan for Innovation points out⁶⁰, businesses, particularly smaller firms, often get lost amongst the plethora of support services which have burgeoned at local, regional, national and Community level. **Given their reluctance to become involved with the university sector for other reasons, the emergence of another support organisation may add to the confusion. However, if such an organisation was operated on a regional basis (and within a regional innovation strategy), acting as the 'liaison-animateur' for all universities, then such an organisation may be possible. Another option would be for the universities to form closer links with Business Innovation Centres (BICs)⁶¹, which have been shown to be a successful vehicle for technology transfer in Europe - the study shows that this approach has been very successful in Dublin.** Therefore, collaboration between universities and enterprise support organisations may be strategy for future development, particularly within smaller countries.

⁶⁰ European Commission (1996) *The First Action Plan for Innovation in Europe - Innovation for Growth and Employment*, European Commission, Brussels.

⁶¹ Fahey, D.C.W. (1997) *European Business Innovation Centres as Regional Innovation Systems*, Paper presented at the Regional Studies Association Conference, Frankfurt (Oder), September 20th-23rd.

SMEs are an important characteristic of the economy and universities in all regions in the study have acknowledged this fact through the development of initiatives to support technology transfer to this sector. However, it is clear that this kind of effort requires considerable resources from both partners - the university and the small firm. **This is another area where the European Commission could make a direct policy intervention - by making finance available to support interaction between local small firms and academia (without the concept of subsidiarity applying as it does for numerous Framework programmes). It is imperative that universities develop links with local firms first, before attracting international SMEs to any future research project.**

Therefore, the previous stage of research allows for the identification of a diversity in terms of policy and forms of interaction with society adopted by each of the universities. The variations detected have been associated to the effects exerted by the combination of historical, cultural and organisational features of the universities and the characteristics of the regions where they are located. The perception of these effects was reinforced by the case studies carried out at the present stage.

While the cases examined can be grouped according to function and market, the diversity encountered in this study actually reveals a deliberate effort to adapt to both structural and regional circumstances. In particular, the nature of initiatives examined is affected by differences existing in national and regional institutional contexts, namely in what concerns either the role of central, regional and local government or the role of the private sector. The relevance of the private sphere is well illustrated in the Welsh and Spanish cases. There is evidence that public policies involving different agents (academia, financing institutions, firms, etc.) and aimed at the development of a shared perception of the role of innovation systems should be promoted. Some of the studied cases, presenting support programmes, debate schemes aimed at the dissemination of ideas or financing initiatives (even if indirectly, such as the case of INEGI at the University of Porto) may contribute to this view.

Therefore, the diversity stemming from both different target groups and the need to adapt to structural and conjunctural circumstances leads to the conclusion that the European Commission should define strategic objectives and guidelines for academic-industry linkages, but the design of policy should be left to either regional bodies or the universities themselves.

4.5. A survey of academic entrepreneurship

In terms of initiating contacts with industry, universities tended to be slightly more reactive (than proactive) to the needs of industry. While this may suggest a demand-led technology transfer system, it is also probable that there is a distinct lack of marketing, by universities, of the services they can offer, as academic institutions, to industry.

In terms of general policy implications, the most interesting finding is probably the high degree of consultancy and contract research activity in each country. This has been identified as the type of entrepreneurial activity, which can, if the right mechanisms are in place, lead to a technology-based spin-off being established⁶². However, given the low degree of spin-off incidence in this study, it would seem that the programmes and support might not be in place in sufficient quantity for this to occur.

⁶² Westhead, P. and Storey, D. (1994), *An assessment of firms located on and off science parks in the United Kingdom*, HMSO, London.

On the other hand, many academics may be satisfied with undertaking 'low-level' activities such as consultancy to gain extra income without the trials and tribulations of starting a new business. Obviously, it is in the interest of both the academic institutions and industrial partners to determine which activities can be further developed within their own institutional and regional setting. More importantly, they need to determine whether the support mechanisms in place will encourage or hold back certain types of entrepreneurial activities. **Given that most of the support mechanisms at a European and national level encourage the direct establishment of spin-off firms⁶³ there needs to be a thorough understanding of the types of activities which academics wish to become involved with at an initial stage before, eventually, moving to organisational development. If spin-offs are to be encouraged, then the relative success of Sweden in generating such organisations may generate models of 'good practice' of such business development, as other parts of the research has demonstrated.**

Given the more sophisticated level of policies and mechanisms to support university-industry links within Sweden, it was an unexpected result of the study to discover that other countries' academics (with a relatively less-developed system of support) had an equal, if not greater, involvement in a number of entrepreneurial activities. Obviously, this research can only give us a quantitative analysis of the degree of entrepreneurial activity within these universities. A more qualitative, in-depth study may reveal the extent of the value and impact of these relationships to both the university and industry. However, if future data does support some of the findings in this study, it may be necessary need to re-evaluate the impact of direct interventionist policies on the development of entrepreneurial activities within universities.

The implications of the increasing pressures to institutionalise entrepreneurship (especially informal activities such as consultancy) within the university environment may actually result in a decrease in these activities. This may be particularly the case within economies such as Ireland, where universities have tended to exert little control over university-industry links and, as a result, entrepreneurial activities have developed naturally as a result of the needs of both the individual academic and the industrial firms. For example, whilst academic entrepreneurship in Sweden has been encouraged as a result of 'top-down' strategies through institutional reforms and initiatives, the Irish approach has been one of 'laissez-faire'. As a result, academics have been allowed to develop their own initiatives relative to their own interests. However, it is worth noting that both countries have a high degree of academic entrepreneurship, and the differences observed may be due to cultural, as well as economic, differences between the two countries.

Overall, about half of the respondents considered their university environment supportive for academic entrepreneurship, with only one in ten stating that the environment is a direct hindrance for such activities. The high proportion of academics - 40% - describing their university environment as having no effect on their activities, despite the existence of an industrial liaison function at each institution, is particularly surprising. Therefore, whilst half of the respondents considered their university environment to be supportive, the remainder consider themselves not supported at all in their entrepreneurial activities. This is unexpected, considering the present climate described earlier with institutions actively developing linkages with industry through proactive technology transfer initiatives. Another interesting result is that the respondents from Sweden were most negative towards the university environment. This is despite the fact that it the one country in the study where linkages between universities and industry are well developed.

⁶³ European Commission (1995) *Green Paper on Innovation - communication from Mrs Cresson and Mr Bangemann, in agreement with Mr Papoutsis*, Directorate XIII/D, European Commission, Luxembourg.

Whilst 65% of the respondents were aware of the ILO function, only a small number actually utilised the ILO in developing external links. This suggests that many academics are bypassing the industrial liaison function within the university and dealing directly with the industrial firms themselves. This calls into question the actual role of the ILO within the university. If academics and university departments are most comfortable in working directly with industry, then the industrial liaison function should be left merely as an administrative position to deal with issues such as contract management and information on European programmes. However, on average, only a small proportion of those respondents who were aware of the industrial liaison office actually used it in developing external links, although this does rise to nearly half of the respondents in Spain and Northern Ireland. This probably reflects the nature of the industrial liaison function in Spain itself (via the OTRI system)

Whilst there are differences between regions, the study demonstrates that across all institutions studied, previous employment outside the university sector or previous small business experience has a positive effect on the likelihood of academics engaging in contact with industry. This is not surprising, as it would be expected that academics with previous industrial experience would utilise industry contacts made during their employment or, in some cases, be given contract work directly by their previous organisation. Previous small business experience would also encourage academics to become entrepreneurial, especially outside of normal duties such as teaching and research. This finding suggests that experience of industry is highly important in developing linkages with firms. Depending on the mission of the individual department or university, such a finding could have implications for employment policies, especially if the institution is looking to develop stronger links with industry. **It also suggests that a 'placement' for existing staff within industry for a period (similar to the TMR/HUMCAP programme) could be beneficial in developing strong attitudes among academics for developing links with industry.**

Academics have informed opinions about their university's supporting environment towards academic entrepreneurship activities irrespective of direct contacts with industry, although it was found that respondents who had direct contacts with industry tended to be more aware of the ILO. Despite this, it is also significant to notice that whilst the majority of staff find the university system supportive of activities. However, those with an earlier employment outside the university sector find the university climate as a hindrance to the development of academic entrepreneurship. This probably reflects the difference in cultures between the two types of institution, with the academic who has worked within industry being most critical of support structures.

Overall, the use of their university's industrial liaison function has a direct influence on academics' perceptions about the supportiveness of their university environment towards academic entrepreneurship. This finding is particularly interesting because it enables an informed evaluation to be made as to respondents' opinions about their university environment by considering the opinions of only those who have used their ILO in developing external linkages. This suggests, as other parts of the study have indicated, that whilst the services offered by the ILO function may be relevant to developing technology transfer linkages with industry, there needs to be a greater awareness, through internal marketing, of the role of the ILO in facilitating such relationships. This result is of varying importance to different countries. For example, in Finland and Sweden, the contacts between academics and the ILO are very rare, with very few of respondent group using the ILO services. On the other hand, in Spain and Northern Ireland, where many respondents have used the ILO services, the result is more relevant. In these universities, the ILO could be increasingly utilised as a catalyst for developing a more positive university culture towards academic entrepreneurship.

Finally, it can be seen that the majority of academic entrepreneurship activities tend to be undertaken by professorial or senior lecturing staff with a Ph.D. This is not surprising as senior academics with a higher degree should be individuals with more experience, influence and position where it is easier to influence resources for undertaking external activities. It is also worth noting that building up a personal network (which is important for all kinds of contacts and collaboration) can take a number of years. **However, institutions should consider whether younger staff members could become increasingly involved in entrepreneurial activities as part of their training process.**

4.6 Cases of Academic Entrepreneurship

This report illustrates thirty seven examples of successful university-industry interaction from six different countries. The cases were selected to illustrate a diversity of forms of university-industry interaction. The main conclusions from this part of the work can be discussed on several levels, including that of the individual academic, the relationship with both the university and industry, and the benefits and barriers to university-industry linkages. This reflects much of the previous work undertaken in the project to date, albeit on a more detailed level.

Analysis of the cases has found that one of the most important factors in the success of any academic entrepreneurial activity in any of the universities studied is the presence of motivated and driven academics. However, apart from the individual academics who establish their own organisations (such as Iona Technologies), such individuals will continue to work within the university institution. Whilst they are very similar to entrepreneurs in that they take personal risks to make new ideas and innovation happen, they still rely on the university for their position and salary. In addition, the sets of skills that define the academic entrepreneur are quite different to the skills needed by either the traditional entrepreneur. For example, unlike traditional entrepreneurs, academic entrepreneurs will need team-building skills and a firm understanding of corporate organisational realities within the university, whilst also possessing the leadership and rapid decision-making qualities of successful owner-managers. Therefore, in developing academic entrepreneurs, the task for university managers is to identify those individuals that possess (or can achieve) both entrepreneurial skills and the managerial skills to manage a project within the boundaries of a large organisation. Therefore, an academic entrepreneur in this study could be described as an academic who has the entrepreneurial qualities of drive, creativity, vision and ambition, but who prefers, if possible, to remain within the security of the university.

The presence of successful academic entrepreneurs can often overcome many of the internal obstacles in developing links with industry. The development of the initiative can also be helped enormously by supportive colleagues and a supportive department, which can allow individual academics to overcome any resistance from within the university. The attitude of the academic towards external organisations can also be an important factor in building linkages with industry. As the previous research has indicated, many firms are often reluctant to approach the university sector for solutions to technical problems. However, the correct approach by the individual academic can convince the firm to work with the university department. More importantly, the success of such individuals' endeavour could be utilised in increasing the links with industry within the university. The presence of such successful 'role-models' of entrepreneurial success can be used by the institution to encourage other academics to develop academic entrepreneurship activities. This should be undertaken by the ILO as part of an overall internal marketing process to encourage academic-industry links.

As stated earlier, the benefits of industrial research to the academic can be additional funding for new equipment and other research resources. However, the cases also clearly demonstrate that entrepreneurial activities can result in a significant degree of personal gain for those individuals involved. However, it is clear that this is not universal across all cases. Whilst the attainment of commercialisation of ideas is often sufficient, the energy and effort expended by the academic entrepreneur in the creation of the new venture needs to be appropriately rewarded. However, as entrepreneurship is a relatively new phenomenon within the academic sector many universities have yet to develop an adequate reward system that is adequate in terms of pay and promotion. In many cases, the traditional reward within a university structure - promotion - is often not sufficient, as the motivation behind the development of the idea is often not career advancement. More importantly, entrepreneurs seldom make good academic managers, as they rarely have the temperament for coping with the university structure. One option for universities, therefore, may be reward entrepreneurial academic is through giving them a position of freedom within the organisation to develop new ideas, or even setting up the academic in a separate venture.

As the cases demonstrate, academic entrepreneurs will often work on their new ideas in their own time, often in addition to other academic duties such as teaching and research. However, the increasing work pressure may stifle the final development of any entrepreneurial idea. Therefore, universities need to make resources available to such individuals in order that these ideas reach the market place more quickly. This can be done by allocating either time or funds to the entrepreneurial academic. Often, if academics cannot find time to make their ideas marketable to either the department or the university, then those ideas will remain in their heads rather than becoming a marketable product, process or service. Once the idea has been shown to be of some value to the organisation, then resources need to be made available to develop this idea to the point where it can be presented to the market-place. If resources, such as time 'bought out' from lecturing duties or discretionary funds, are not available, the academic who is a potential entrepreneur may be becoming frustrated to the point of abandoning the commercialisation of the idea altogether. For the academic climate to be receptive of industry's changing needs, the university in terms of organisational structure and culture must be supportive of these new initiatives. Acceptance of a change in university policy toward enhancing the entrepreneurial environment depends on the degree to which new initiatives enhance the fundamental aspiration of academics. As a general criterion for entrepreneurial initiatives, universities have to examine which incentives can be provided to its personnel which do not interfere, but contribute to the generally long term academic work performed.

Whilst there are examples of good practice within this section of the research, the previous survey indicates that not all academics in a university are capable (or willing to be) successful entrepreneurs. Being an academic entrepreneur is not something that can be assigned to individuals within the university, like other job descriptions such as course administrator or research project manager. In many cases, such individuals are self-selected i.e. they come up with an idea which they will develop further, often in their own time. Entrepreneurship can only be developed within an organisation by creating the right climate for such individuals to flourish⁶⁴.

However, the evidence from this study indicates that, in general, the majority of the academics do not utilise the industrial liaison function within the university. Instead, they form a direct

⁶⁴ Morris, M.H. and Trotter, J.D. (1990) "Institutionalising entrepreneurship in a large company: a case study of AT&T", *Industrial Marketing Management*, Vol. 19, pp. 131-139; Pinchot, G. (1986) *Intrapreneuring* Harper and Row, New York.

relationship with industry, with the university having little or no influence in setting-up contracts or in finding new potential clients. As a result, the gradual build up of trust between academics and industrial partners, based on the achievement of tangible mutual benefits seems to be the key of success. In some cases, the maintenance and development of co-operation activities is deeply rooted in the informality of relationships and in personal contacts.

In most of the universities studied, the role of the ILO is restricted to mainly undertaking administrative functions, with many institutions lacking an infrastructure that is relevant to the needs of the academic entrepreneurs and, more importantly, the industrial clients. As a result, the management of technology transfer work is dealt with largely on an ad hoc basis. The exception is probably Sweden, where the role of the ILO is recognised as the supporter and (in some cases) facilitator and of the entrepreneurial activity, and provider of administrative and technical advice on issues such as Intellectual Property or Licensing Agreements). This probably reflects the loose organisational structure of the industrial liaison function within the Swedish university system, with all external activities driven through departments or individual academics, but organised and supported under an umbrella organisation which is not strictly part of the university administrative hierarchy.

This report shows that there are significant barriers and difficulties experienced by individual academics when they become involved with industry. Principal among these difficulties is the considerable difference between a traditional university culture and an entrepreneurial culture, with the former having an emphasis on a system that tends to favour caution in decision-making. For example, universities rarely operate on a 'gut-feeling' for the market-place, as many entrepreneurs do. Risky decisions are often postponed until enough hard facts can be gathered or a consultant hired to provide extra advice and information. As a result of such a culture, large organisations will often face difficulties in attracting suitably entrepreneurial staff. Moreover, universities may discourage the employment and advancement of entrepreneurial individuals. This is because the presence of entrepreneurs within a large company could possibly alienate other academics within the organisation, especially if those individuals' career development is dependent upon conforming to the accepted structures and norms of the corporation, where promotion is normally based on success in teaching, administration or basic research. There is also the hierarchical nature of academic organisation itself, where the established procedures, reporting systems, lines of authority, and control mechanisms of a traditional organisation are there to support the existing management structure, and not to promote creativity and innovation. Finally, the performance standards imposed by large organisations, especially in the short-term, may adversely affect the development of entrepreneurial projects, many of which are long-term in nature. In many large organisations, short-term gains are generally used as the main measurement of success. Within public sector institutions such as universities, there are obvious fiscal targets and performance measures that need to be achieved every academic year. This will lead to pressure on managers to devise short-term strategies rather than look to long-term investment. Entrepreneurial activities, especially innovative new projects, will take time to develop sufficiently, and a short-term policy attitude will lead to problems with regard to financing such projects.

There are therefore considerable differences in organisations, cultures and missions, not only in the reality of the institutional framework, but also in the perception of the academics in all of these entities as to what their goal is and what are the resultant behaviours and decision-making processes. As discussed earlier, industrial partners saw different problems compared to those seen by the academics, and as recent research indicates⁶⁵, the challenge is to match these. While

⁶⁵ Scott, N.R. (1998) "Strategy for activating university research", *Technological Forecasting and Social Change*, Vol. 47, No 3, pp. 217-220

academics frequently believed their technological ideas had commercial potential on a global scale, industrial partners often complained that these ideas had not been fully researched for commercial viability. This caused conflict as the industry players focus on marketing and balance sheets, while academics tend to place more emphasis on researching new ideas. **However, albeit on a personal and ad-hoc basis, some academics are becoming more commercially aware, although universities (and other policy-makers) may need to develop specific programmes to encourage this further. This could involve a secondment or placement within and industrial organisation. Whilst it is clear that universities must not abandon teaching and basic research, it must, nevertheless apply the same professional standards to the transfer of technology to industry as it does to the other two functions.**

The cases described in this report show that university-industry linkages can be very successful for both the industrial and academic partners. There are considerable benefits for both partners, especially through a greater understanding of each others milieus, values and cultures which, as has been repeatedly emphasised, is fundamental to be able to success in academic-industry partnership. The development of such partnerships do take time and patience and as a result, there needs to be a longer term philosophy towards the success of academic-industry collaborative ventures. The adoption, by the university, of a purely 'market-oriented' approach may lead to a focus on short-term market performance, in order to 'prove' the success of the new venture. Therefore, the university must be prepared to establish a long time horizon for evaluating the success of individual ventures as well as the overall entrepreneurship programme. An entrepreneurial climate should not be established within an organisation unless it is willing to invest money with no expectation of return over a number of years. It is also important that ideas are allowed to develop fully, and that the resources allocated to such entrepreneurial project are not withdrawn before that idea has progressed to commercialisation.

Most academics emphasised the importance of identifying industrial linkages that provide a benefit to both partners. Consequently the choice of industry partner is critical to ensuring that the academic achieves the expected benefit from the project. The benefits identified by most of the academics in this study include the focusing of the research activities of the university on the needs of industry, funding for research activity, facilities and research staff, improved teaching within the university and increased job opportunities for graduates, and the development of new knowledge within the university.

The benefits described by industry partners relate to the solving of specific industrial and commercial problems. In the majority of cases, the industrial partner measured the success of the university-industry linkage in terms of the delivery by the academic of a solution to a specific short-term industrial problem. Few identified the development of an ongoing linkage with the academic as a critical benefit of the project. Overall the industrial partners did not identify problems in working with universities and academics such as a lack of professionalism or poor project management. The industrial partners of those entrepreneurs were, obviously, aware that these academics are in possession of skills than can be commercially utilised and have thus placed a high degree of value on nurturing these relationships. However, a number of industrial partners did state that they initially had a 'culture-shock' when first dealing with universities, particularly in respect of time-scales and project scheduling.

Therefore the examination of the case studies of academic-industry interactions supports similar findings from other parts of the research, that most important condition for successful university-industry interactions is the ability to understand each other's cultures and values. This is a fundamental issue, among all participant countries, in the development of successful co-operation between the academic and the industrialist. There are still some basic misconceptions, by both parties, of each other's attitudes towards collaboration. However, the

development of such an understanding, based on the achievement of tangible mutual benefits, seems to be the key to the success of any venture. From the examination of these cases, it is also clear that many of the initiatives have taken place despite the university, and the industrial liaison function. As a result, the actual strategy of the university (and the role of the industrial liaison function) needs to be clearly defined.

4.7 Conclusion

This study has established a new and detailed picture of the state of academic entrepreneurship within the different regions of Europe. It has shown that there academic entrepreneurship is a phenomenon which exists in a range of different institutional and regional settings, often having to overcome the same barriers for success in all countries. Most importantly, it has ascertained that there is a strong potential for developing increased university industry linkages across Europe IF the right institutional policies can be put into place. In general, the study does demonstrate that policy-makers at European, national and regional level have generally neglected the proactive role that the university itself can play in developing strong linkages with industry. Instead, individual universities have had to, independently of any regional strategy for innovation, develop the mechanisms for academic-industry links.

At a European level, universities are appreciated as important partners within the Framework programmes and other policy initiatives to strengthen the science base of the European Union. However, with regard to the dissemination and absorption of knowledge, and addressing the crucial issue of commercialisation of this science base, there has been no coherent strategy undertaken to increase the process of technology transfer from academia into European business. With the increasing complexity and diversity of technology and technological practices, it is imperative that universities and other research organisations are supported in their efforts. However, the study clearly demonstrates that in terms of developing policy initiatives to establish closer academic-industry links, and to get closer to the 'holy grail' of a perfect system of technology transfer from the science base into the market-place, the role of the European Commission should be essentially as a facilitator. The study has demonstrated that for any initiative to succeed, it makes take into account the local circumstances - for both university and the industrial partners. Policy instruments will only work if they are applied at the level of the institution.

Therefore, the main policy recommendation from this study, which is supported through the variety of different studies and methodological approaches, is for universities to develop their own individual strategies which reflect their strengths and the needs of local (as well as international) industrial firms. The European Commission could facilitate this action by developing a programme similar to the RITTS initiative that would part-fund the employment of independent consultants to determine an appropriate technology transfer strategy for the university. This would overcome many of the other problems, relating to academic-industry relations, which have been encountered in this study, especially with regard to the structure for industrial liaison and the barriers to closer collaboration. For example, recent research has called for universities to evaluate key researchers and facilities in order to develop industrially relevant research⁶⁶. Such an initiative would help to facilitate this development.

The study also shows the importance of focusing on, and developing, the efficiency and effectiveness of the different forms of technology transfer in order to bridge the gap between

⁶⁶ Lopez, W.H. (1998) 'How universities can organize to support industrially relevant research effectively' *Technological Forecasting and Social Change*, Vol. 47., No 3, pp. 225-228.

university research, technological development activities and the commercial market. Whilst the impact of scientific research might be the formation of skills and competences necessary to develop and use science-based research, perhaps what seems to be missing in some of the universities examined in the study to date is a lack of experience and expertise in the exploitation of science and technology. Another complementary measure for this programme, again to be developed by the Commission, would be the establishment of a databank of good university practice, which the above initiative could draw on in developing relevant policy initiatives. The cases of good practice highlighted in the research of successful university-industry relationship could, obviously, be adopted and adapted by other institutions. However, this diffusion of 'good-practice' may be dependent on whether these organisations are flexible and innovative enough to be able to absorb such policy changes. Indeed, whilst new forms of organisation are needed to interact with external actors, the analysis of the data from universities suggest that the skills related to co-operation and building relationships may be lacking in a number of universities.

The Commission could also initiate a new professional body for European Industrial liaison Functions. This would play the same role that the European Business Network (EBN) does for the Business Innovation Centres (BICs) in Europe. It could take responsibility for minimum accreditation, thus raising standards among ILOs. It could also determine a set of guidelines for working with industry in an attempt to break down the cultural barriers that have been prevalent in all stages of this research project.

In terms of more general policy issues, the European Commission could influence national educational bodies within member States to recognise the importance of collaborative work with industry. It could also encourage greater university-industry linkages through the Fifth Framework programme. Indeed, whilst it is widely acknowledged that the age of 'science push' as the dominant influence on innovation policy has passed, there remains a vacuum in terms of Europe-wide policy initiatives to address the crucial issue of increasing the dissemination of the technologies from the research sector to the commercial sector. To a large extent, this has continued through to the planned proposals for the Fifth Framework programmes. Whilst it can be argued that some of the horizontal initiatives, such as "Innovation and the participation of SMEs", and "Improving human potential" could be applied within the context of the development of closer links between industry and academia, there is no specific proposal which attempts to address, on a European policy level, this vitally important issue. In particular, the European Commission could make further resources available to support interaction between small firms and academia. However, this should be based at a local, rather than international level.

The study also demonstrates that academic entrepreneurship is not merely related to the development of 'campus companies' or 'spin-off firms'. Many academics have no desire to establish a new organisation and to learn the new competences required to successfully manage an entrepreneurial venture. Instead, they wish to apply their existing technological skills and experience in the context of industry. Currently, one of the main foci of the First Action Plan for Innovation has been the issues of start-up and growth of technology-based enterprises, especially in relation to campus companies. Given that this study (supporting previous research) suggests that the most effective forms of technology transfer are consulting and contract research, the whole issue of the development of 'campus companies', at least in relation to effective technology transfer, needs to be considered in more detail. In particular, increasing the efficiency of collaboration between universities and existing high technology firms should be a priority

A wealth of data has been collected for this study, and there will be an on-going process of re-evaluating and re-analysing this work during the next 12-18 months. In particular, it is expected that the survey data will examine a variety of other questions (not possible during this study), such as the issue of gender on academic entrepreneurship activities, the characteristics of individuals who initiate different types of entrepreneurial ventures, and the types of universities which encourage academics to become entrepreneurial.

5. DISSEMINATION AND EXPLOITATION OF RESULTS

To date, the results have been disseminated through various academic and policy-making channels:

- a series of in-house interim progress reports and working papers. At the end of each stage of the research project, each of the partners has produced a country report. In addition, five comparative reports have been produced for the study. In total, the partners, in addition to an overall report for each country, have produced 40 reports
- a number of articles have appeared in international refereed management journals including R&D Management, Technovation, and European Planning Studies. Book chapters have appeared in 'Technology Policy in Regional Blocks' (editor: A Bartzokas); High Technology based firms in the 1990s, (editor: R. Oakey) Innovation at the Frontiers of Learning (editors: Asheim, B., Lawton-Smith, H. and Simmie, J.)
- papers, from all the partners, have been presented at a series of major international conferences, symposia and workshops, including Research on Innovative Strategies and Entrepreneurship conference, EUNIT International Conference on Industry, Innovation and Territory, Babson College-Kauffman Foundation Entrepreneurship Research Conference, The Future Location of Research in a Triple Helix of University-Industry-Government Relations, Technology Policy and Less Developed R&D Systems in Europe, European Urban and Regional Research Network, 1st International Conference on Technology Policy and Innovation, Fifth International High Technology Small Firms Conference.

A full list of all publications to date is shown in Appendix three.

Future plans for dissemination of the material will include further journal and conference papers. A publication team from the project will meet in Sweden during the Autumn to determine the publication strategy for the project. The co-ordinator is currently in negotiation with various publishers with a view to publishing the main research results during 1999. Individually, it is expected that each partner will make material available to various development and support agencies within their country. For example, the Irish partner is currently discussing with the publication of an Irish review of Academic-Industry relationships, based mainly on the research undertaken within the country, with the main Irish policy think-tank, the National Economic and Social Council.

It is intended that there will be further analysis of the dataset of academics. Further research is required in comparing different variables and various partners, in agreement with the co-ordinator will develop this. This will result in a number of other research papers during the next couple of years. The methodological instruments, along with the main results of the project, will be made available on the World-Wide Web in the autumn. This may encourage other academics to use these instruments to undertake similar research within their institution. Already, South African researchers at the University of Rhodes have adapted the survey instrument to examine the phenomenon of academic entrepreneurship.

The final report will also be widely disseminated to various policy bodies. This may enable some of the policy recommendations to be adopted. In particular, the co-ordinator has discussed the development of a 'databank' of good practice in academic-industry relationships with a number of organisations, including the ILO and IC² (the US-Based technology transfer organisation). The aim will be to develop a web-based site for this in the near future which all universities and academics can access.