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SCIENCE PARKS AND UNIVERSITY-INDUSTRY LINKS:
A CASE-STUDY OF THE SURREY RESEARCH PARK

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I declare that this thesis is the same as
submitted to the University of Sussex.



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UNIVERSITY OF SUSSEX

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DECLARATION

I hereby declare that this thesis has not been submitted, either in the same or different form, to this or any other University for a degree.

Signature: *Conrado F. Dela Cruz*



*To my beloved brother Pedro Luiz,
in his eternity.*

*Special thanks to
Celina Roitman and Vera Lucia Suyama,
for everything you have done for me.*



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"I don't think I am a better person, or even a happier one; but perhaps there has been a small advance" (David Lodge, "Ginger, You're Barmy", Prologue)

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Science Parks and University-Industry Links:A Case-Study of the Surrey Research Park

This thesis concerns the links between industry and university R&D, and the expectation that Science Parks will strengthen their links. It concentrates on the analysis of these links through a case study of a single British Science Park. The research explores the factors affecting the strength of links. It focuses on two issues that have been superficially approached by contemporary studies. The first refers to the key characteristics of Science Park firms that might influence the establishment and strength of their links with the host university. The second relates to the argument, extensively used by advocates of the Science Park mechanism, that geographical proximity between universities and firms will facilitate and strengthen the links between these partners. The field-work is based on personal interviews conducted through questionnaires addressed to the (i) the Park management, (ii) a sample of firms located on the Park, and (iii) a sample of the host university researchers. The study examines a wide range of possible links in three broad categories concerned with (i) formal R&D and consultancy, (ii) human resources, and (iii) informal contacts. The research demonstrates that the links between university and industry in this Park are not profuse. However, the higher the involvement of firms with R&D activity, the higher the possibility of linkage with academe. In addition, through a comparative analysis provided by data related to links established with other universities (from the firms' side) and other firms (from the researchers' point of view), it is shown that geographical proximity between the partners is not an important influence on the existence or strength of links between university and industry.

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CHAPTER 1 - Introduction



The interaction between university and industry (U-I interaction) in areas concerned with science and technology is part of the broader national infrastructure involving other Higher Education Institutions, public and private research organisations and companies that are engaged in the generation, transfer and use of knowledge, information and technology.

This area of the U-I interaction is not new, but it has become more formal, frequent and planned mainly since the 1970's. It has also aroused a growing interest in governments and policy-makers, from both developed and developing countries, who still regard it as an under-utilised scientific-technological resource. It has been argued that the closer interaction between universities and industries may not only generate mutual benefits but also contribute to improving countries' industrial competitiveness.

The implicit argument of this reasoning is that universities, as generators and repositories of scientific knowledge and expertise, could transfer, through articulated mechanisms, at least part of such a stock of knowledge to companies. From the point of view of firms, their interaction with universities could positively contribute to their innovative ability and capacity, and hence, improve their competitive performance. On the other hand, universities could gain extra financial resources for the development of their research projects in periods when their traditional sponsors - governments - operate under financial constraints. In addition, the enlargement and updating of their research agenda through issues related to firms' technical and scientific demands would create a positive stimulus for linkages. It is in this context that both universities and companies, motivated by different purposes, have been stimulated to promote and strengthen their links.

The University-Industry interaction debate has produced a significant bulk of research and literature that may be clustered in several broad categories. One group of mainly descriptive



studies have concentrated on: (a) the observation of the University-Industry interaction in terms of their variation over time and between countries; (b) the examination of this relationship in certain areas of knowledge or specific industrial sectors (e.g. biotechnology) and (c) the managerial aspects of the U-I interaction. Prescriptive studies have focused on such issues as (a) the provision of guidelines for the establishment of the U-I interaction, and (b) the mechanisms that might promote and improve U-I linkages. Finally, more analytical studies have mainly focused on: (a) the examination of the contribution of universities, particularly in terms of their research activity, to the innovative activity of firms, and (b) the more general treatment of factors affecting both the establishment of links between universities and companies and the effectiveness of these linkages.

The necessity of an accurate analysis of the University-Industry relationship has been recognised by experts and policy-makers. For instance, the OECD Committee for Scientific and Technological Policy, in its more recent report (OECD, 1990), stresses that:

...the study notes the striking inadequacy of the quantitative [and also qualitative] analysis of university-industry relations, and the small number of evaluation studies...systematic evaluation of past and current schemes and programmes is acutely needed as a basis for designing revised or new ones....(OECD, 1990:8).

Also,

...little work seems to have been done on assessing the performance of existing relations...generally speaking, there is a regrettable lack of concrete information (i.e. quantitative studies and objective assessments) about the nature of the [U-I] relations (OECD, 1990:16-17).

The difficulty in carrying out analytical studies about the U-I interaction is quite clear: the links established between university and industry are multi-purpose, complex and diversified (OECD, 1984). Moreover, due to the high economic expectation put on these linkages and the political implication they incorporate, a more accurate assessment about these links could provoke "an impact which is not necessarily desirable" (OECD, 1984:13).

Regarding the mechanisms of University-Industry interaction, a substantial part of the literature has been dedicated to Science Parks. A Science Park is "a planned development of high-technology enterprises in an attractive physical environment with close links to a university" (Matthias, 1986:23). This mechanism has usually been examined as a tool of regional development policy. In this respect, several studies (e.g. the reports prepared by the United Kingdom Science Park Association (UKSPA) concerning the British Science Parks) have focused on the aspects of Parks related to regional economic impact. The generation of new jobs, the creation of small technology-based firms, and the revitalisation of the local economy are topics that have received intensive examination by researchers and all those involved with local, regional or national policy and planning.

The importance of universities for the successful implementation and operation of Parks has been strongly emphasised in several studies (e.g. Miller and Côté, 1987; Monck et al, 1988; Luger and Goldstein, 1991; Massey et al, 1992; Westhead and Storey, 1994). In addition, part of these studies has also explored the nature of the links established between firms located on Parks' sites and their host universities. However, as Massey and her colleagues (1992:38) recognise, "the depth of these links is unclear".

Three important aspects of the University-Industry interaction occurring through the Science Park mechanism have not been fully examined by these studies. On the one hand, several aspects related to the links established between on-Park firms and the local university have not been captured by these studies. As a consequence, little has been said about the frequency (or intensity) of these links, and almost nothing about their outputs and their importance to the development of the partners' activities. On the other hand, aspects related to the influence certain characteristics of on-Park firms have on the establishment of their links with the host university have also received little treatment.

Finally, the third aspect that has been neglected in traditional studies of Parks refers to the analysis of the importance, or not, of the geographical proximity between firms and

universities for the promotion and strengthening of their links. Some studies that have been carried out within the British context (as those above mentioned), have superficially approached this point by comparing similar samples of on and off-Park firms and their interaction with the nearby universities. However, nothing has been said in relation to the interaction of on-Park firms and other universities as well as on the university's side of this relationship. Amazingly, the lack of empirical evidence about this particular topic does not prevent policy-makers from extensively using the geographical proximity between the partners as an argument for the justification and stimulation of the establishment of Science Parks.

The studies that have been developed about the University-Industry links and Science Parks have concentrated on the experience of developed countries. However, developing countries have also been strongly motivated - by the same reasons and expectations as those presented in developed countries - to strengthen the interaction between their universities and industry. The establishment of mechanisms as Science Parks has, in the recent years, acquired a greater importance.

There are huge differences between developed and developing countries. For instance, considering the Ibero-American and East European countries, Balázs and Plonski (1994) argue that the industrial structure of that set of countries has not been driven to the promotion of innovative activity. Moreover, when their universities and Research Institutions are able to generate a relatively strong science base, such a base has been completely disconnected from the productive sector. In order to adjust this scenario to a more competitive international milieu, the authors stress that:

In Ibero-America there is a growing governmental attempt to build and strengthen university-industry co-operation through various initiatives in different countries. Typically these involve investment in scientific capacity while developing policies to cope with a turbulent macro-economic environment. In East Europe, science and technology policy has also had to be two-dimensional, first introducing reforms to R&D organisations and second, developing an economic and cultural climate more conducive towards innovation...Models of A-IR [Academic-industry relations] have

also been imported and the spread of science and technology parks, incubators and technology centres is commonplace in both region (Balázs and Plonski, 1994:109-110).

An example of Governmental effort in this area is the Brazilian Programmes for Industrial Competitiveness, Quality and Productivity launched in 1990. These programmes indeed recommend the strengthening of the interaction between university and industry as a means of generating and increasing the Brazilian industrial technology capability. Regarding the establishment of Brazilian Science Parks, Medeiros et al (1992) identify the existence of 19 incubators and Science Parks (Technological Poles) whose activities are those related to the development and transfer of new technology products, processes and services. Also, these authors note the establishment of 11 Poles of Technological Modernisation whose foci are on the traditional industrial segments of the economy.

In the light of these observations and evidence, it is clear that a better understanding of the links between university and industry, and particularly of those taking place in Science Parks, is essential if improvements to relationships and mechanisms are desirable.

The objective of this research is to complement the current studies about University-Industry interaction and Science Parks and illuminate some gaps still present in the literature as mentioned above.

This thesis concerns the links between industry and university R&D, and the expectations that Science Parks will strengthen these links. The research describes the technology-related links of the Science Park firms and the host university. It assesses frequency, or intensity, of links, their outputs and importance for the development of the partners activities, and explores the factors affecting the strength of links. This last aspect is analysed through the observation of the significance of selected characteristics of the Science Park firms as well as through the importance of the geographical proximity between the partners.

This research addresses three broad questions:

- (1) What are the nature, frequency and outputs of linkages established between firms located on a Science Park and the host university?
- (2) What are firms' key characteristics that might influence the establishment of links with universities? To what extent do these characteristics determine the nature and intensity of the links?
- (3) To what extent does the geographical proximity between companies and universities, as proposed by the Science Park mechanism, facilitate the promotion and strengthening of their links?

The research is based on a case-study of a single British Science Park. The choice of this methodology (whose details are expanded on Chapter 4) is because a case-study allows a detailed and in-depth exploration of the links between university and industry in a Science Park. This methodological approach allows a deeper understanding of the type of interaction and mechanism, and complements the current studies in this area.

The Surrey Research Park, located at Guildford, in Southern England, with a sample of its firms and the University of Surrey as the host university, is the case-study of this thesis. The main results of the research derived from the application, through personal interviews, of three different questionnaires, addressed to (a) the Park management; (b) a sample of the firms located on the Park and (c) a sample of researchers from the University of Surrey as well as those responsible for its policy implementation and the business area.

This thesis is structured in two main parts. Chapters 2 and 3 review previous research about the University-Industry interaction (Chapter 2) and about this interaction occurring

through the Science Park mechanism (Chapter 3). Chapters 4 to 7 refer to the empirical study.

Chapter 2 reviews previous research about the possibilities and limitations of the University-Industry interaction. The analysis of the university' functions, of the research activity developed within the university context and the perception and use of this activity from the point of view of companies establish the ways in which the University-Industry interaction might flourish. Information emerging from the history of the University-Industry interaction, through its variation over time and between countries, testifies to the modest contribution universities have provided towards firms' innovative activity. The Chapter goes on to consider what actually occurs in University-Industry interaction. It explores how the U-I links have been systematically assessed since the seventies and what the evidence and limitations are emerging from empirical studies. Finally, the Chapter reviews previous analyses of the specific factors that might influence the establishment of the links between firms and academe. These factors relate to a selected set of key characteristics of firms, the maturity of technological fields and the geographical proximity between the partners.

Chapter 3 deals with the Science Park mechanism. Firstly, the different concepts, participants and objectives of Parks are described. Then, the Chapter presents historical information about the establishment of Science Parks based on the American and European experiences. Finally, the establishment of links between firms and universities through the Science Park mechanism is analysed in the light of available empirical evidence. However, as already stressed, such an analysis has been limited in, at least, three important aspects. The first concerns the lack of a broad exploration of the patterns of linkage between firms and academe through Science Parks (e.g. the frequency, outputs and importance of the links for the partners). The second aspect relates to the lack of consistent analysis about the influence certain characteristics of on-Park firms have on the establishment of their links with the host university. Finally, the third aspect, concerning the validation of the geographical proximity between the partners as an important factor



influencing the establishment of their links, has been observed only from the point of view of on and off-Park firms. These topics constitute the core of the empirical study of this thesis.

The empirical study of this thesis is carried out through Chapters 4 to 7. Chapter 4 initially deals with the research design and methodology used in this study. Then, it contextualises the object of investigation of this case study: the University of Surrey, its activities and the origins of its Research Park. Regarding the last topic, the Chapter explores the activities developed by the Park Management as well as the main characteristics and R&D activities of the sample of on-Park firms that are investigated in this study.

Chapter 5 investigates and describes, in detail, the links that exist between the sample of firms located on the Surrey Research Park and the University of Surrey. The same procedure considers the links established between the same sample of on-Park firms and other universities located elsewhere. Descriptive and qualitative information emerging from these two different sets of links are used to clarify the nature of these links and their achievements. These also shed some light on the argument used by Science Park promoters that geographical proximity between firms and universities is an important factor for the improvement of their interaction. This specific aspect is also discussed in the last empirical Chapter.

Chapter 6 examines the relationship between (i) selected characteristics of on-Park firms and (ii) the establishment and strength of their links with universities. The characteristics chosen for analysis are: firms' R&D activity, firms' R&D intensity, size of firms, firms' productive sectors, status of firms and "age" of firms taking into account the number of years they have been located on the Park.

To complement the information concerning the firms' side of the U-I interaction within the context of the Surrey Research Park (Chapters 4 to 6), Chapter 7 considers the more visible part of this interaction from the point of view of universities, i.e. that related to

researchers. Initially the Chapter provides background information about the sample of researchers that took part in this research. Then, it investigates and details the links that existed between these researchers and on-Park firms as well as other firms located elsewhere. Finally, Chapter 8 presents the conclusions of the thesis.

CHAPTER 2 - THE UNIVERSITY-INDUSTRY INTERACTION

This Chapter aims to analyse the potential and limits of the University-Industry interaction and links. It is divided into three sections, as follows.

Section 2.1 begins with a brief presentation of national innovation systems and the specific roles of universities and firms within these systems. Information emerging from the history of the University-Industry interaction, its variation over time and between countries, as well as on the industrial R&D investment in universities and Higher Education Institutions, provide the initial argument for analysis of the potential and limits of the University-Industry relationship.

Section 2.2, divided into two sub-sections, looks, in detail, at the establishment of links between universities and industry. Initially, sub-section 2.2.1 assesses the strength and significance of University-Industry links in the light of empirical studies. Then, sub-section 2.2.2 approaches the factors that may affect the strength and significance of these links. Besides briefly presenting the organisational and cultural differences between companies and academe (sub-section 2.2.2.1), the section goes through the analysis of specific key characteristics of firms that may influence the establishment and the strengthening of their links with universities (sub-section 2.2.2.2). Finally, two other aspects that may influence the establishment of these links are analysed: the maturity of technological fields and the geographical proximity between academe and firms.

Section 2.3 presents a brief conclusion.

2.1 - National Innovation Systems

Both the emergence of new technologies underlying the development of new and improved processes and products, and the presence of new competitors in the international market, have, in the recent years, stimulated a critical evaluation of industrial competitiveness in both developed and developing countries. This evaluation has assumed such a scale that led Dasgupta and David (1992, 1994) to identify the contemporary nations' search for improvement of industrial competitiveness as a euphemistic way of referring to "the pursuit of national economic security - the successor goal to military security" (Dasgupta and David, 1992:5). In fact, what has been amply debated is the adequacy of national innovation systems¹. These systems involve various institutions and mechanisms which give support and mould the ways in which innovation takes place within society at large (Nelson and Rosenberg, 1993).

The aims of the current appraisal of national innovation systems are, firstly, to scrutinise the purposes or functions of each of the institutions involved in innovative process. Secondly, to promote the necessary policy adjustments to collaborate with the development and implementation of mechanisms supporting innovation within firms, and, as a consequence, to maintain or improve their established positions in the market-place.

Among the institutional actors involved in innovative process are companies, public and private research organisations, universities and other Higher Education Institutions. For these institutional actors the generation, transfer and use of knowledge and/or technology constitute a paramount activity or are an essential innovative input.

However, the relationship between institutional actors is not straightforward. On the contrary, they interconnect with each other in such an intricate manner that experts have so far not been able to completely clarify all of their linkages. Moreover, the innovative process

¹ For a detailed discussion about this topic, see Nelson and Rosenberg (1993:3-21).

in firms is not homogeneous. It takes very diverse forms and makes use of different sources of knowledge. It also varies with several characteristics of firms themselves and it depends on the stage of technology development in specific productive sectors and on the firms' capacity to cope with that development.

This research deals with two of the above mentioned institutional actors and their interaction, namely: firms and universities. The interaction between university and industry has become a policy priority in both developed and developing countries. Quoting Lundvall (1988:364):

It is not surprising that the link between universities and industry has become a political issue. The growing recognition of the role of science in relation to technology and production has made it a national priority to strengthen this link.

Policy-makers and governments have therefore considered that the University-Industry interaction still remains an under-utilised scientific-technological resource. They have created several mechanisms and policies aiming to intensively stimulate their closer relationship.

The next sub-section briefly discusses the different purposes of universities and firms in order to shed some light on the limits of their interaction.

2.1.1 Universities and Firms: Specialised Roles

Universities and firms are different social entities. They differ considerably in the nature and objectives of their activities (Pavitt, 1993:31). Their research activities also have different purposes, outcomes and reward procedures. These differences provide them with specific comparative advantages and also define the limits or the scope of the action they can take concerning each other.

Traditionally, Universities have performed two main tasks: to train qualified manpower and to increase the knowledge stock through independent research.

The first traditional mission - to train qualified manpower - does not cause much controversy. However, this function should not be reduced to the transmission of formal knowledge. It also represents the transfer and acquisition of specific skills, methods, techniques and even the establishment of a network of professional contacts that are crucial inputs for industrial activities (Pavitt, 1987, 1993; Nelson and Rosenberg, 1993).

The same line of thought is shared by Preston (1993:207), then Director of Technology Development at the Massachusetts Institute of Technology (MIT):

Well-trained students and professional staff who leave the university to work in industry probably represent the universities' greatest contribution to industry by stimulating creativity and bringing new ideas and perspectives to industry.

However, the application and commercial exploitation of the results of university research constitute the focal point of the current dispute about the universities' function.

Research activity has been classified according to its aims and outputs². Even though presenting several restrictions (Nelson, 1959; Nason, 1981; Rosenberg, 1990, de Marchi and Napolitano, 1993), this classification has been widely accepted and its different forms have been summarised as basic research (pure or oriented), applied research and strategic research.

The orientation of the research activity undertaken by a university varies considerably (Blume, 1987) depending on both the purposes of the university as a Higher Education

² The Frascati Manual (1993 Edition) offers a detailed conceptualisation of the different kinds of research - basic research, applied research and strategic research. However, it also recognises that its classification may not be adequate for all OECD countries or to the social sciences and humanities.

Institution - more industry-oriented, for example, such as the former British Polytechniques and the Swedish Technical Universities - and the availability of human and material resources - such as academic staff expertise, financial resources, laboratories and equipment - the university has in order to pursue its objectives.

But, as has been stressed (Nelson, 1959; Nelson and Rosenberg, 1993), universities, in most countries, have typically been involved with the development of basic research, the kind of research in which the generation and advancement of knowledge constitutes its main input and output. As Nelson (1959:306) stated more than thirty years ago, "[universities'] comparative advantage lies in basic research", which, due to its nature and objectives, must be understood within the long-term context.

Several academic disciplines, such as physics or at least parts of it, have been expressly oriented to the increasing of the stock of knowledge and might indirectly contribute to firms' innovative activity (EIRMA, 1972; Nelson, 1988; Nelson and Rosenberg, 1993).

This does not mean that universities cannot undertake research with more pragmatic goals. Certain academic fields and disciplines are explicitly oriented to application such as the engineering disciplines, material sciences, computer sciences (Nelson and Rosenberg, 1993). In addition, research performed by social scientists such as that linked to management, law or languages may have a direct impact on industrial sectors (Goddard et al, 1994:28). Related to these groups of disciplines, it is clear that at least part of the knowledge stock generated through university research can be transferred to and used by industry in their innovative process or in the improvement of existing products, processes and managerial techniques. The problem with the commercial application of this group of disciplines by firms is restricted to the design of mechanisms in which the transfer of research results can be better exploited.

From the firms' point of view, their aim is to increase their profits and maintain or improve their established market position and economic performance. The research activity is one of the possible inputs in their search for technical solutions or the implementation of product or process innovation. Even in a world in which innovation has become increasingly dependent on the commercial exploitation of knowledge (Gibbons, 1992), firms usually undertake research on a short-time basis and in combination with other activities such as design, development, testing and production (Pavitt, 1993; Rosenberg and Nelson, 1994).

As Pavitt (1987:184) has suggested, although up to one quarter of the research undertaken by firms can be classified as basic or applied research,

...three quarters or more is the development and testing of prototypes and related production systems: in other words, knowledge related to the specific products and the specific production processes that firms eventually hope to commercialise.

Table 2.1 summarises the university and firms' differences related to their research activity approaches.

Table 2.1 - Differences between academic and industrial research

TYPICAL ASPECTS	UNIVERSITY	INDUSTRY
Focus of the R&D	basic research; curiosity-oriented	applied research; exp. development
Basic rationale	advance knowledge	increase efficiency
Aim	new ideas	profits
Characteristics	idea-centered	practical, product-centered
Framework	open	closed, confidential
Evaluation	by peers	by the boss
Schedule	open-ended	tight, predetermined
Recognition	scientific honors	salary increases

Source: Parker (1992)

It is worth mentioning that some firms do sometimes engage in certain basic research activity, regardless of its long-term aims, high investment, high degree of risk, uncertainty and the problems of appropriability that surround its possible results (Rosenberg, 1990).

However, the chief reason driving this engagement is not the increase of the knowledge stock per se, as for universities. Firms are driven by potential financial benefits they might obtain through the commercial application of, at least, part of basic research results.

The recent engagement of firms in large and expensive collaborative alliances with universities and research institutes in order to undertake basic research in specific fields has become more frequent. Among the examples quoted by Webster and Etzkowitz (1991), are some long-term alliances such as: the \$ 23.5 million dollar project set up by Harvard Medical School and Monsanto over 12 years for the development of cancer research; the \$ 70.0 million dollar project established between the Massachusetts General Hospital and Hoechst for the development of molecular biology over 12 years; the \$ 75.0 million dollar project in neuroscience set up between University College London and Eisai.

As these authors stress:

These [alliances] have been primarily in the biomedicine/pharmacology area [but also in information technology, new material science] and since 1985 [they] have increased in both frequency and in the absolute as well as relative volume of corporate investment they have attracted (Webster and Etzkowitz, 1990:7).

Firms also have secondary benefits emerging from their involvement in basic research activities. These relate to the skills, techniques and abilities firms acquire during such process that constitute in themselves a sufficiently good reason to carry it out (Rosenberg, 1990). In addition, firms enlarge their potential for interacting and collaborating with other basic research developers such as academics from Universities. This last point reinforces the complementary character of the relationship between in-house R&D effort and external sources of knowledge for firms (Faulkner and Senker, 1994; Feller, 1989).

The different nature and objectives of universities and firms and their different approaches to research activity inevitably affect and limit their interaction (Gering, 1993; Curran, 1993).

However, generalisation must be done very carefully. The patterns of the University-Industry relationship have differed widely over time and between countries.

The next sub-section explores these variations of University-Industry interaction in the light of the American and European experiences.

2.1.2 - University-Industry Interaction: Variations over Time and between Countries

2.1.2.1 - Variation over Time: The American Experience

Rosenberg and Nelson (1994) make a very illuminating contribution to the understanding of the history of the American University-Industry interaction. According to these authors, their work is an attempt to clarify:

...the history of involvement of American universities in research that has been germane to industry, and the different kinds of connections that have existed between university and industry (1994:324).

They divide the history of American University-Industry interaction into two broad phases. The first, named "vocationalist", lasted from the 19th century to the end of World War II (1945). Its main characteristics are as follows.

- The American higher education system, and particularly the university system, was strongly concerned with the solution to the problems of the local society who provided its finance. It was decentralised and accessible to large proportions of the populations (source for its commercial and personal success). The core of the relationship between American universities and society resided on the support for general and professional education (Geiger, 1988). University research was not a priority for federal government funding (Mowery and Rosenberg, 1993).

- University research and teaching were concentrated in fields like agriculture, mining and commercial subjects (accounting, finance, marketing, management). Several engineering subjects (civil, mechanical, electrical, chemical, aeronautics) received attention.
- Strong synergy, and even a certain dependence, existed between university teaching and research and the local industry (such as University of Akron and rubber industry; land-grant colleges and food production; University of Oklahoma and petroleum industry; University of Kentucky and North Carolina and processing of tobacco; University of Illinois and Purdue and railroad technologies).
- Strengthening the links between American universities and industries occurred through (1) the institutionalisation of the new engineering and applied science disciplines at the universities in accordance with industrial needs (for example, chemical engineering, electrical engineering and aeronautical engineering; initial development of computing sciences) and (2) establishment of professional organisations and associates journals. To those factors, Geiger (1988) added that the advent of the World War I stimulated the emergence of an American "research economy" and both private industry and general-purpose foundations began to fund university activities regularly.
- The more pragmatic character of engineering and applied sciences generated two important ramifications: (1) the growing use of university-trained engineers and scientists in industry, and (2) the increase in industrial research laboratories in the chemical industry and new electrical equipment industries, and later throughout industry. Among the first industrial research laboratories, Bower (1992) quoted General Electric, Du Pont, AT&T and Eastman Kodak. From the university's side, Cohen, Florida and Goe (1994) mentioned that some research laboratories were set up, such as the MIT's Physical Chemistry and Applied Chemistry Research Laboratories or the Mellon Institute (University of Pittsburgh and Carnegie Mellon University) to carry on applied research on the fields of physical chemistry and chemical engineering.

- Initial consultancy activities and generation of spin-off companies from academe (for example: Stanford University) took place within the American scenario.

To summarise all this, one could denote that during the first phase American universities performed two paramount roles: the provision of skilled manpower to the society and the development of more applied research. Both activities were strongly connected to consideration of the needs of the local community and economy and the R&D undertaken by industry. In several cases, "training activities and research concerned with the problems of local industry went together" (Rosenberg and Nelson, 1994:326).

The second phase started in 1945 and has been named "the post-World War II era". Quoting Rosenberg and Nelson (1994:333):

World War II was a watershed in the history of American science and technology and, in particular, led to a dramatic change in the roles played by American universities in scientific and technical enterprises.

The main features of this second period are as follows.

- Large-scale public support was provided for university research mainly in fields related to computers, electronics in general, materials and the applied sciences and engineering disciplines. Such a support aimed at preserving the American military R&D capabilities acquired during the war-time as well as supporting medical R&D and basic research at the universities in a broad sense. These broad objectives were designed by Vannevar Bush - the war-time Director of the American Office of Scientific Research and Development - in his 1945 report "Science, the Endless Frontier".
- The main sources of financial resources for university research were centralised by federal agencies such as the National Science Foundation, the Department of Defence, the Department of Energy, the National Aeronautics and Space Administrations (NASA) and



the National Institutes for Health. Both the allocation of federal funding and the design of the university research agenda tended to be in accordance with the purposes defined by those sponsors.

- The emergence of two remarkable industrial and university research fields - electronic digital computer and biotechnology - collaborated to the strengthening of links between university and industry (mainly through the consultancy activity and establishment of start-up companies by academics).

This second period saw a substantial increase in the provision of financial resources by federal government to university activities and, to some extent, to industrial research (Cohen, Florida and Goe, 1994). This was a direct consequence of the successful American military R&D capabilities acquired during war-time, taking into account the support of researchers and scientific staff from American universities. From 1945 onwards, basic research became the mission of the American university, and its relationship with society changed its focus from the local to the national sphere, particularly concerning national security matters.

For some analysts (Bower, 1992; Webster and Etzkowitz, 1991³; Geiger, 1988), it was the political interference through financial investment by the federal government in American universities that undermined the previous interaction between American universities and industries. Bower (1992:46) looks at this problem as follows:

The dominance of the federal government as a source of research funding reduced the need to solicit industrial sponsorship. With the exception of a few institutions, such as MIT, prewar links with industry were eroded to a large extent.

³ Webster and Etzkowitz (1991:5) have extended the huge Government financial support to other countries: "State support for science (within all NATO and generally all OECD countries) has grown over the past three decades, apart from a period during the 1970s when funding was hit by the then structural instability of most industrial economies".

And Geiger (1988:342) states that:

...The great proliferation of basic research support in the 1960s fostered a sacred-cow mentality in our [American] universities - a disdain for entanglements with private industry or with the Department of Defense".

However, Rosenberg and Nelson (1994) argue that the observable distancing between the American universities and industries did not occur abruptly. On the contrary, it was a gradual process based mainly on two factors. The first one is represented by the establishment of engineering schools and applied sciences as academic disciplines. Those disciplines, more connected with industry, brought to the new departments research that was previously done in other university departments more related to basic research. On the other hand, from the support of the local economy, the focus of the interaction between university and industry changed to the consideration of national needs.

A third phase, not identified by Rosenberg and Nelson (1994), should be added to the history of the American University-Industry interaction. Since the eighties, the American government at the national, state and local levels, has taken several steps to revive the previous linkages between its universities and industries in order to overcome declines in industrial productivity and safeguard market positions. This revival has been mainly motivated by the commercial possibilities of new and emergent technologies in the middle-70s. Bower (1992) makes explicit reference to the emergence of biotechnology. According to her:

Genentech Inc. was formed in 1976...It brought home dramatically the realisation that much of the basic research work happening on the campus could be transformed virtually overnight into the core technologies of new companies...It was speedily realised that the new, biologically based technologies had a very broad range of possible applications. They were, in fact, generic technologies - core technologies for processes in many industries (1992:48-50).

The American government action, according to Baldwin (1988), varies from one case to another: it has been concerned generally with the adjustment of technology transfer policies

through, for example, a new patent and trademark orientation and incentives to the industrial R&D activities and industrial support for university activities. Also, the National Science Foundation has set up several special programmes such as University-Industry Research Centres and Innovation Centres (early seventies); the University-Industry Cooperative Research Projects Program (in 1978); Engineering Research Centres and Science and Technology Centres (mid-eighties) (Cohen, Florida and Goe, 1994).

2.1.2.2 - Variation between Countries: The European Experience

In the Introduction of "National Innovation Systems: A Comparative Analysis", Nelson and Rosenberg (1993) emphasise the importance of differences between countries regarding their institutions in order to explain their different economic and industrial achievements. Particularly related to the university systems, they point out that:

...The university systems are different and play different roles in the national R&D systems...And the reasons for these differences reside, to a significant degree, in differences in national histories and cultures including the timing of a country's entry into the industrialization process. These have profoundly shaped national institutions, laws, and policies (1993:18).

Such differences can be seen at a very general level by contrasting the American and European experiences.

Looking at the history of the American University-Industry interaction, a very important aspect comes out: both the American universities and modern industrialisation emerged at the same time in the American scenario. As Nelson (1988:320) stresses "within the United States, university science and engineering and our science-based industries grew up together". Traditionally, American universities and industries have had a much closer relationship than some of their European counterparts. Moreover, American universities have been the natural loci for the development of basic research. In contrast to the American experience, the European university system, as a whole, has been marked by

centralisation, predominance of elitism (class-rigidity) and a certain contempt for commercial affairs, a picture substantially different from that in America.

As Rothwell (1991:2) points out:

While for many years there has been a fairly close relationship between higher educational institutes (HEIs) and industry in the United States, the "normal" situation in most countries in Europe during much of the post World War II period has been one of "ivory towerism". In other words European HEIs traditionally pursued their own research interests independently of, and often indifferently to, the technical requirements of industry. It was government laboratories, collective industrial research institutes and other private non profit (PNP) organisations that played the major role in Europe in transferring technology to industry.

At another level, however, the main feature of the European pattern of University-Industry interaction is not in the difference from the American pattern, but more in its own great heterogeneity. This becomes very evident when the different attitudes to University-Industry interaction among the different European countries is observed. As the EIRMA report (1972:19) stress:

...a distinct geographic variation in mental attitudes has been observed [among different European countries]. A widening of the mental gap between industry and universities was found in travelling from Northern European countries, such as Sweden and the Netherlands, south to Mediterranean countries such as France and Italy⁴.

The next paragraphs shed some lights on the main variations of the history of the University-Industry interaction for some European countries.

⁴ In a subsequent Report (1988, Appendix 2) EIRMA presents a very succinct and general view of the different University Systems in some European countries (the United Kingdom, France, Germany, the Netherlands and Finland).



Germany

Keck (1993) reports that German universities, whose origin dates back to the nineteenth century, have been the institutional loci of German scientific research. As early as the middle of that century, fields such as medicine, chemistry and physics achieved international recognition. The constant financial support from the government and supervision moulded German universities and encouraged their specialisation.

Contrary to the American experience at that time (nineteenth century), the engineering disciplines and profession lacked the same social status as scientific fields. Independent polytechniques were set up in order to carry out applied research. But those institutions, in their search for social recognition, over concentrated on theoretical aspects, keeping a certain distance from industrial needs. The solution to this problem came through the emulation of the American experience and the installation of experimental laboratories in several departments (such as machine construction).

Besides the universities and polytechniques, the federal government devised several research institutes to carry out research in more practical and applied areas. Their purposes varied from military needs, the accomplishment of public tasks to the support of technical innovation for the private sector. Most of them received financing from the government; however, industrial support emerged as an alternative financial source for research. At the beginning of the twentieth century, more than 40 such institutes were founded in Germany covering fields such as the weather and atmosphere, geography and geology, health, shipbuilding, biology, agriculture, fishery and forestry.

The German government has been the funder of German higher education and science systems. Even though the German industry performed and financed R&D activities, its investment was reduced during and between the World Wars. Industrial R&D efforts were more related to traditional (or incremental) innovations.

From the 1970s onwards, Germany has experienced an upsurge of concerns over the current state of her higher education system, with particular concern from the universities. Insufficient financial provision and inadequate policies to drive university activities have been the main sources of worries. Particularly from the 1980s, the intensification of links between industry and education has been recognised as **essential** to strengthen regional and industrial performance. Several mechanisms, such as industrial liaison offices and regional innovation centres have been set up. Their principal aim is to reduce the gap between the productive sectors of the German economy and universities and other higher education institutions (Kuhlmann, 1991).

United Kingdom

Great Britain was the world's cradle and leader of the technological revolution that took place during the nineteenth century. However, this leadership had ceased by the end of that century, partly due to the lack of co-ordinated action between British technological development and its institutional infrastructure. Quoting Freeman (1992:171):

The really important point about Britain's loss of technological leadership in the 1880s and 1890s was not that Britain ceased to make scientific discoveries or radical innovations, but that British institutions proved incapable of diffusing these innovations, of scaling them up and of using them in a wide variety of new applications...it was the slowness of institutional innovation in the wider social system which further hindered the pace of technical change in Britain.

The education system is one of the arms of that wider social system referred to above. And as William Walker (1993:178) stresses:

Until the late nineteenth century (perhaps even later), an education "system" did not exist in Britain, although proposals to establish one extended back to the eighteenth century...in Britain education was disorganized and lacked the strong association with the aims of economic development.

In contrast to the American model, the British education system was severely marked by elitism (as in France) and lack of technical training and specific technical institutions to provide and support the development of such an ability. Also, the engineering profession lacks social prestige (as in Germany) and higher involvement with the industrial sector. Private schools, allied with some prestigious universities (such as Oxford and Cambridge) provide Britain with its economic and political elite.

Mainly from the 1980s, several factors have contributed to the impoverishment of the British scientific, technological and industrial performance. Concerning the British R&D activity, Sir Robin Nicholson and his colleagues (1991) identify, among others, the following factors as contributing to declining British economic performance:

...government emphasis on defence and nuclear power; inadequate levels of R&D in the manufacturing sector and especially by private firms (itself often said to be linked to city short-termism); an education system which underemphasises science and mathematics, which prefers the theoretical to the practical, and which fails to reach large numbers who by it could benefit both themselves and society; and social values which while according status to the professions chooses not to regard engineering as among them...at least until the 1980s, much of university science tended to stand aloof from industry. The overall outcome has been a poor fit between the country's economy and the pattern of its R&D... (1991:4-5).

On the other hand, Britain has been able to structure and establish "a complex infrastructure for the transfer of technology from academia to industry"⁵ (Noonan, 1991:391). This infrastructure has been built on the promotion of collaborative research in the UK involving several regional agencies, government departments such as the Department of Trade and Industry (DTI), the Department of Education and Science (DES), universities and polytechnics. Another arm of the current British infrastructure is

⁵ According to Blackman, C. And Segal, N (1992:935), the United Kingdom has established links between its Higher Education Institutes and industry since the last century. Those authors report that "In the United Kingdom the debate about industry's need for technological advance and the role of universities can be traced back to the mid-nineteenth century. Awareness of the inadequacies of British science and technology in comparison with Germany in particular was one of the motivating factors that eventually led to industrial cooperation in the establishment of the universities of Birmingham, Bristol, Leeds, Liverpool, Manchester, Newcastle, and Sheffield".



represented by the technology transfer organisations such as the British Technology Group (BTG) or Defence Technology Enterprises (DTE).

Finally, the improvement of the interaction between university and industry constitutes the third component of the above mentioned infrastructure. This interaction involves three main lines of action: (1) the exchange of personnel and ideas (the movement of academic staff to industry; absorption of undergraduate and post-graduate students, training courses and establishment of spin-off companies); (2) "selling" external research and expertise (consultancy, contract research, collaborative research, establishment of innovation centres, selling of licenses and patents); and (3) facility provision (establishment of Science Parks) (Noonan, 1991).

France

The emergence of French universities and polytechnics (Grandes écoles) had started by the end of eighteenth century. Since the very beginning, basic research was strongly connected to military and industrial applications. This was a result of the State's "umbrella" for both scientific and educational infrastructures and industrial manufacturing, in order to overcome the internal political constraints of the nascent capitalist society.

However, from 1840s onwards, the connections between the industrial sector and research did not last long. French industries did not show the necessary interest or sufficient investment in order to keep closer ties with research. As Chesnais (1993:195), quoting Papon, observed: "...the relations between science and industry are those of "a very precocious divorce"".

The reasons this partition lay not just on the slower French industrial capitalism. The scientific and technological infrastructures inherited from the Napoleonic period, with its conservative policies and lack of dynamism, undermined the initial successful partnership.

During the whole of the 19th century, due to political problems, or in order to solve them, French universities did not have a high performance either as training or as research centres. Polytechniques and engineering schools, once leaders in basic research, also lost their vitality. In addition, French industrial R&D laboratories did not develop in the same way as those implemented in the United States and Germany at the same period. Apart from some exceptions such as the automobile and aeronautics industries, French industries were far from the front line of industrial development based on scientific orientation and application.

The dynamism of industrial activity and scientific and technological rebuilding came into the French scenario at the end of the World War II. As Chesnais (1993:200) affirms:

...Along with economic planning, and active industrial policy, and large public investments in basic infrastructures, France's vigorous institution building in science and technology and large investments in R&D must be seen as one of the central instruments of the country's fairly spectacular economic and political recovery following the end of World War II.

The re-organisation of CNRS (National Centre for Scientific Research), founded in 1939, instilled a new dynamism and structure in French scientific research activity, related to both the provision of highly qualified research personnel and overall support for research. CNRS has oriented and administered the establishment of several other national laboratories (some of them linked to the front-line of basic research) that could not be placed within the university system. In fact, CNRS has absorbed the functions that in other countries have been performed by industry and other foundations: to support university research.

French universities do not still have a strong research activity. As part of the public sector infrastructure, universities have been driven and dominated by the very strict public rules and environment. Significant research development is present in only a handful universities and the links with industry still remain at an inadequate stage. According to Chesnais (1993:210):

...Discussion in the 1970s and 1980s about the need for closer university-industry relationships has not yet freed university research from the fetters of traditional state accounting procedures. The establishment of R&D contracts with firms forces laboratories to circumvent the law and to hide part of their resources from official university accountants and tax inspectors.

However, some efforts have been made by the French government to reduce the gap between French research institutions - among them universities - and industries. The network started with the establishment of ANVAR (National Agency for the Exploitation of Research), in 1967, and ARIST (Regional Agencies for Scientific and Technological Information), in 1972. A third arm, set up in 1983, is represented by the Regional Centres for Innovation and Technology Transfer (CRITT) whose principal objective is "to pool the skills of diverse regional institutions such as universities, government research centres, professional organisations, etc" (Gonard and Wu, 1991:147).

Italy

The OECD report (1983) on "New Forms of Co-operation and Communication between Industry and Universities - National Surveys: Italy" provides information about the Italian research system for the period from the 1950's onwards.

The Italian research system is mainly based on state research organisations. The National Research Council covers more than one hundred research institutes, some of which are involved in applied projects related to fields considered important to the development of the country. Also, Italy has a National Committee for Nuclear and Alternative Energy Research and Development. It has a close proximity to the industrial milieu; a National Institute for Nuclear Physics, which cooperates with universities; and a Experimental Stations for Industry, which main task is to support, as research laboratories, the industrial sector (particularly those related to traditional industries such as leather, citrus fruit production, food oil, cellulose, paper and natural and artificial textile fibres, food preservation, fuel production, glass, silk production). The Experimental Stations for Industry are financially

supported by industry and "provide a valuable link between university research and research in industry" (OECD, 1983:8).

Italian universities, numbering more than 50, are under the control of the Ministry of Education and have, as their main activity, the development of basic research. However, as the OECD report (1983:9) emphasises

...from March 1982 universities can provide schools in specialized areas with a university diploma after two or three years. These schools are more directed to the needs of industry and companies will be able to participate in their creation and running.

Traditionally, the interaction between Italian universities and industries has not been very vigorous. The main reason for this is typical barriers: different kinds of research undertaken by each partner and lack of managerial flexibility, mainly on the university side. Malerba and his colleagues (Malerba et al, 1991) point out that the Italian university system has acquired advanced scientific capabilities in several fields such as physics, chemistry and certain areas of engineering. However, the sector lacks more applied interdisciplinary research and mobility of its academic staff to industry. Also,

...Obstacles to co-operation [with industry] and technology transfer [to industry] include both current university legislation...and the tendency of lecturers and researchers to specialize and to have a single discipline background...[the] criteria for a career often depend on purely academic standards that ignore more applicational aspects (Malerba et al, 1991:287).

Particularly from the middle 1970s-1980s, Italian University-Industry interaction has had some improvement. The establishment of specific research agencies, such as Tecnomare (Marine Technology) or Sago (Health Organisation), aims to promote and assist the relationship between companies and universities and between banks and industries. Also, the National Research Council, through its application-oriented projects, has bridged the gap between universities, government research and industry. These projects, allowing for no evaluation at the time of the OECD report, have been organised in four main groups:



food, health, the world and environment and advanced technology (OECD, 1983:16-19). In addition, other infrastructures have been set up within the Italian context. Many are associated with sharing human and physical capabilities, and business consultancies, such as those provided by industrial centres, business innovation centres, and technological and research areas or parks.

2.1.2.3 - Summary of Variations of The University-Industry Interaction

The two previous sub-sections described the history of the University-Industry interaction in the light of the American and some European countries experiences. This description highlights the variation of such interaction over time (the American experience) and between countries (European experience), emphasising the diversity of historical, social, political and economic contexts in which universities have supported innovative process.

Even though there is inadequately detailed information about the nature of links set up between universities and firms in their interaction, it is possible to observe that, historically, universities, through the development of their principal activities (teaching and research), have had an important but diverse effect on the innovative process of firms.

Since the middle of the 1970s-beginning of the 1980s, both developed and developing countries have stimulated a closer relationship between their universities and industries. This approach aims, roughly speaking, to improve the application and commercial exploitation of the results of research undertaken in universities and, consequently, to overcome potential economic problems firms face to keep their market-position. The shortage of resources for financing not only the research performed at universities but also for financing an activity that tend to require large amounts of investment in a very risky environment have also contributed to the contemporary view of the interaction between universities and industry.

It is interesting to observe the industrial R&D investment for universities/Higher Education Institutions activities. The next sub-section presents some information about this investment. Once again, it is possible to observe the diversity over time and between countries the industrial financing for HEIs activities has assumed.

2.1.2.4 - Industrial R&D Investment In Universities/HEI

Examining the financial support provided by industry for the development of university activities is one way of evaluating University-Industry relationships. However, this kind of information must be considered with care. Differences in the assessment of R&D activities in different countries (Webster and Etzkowitz, 1991) allied to aggregated information for the Higher Education Sector as a whole - and not for universities specifically - provide only a partial view about industrial R&D investment in universities.

Table 2.2 presents statistical information about the proportion of the Gross Domestic Expenditure on R&D (GERD) performed by Higher Education Sector for some OECD countries.

Table 2.2 - Proportion (%) of the Gross Domestic Expenditure on R&D (GERD) performed by Higher Education Sector for some selected OECD countries

Country	Year	1985	1987	1989	1991
France		15.0	15.0	14.9	-
Germany		13.5	14.5	14.4	15.8
Italy		19.7	20.2	19.8	19.8
Japan		20.1	19.9	18.0	17.5
Sweden		27.5	28.9	31.8	32.9
United Kingdom		14.4	15.5	15.0	16.7
United States		12.8	14.5	15.5	16.4

Source: Basic Science and Technology Statistics, OECD (1993)



As the table shows, the proportion of R&D performed by HEIs for this group of OECD countries presents variations over time and between countries. Sweden, for example, has been the only country in which R&D activities performed by its HEIs have accounted for more than one quarter of total R&D, and this proportion is almost twice as high as in other countries such as Germany or the United Kingdom.

On the other hand, looking at this set of countries as a whole, one may notice the evolution of the R&D activity performed by HEIs. At the exception of France and Japan, whose proportions of HEIs R&D performance have presented a negative rate of growth (-7% and -13% respectively), other countries have shown a positive increasing over time, as follows: Italy (5%), the United Kingdom (16%), Germany (17%), Sweden (19.6%), and the United States (28%).

Table 2.3 below shows the proportion of R&D performed by High Education Sector that has been financed by industry for some OECD countries.

Table 2.3 - Proportion (%) of Higher Education Institutions (HEI) performed R&D that was funded by business for some selected OECD countries

Country	Year	1985	1987	1989	1991
France		1.9	3.5	4.6	-
Germany		5.9	6.3	7.0	7.7
Italy		1.5	1.0	2.6	2.4
Japan		1.5	1.8	2.2	2.4
Sweden		5.5	5.9	7.9	-
United Kingdom		5.2	5.7	7.7	7.7
United States		3.8	4.2	4.5	4.9

Source: Basic Science and Technology Statistics, OECD (1993)

The industrial financing for R&D activities performed by HEIs also presents variations over time and between countries. Among the countries listed above, Germany, Sweden and the United Kingdom have been those in which industry has presented a steady increasing in its

financing for R&D activities performed by HEIs. However, these proportions do not exceed the modest proportion of 8% (for 1991). For the other countries, such financing has also shown some increasing but in a much more modest rate.

Finally, Table 2.4 below compares the proportion of the R&D performed by HEIs and financed by industry in relation to the total R&D expenditure for some OECD countries.

Table 2.4 - Business funded R&D in the HEI Sector as a proportion of Gross Domestic Expenditure of R&D (GERD) for some selected OECD countries

Country	Year	1985	1987	1989	1991
France		0.3	0.5	0.7	-
Germany		0.8	0.9	1.0	1.2
Italy		0.3	0.2	0.5	0.5
Japan		0.3	0.3	0.4	0.4
Sweden		1.5	1.7	2.5	-
United Kingdom		0.7	0.9	1.1	1.3
United States		0.5	0.6	0.7	0.8

Source: Basic Science and Technology Statistics, OECD (1993)

Sweden, again, has been the country in which the industrial financing for R&D performed by its HEIs and compared to its total GERD, achieves the highest levels for the years of 1985, 1987 and 1989: 1.5%, 1.7% and 2.5% respectively. Among the other countries, except for the United Kingdom whose proportion achieves 1.3% in 1991, the participation of industry in financing the R&D activities performed by HEIs in relation to their total R&D expenditure is still in a very low level.

Even presenting variations over time and between countries, the industrial financing for the development of HEIs' R&D activities still remains extremely modest, and even marginal, in most of the OECD countries. However, it has been recognised that in countries whose "public funding for university research is becoming increasingly scarce, cooperation with

industry may even...become a condition of survival for some university institutions" (OECD, 1990:60).

2.2 - University-Industry Links

This section turns from the preceding broad, macro perspective on University-Industry interaction, and reviews previous research on more detailed aspects of the specific links and mechanisms involved in that interaction. The section has two main parts but, before outlining the issues addressed in these parts, preliminary comment is needed on three points: the terminology, the literature primarily drawn on, and some of the issues that are not covered in any detail here.

Terminology

Terms like "links", "channels" and "mechanisms" together with others like "transfer", "communication" and "flow" have been used in a wide variety of ways to cover different aspects of the scientific or technological interaction between universities and industries. There seems to be no consistency in the use of these terms. As Charles and his colleagues (1991:14) note in their study commissioned by the Commission of the European Communities:

A distinction between "links" and "mechanisms" is somewhat arbitrary and blurred..."links" has tended to be used in a more general sense covering both informal/formal links between industry-academia-government whilst "mechanisms" has a more specific policy orientation and covers more formal and focused applied research and technical contacts between industry/HEI/PRE.

Also, Geisler and Rubenstein (1989:52-3) note that "mechanisms" may cover a wide range of very different kinds of interaction varying in terms of the time involved. They may

range from a one-shot transfer of information to a complex and long-term relationship, as in a research park or a cooperative research center...A healthy [U-I] relationship should involve multiple mechanisms and linkages between the firm and the university...

Other studies have attempted to distinguish between (i) the institutional conduit or vehicle by which, or through which, interaction takes place, and (ii) the substantive content that flows through the channel or conduit. The first might include, for example, formal contracts for R&D or consultancy services; the latter might include the particular types of knowledge or information acquired through those contracts.

In most of this study the term "link" or "linkage" is used rather loosely to describe either or both of those phenomena. Where a distinction needs to be made, terms like "channel" or "mechanism" will refer to the institutional conduit or vehicle for interaction. These institutional channels or mechanisms may take the following main forms:

- Informal relations⁶;
- Research relations involving the establishment of joint research or contract research as well as the provision of services (e.g. consultancy, technical assistance, analysis and testing). This modality also encompasses incentives to business creation (e.g. spin-off companies⁷ and science parks⁸) and technology transfer centres (e.g. Industrial Liaison Offices (ILOs)⁹ and University-Industry Research Centres (UIRC)s¹⁰;

⁶ These studies have not been able to define what they mean by "informal relations" due to the difficulties in characterising these relations and assessing their strengths and weaknesses.

⁷ Detailed information about spin-off companies is provided by Brett, Gibson and Smilor (1991) and Stankiewicz (1994).

⁸ As Chapter 3 illustrates, the concept of Science Parks covers a huge set of objectives besides the incentive for business creation.

⁹ Detailed information about ILOs within the European context is provided by the Commission of the European Communities (1991a). Within the American context, see Preston (1993:207-215).

¹⁰ Detailed information about UIRCs within the American context is provided by Cohen, Florida and Goe (1994).

- Training relations involving, for example, the development of joint advanced programmes, the design of special courses for firms and the staff mobility;
- Other forms of relations such as promotional, organisational, marketing and financial activities which provide general background for the University-Industry interaction (e.g. fairs, meetings, round-tables).

When particular reference needs to be made to the substantive content of communication through channels or mechanism, this study will use a variety of terms such as "knowledge flow", "technology transferred", and so forth.

The literature drawn on

Several extensive studies about the links between university and industry have been carried out by several researchers (Prager and Omenn, 1980; Baldwin and Green, 1984; Stankiewicz, 1986; McDonald and Geiser, 1987; Feller, 1989; Brunet and Reverdy, 1989; Geisler and Rubenstein, 1989; Dill, 1990; Rothwell, 1991; Bell, 1993; Barden, 1993; Bonaccorsi and Piccaluga, 1994; Liyanage and Mitchell, 1994; Fusfeld, 1994) and organisations (EIRMA, 1972, 1988; National Science Foundation, 1982; OECD, 1984, 1990; the DTI/CIHE, 1989, 1990; Commission of the European Communities, 1991a, b). There is no intention to disregard some of these studies. However, in this research reference has been made to those more extensive (e.g. OECD 1984, 1990) due to the fact that they provide a comprehensive view about certain aspects of the U-I interaction that are important to this thesis but not discussed in detail.

Issues not addressed in any detail

Many of the studies above give particular attention to the justification for strengthening University-Industry links, and identify the types of benefits that might be generated by them.

Since these issues are not pursued in detail in this study, only a brief summary is provided here.

Among the justification for the establishment and strengthening of links between university and industry, those studies emphasise:

- provision of a better orientation of public investment in Science and Technology;
- increasing interrelationship between Science and Technology (multidisciplinary approach to research and the pace of technological development);
- globalisation of the world economy;
- strengthening of industrial efficiency and competitiveness;
- provision of financial resources for universities;
- provision of support to small and medium sized companies (which, in general, have few research facilities).

The potential benefits emerging from the establishment of links between university and industry are summarised as follows:

To universities:

- better job prospects for graduates;
- contribution to training for faculty members;
- improvement or updating of university curricula;
- contribution to the financing of research;
- co-operation in design course plans and research programmes;
- access to business culture and facilities.

To firms:

- graduates better adapted to the actual working conditions and needs of firms;
- access to highly qualified scientists and engineers;



- access to the Government research funds;
- access to university culture and facilities.

To society:

- greater return on investment in higher education;
- more efficient and flexible Science and Technology system, improving the transfer of knowledge and technology;
- innovative culture becoming more prominent in society as a whole.

The focus of the review

The remainder of this section of Chapter 2 examines previous research that has addressed two main issues. The first is concerned essentially with the "importance" of U-I links focusing primarily on links relating to the research activity of universities and viewing their importance basically from the perspective of the contribution made to industrial firms and their innovative activities. This issue is addressed in sub-section 2.2.1.

The second issue is concerned with the factors that influence the importance or effectiveness of the research-based links between universities and industry. Why does the "strength" of these links seem to vary and what factors appear to contribute to their effectiveness and importance? These questions are addressed in sub-section 2.2.2.

2.2.1 - The Strength and Significance of University-Industry Links

The OECD Committee for Scientific and Technological Policy notes the lack of evaluation of University-Industry links and mechanisms in its member countries. It also recognises the necessity of such an evaluation "as a basis for designing revised or new ones..." (OECD, 1990:8). As the report stresses:

...little work seems to have been done on assessing the performance of existing relations...generally speaking, there is a regrettable lack of concrete information (i.e. quantitative studies and objective assessments) about the nature of the [U-I] relations (OECD, 1990:15-16).

However, several empirical studies have been carried out to assess the contribution of university research to the development of industrial innovative activity. These studies vary quite widely in the level of detail at which they define and assess links. For example, in the classic analysis by Gibbons and Johnston (1974), analysis focused on specific, individual innovations implemented by firms and on detailed "units" of information that contributed to those innovation. It identified the relative importance of "units" that originated in scientific activities in universities compared with "units" originating in other sources. More recently, Faulkner and Senker (1994, 1995) have further developed that very detailed level of analysis. They do not focus on individual innovations in industry, concentrating more generally on the innovative activity of firms. However, they analyse in great detail the ways in which scientific and technological inputs (STI), emerging from institutions linked to the Public Sector Research (PSR), might contribute to the innovative activity of firms.

At a less detailed level, several studies have still examined the contribution made by universities to innovation in industry, but have not focused on individual innovations or specific "inputs" of knowledge or information. Instead, they have relied on more general responses by firms to question about the importance of the contribution from university research. The study of innovation in Sweden by Deiaco (1992) falls into this category. So also does the study by Mansfield (1991), although he adopts a much more rigorous definition of the contribution made by academic research.

Finally, some studies have adopted a yet more general approach. For example, Nelson, Klevorick and colleagues (Nelson, 1987, 1989; Klevorick et al, 1995) identified American firms' assessment of the "relevance" of university research to their activities and the similar "relevance" of particular scientific fields. Avveduto and colleagues (Avveduto et al, 1988a)

take a similar approach but within the Italian context. Peters and Fusfeld (1982) also generated a very broad assessment of the contribution to US industry that was made by university research. However, they concentrated more on the scale and significance of particular channels and mechanisms rather than on the significance of knowledge flowing through them.

The main findings of these studies are reviewed below, starting from those using the more general types of assessment methodology and moving to those that used progressively more detailed approaches.

Nelson, Klevorick and colleagues (Nelson, 1987, 1989; Klevorick et al, 1995), for example, have as a major objective to analyse the different degrees of contribution made by external sources of knowledge and information to the technological advance in different industries. Part of their study looks at such a contribution emerging from universities, and aims to answer the following question: "Which fields of university research most strongly influence technical advance in industry?" (Klevorick et al, 1995:190).

Their strategy in answering this question consists of assessing the relevance of some fields of basic and applied sciences to the development of innovative activity in different industries compared to the relevance of research undertaken by universities in the same fields for the same set of industries.

Such an assessment is based on a survey the authors undertook in 1983-1984, in which 650 executive managers representing 130 American business lines (industries) were asked to evaluate the above mentioned relevance for their industries over the preceding 10-15 years. Relevance, in both cases, is measured according to "a 7-point Likert scale...running from "not relevant" to "very relevant" (Klevorick et al, 1995:193).

Table 2.5 presents their main findings concerning the relevance of some basic and applied sciences and research undertaken by universities, in the same scientific fields, for the development of industries' innovative activity whose score was rated 5 or higher by the executive managers.

Table 2.5 - Relevance of scientific fields (basic and applied sciences) and research undertaken by universities for the development of industries' innovative activity - Score rated 5 or higher

Scientific Fields	(A) Number of industries indicating the relevance of scientific fields greater than 5	(B) Number of industries indicating the relevance of univ. research greater than 5	(C) Difference between (A) and (B)	(C/A) Proportion of industries rating scientific fields as more relevant than univ. research
Basic Sciences				
Geology	4	0	4	100.0
Physics	44	4	40	90.9
Mathematics	30	5	25	83.3
Chemistry	74	19	55	74.3
Biology	14	12	2	14.3
Applied Sciences				
Material Sciences	99	29	70	70.7
Metallurgy	60	21	39	65.0
Computer Science	79	34	45	57.0
Applied Maths.	32	16	18	50.0
Medical Science	8	7	1	12.5
Agricultural Science	16	17	+ 1	+ 6.3

Source:- Based on Klevorick et al (1995)

As the table shows, the number of industries rating the relevance of research undertaken by universities as 5 or higher for the development of their innovative activities is, except for Agricultural Science, substantially lower than the number of industries rating the same score for the relevance of scientific disciplines. For instance, Chemistry, Computer Science, Materials Science and Metallurgy, and even Physics and Applied Mathematics, as academic scientific fields, are rated as relevant for a higher number of industries than research undertaken by university in the same scientific fields. Through columns 4 and 5, it



is possible to observe that the difference in relevance rating for scientific fields and academic research is remarkable accentuated. Except for Biology (Basic Sciences) and Medical Science (Applied Sciences), all of the scientific fields are considered more relevant for the development of innovative activity of industries than academic research in a proportion varying between 50.0% (Applied Mathematics) to 100.0% (Geology).

When the relevance of scientific fields and academic research is scored 6 or higher by the executive managers, the results become even more remarkable since the proportion of industries rating scientific fields as more relevant than university research is higher than the precedent evaluation. Table 2.6 below presents these results.

Table 2.6 - Relevance of scientific fields (basic and applied sciences) and research undertaken by universities for the development of industries' innovative activity - Score rated 6 or higher

Scientific Fields	(A) Number of industries indicating the relevance of scientific fields greater than 6	(B) Number of industries indicating the relevance of univ. research greater than 6	(C) Difference between (A) and (B)	(C/A) Proportion of industries rating scientific fields as more relevant than univ. research
Basic Sciences				
Geology	3	0	3	100.0
Chemistry	43	3	40	93.0
Mathematics	9	1	8	88.9
Physics	18	2	16	88.9
Biology	8	3	5	62.5
Applied Sciences				
Metallurgy	35	6	29	82.9
Material Sciences	46	8	38	82.6
Computer Science	35	10	25	71.4
Applied Maths.	6	2	4	66.7
Medical Science	5	3	2	40.0
Agricultural Science	9	7	2	22.2

Source:- Based on Klevorick et al (1995)

These results do not mean that research undertaken by universities is not important for firms' innovative activity. However, as Nelson, Klevorick and colleagues (Nelson, 1987, 1989; Klevorick et al, 1995) emphasise, most of the academic research has a limited and indirect relevance over the firms' technological activities. Their impact on firms activities occurs through research developed in more applied sciences and engineering as well as through the training of qualified manpower. According to Klevorick and colleagues (1995:197):

...research in the applied sciences and engineering disciplines is guided to a large extent by perceptions of practical problems, and new findings often feed directly into their solutions. In contrast, to the extent that new research in basic science is relevant to industrial technology, it is likely to be as an addition to the broad knowledge base rather than as directly useful results...advances in fundamental scientific knowledge have their influence on industrial R&D largely through two routes. One...is through influencing the general understandings and techniques that industrial scientists and engineers, particularly those whose training is recent, bring to their jobs. The other is through their incorporation in the applied sciences and engineering disciplines and their influence on research in those fields.

In the Italian context, Awveduto and colleagues (1988a), commissioned by the Italian National Research Council, investigate the R&D co-operation between Italian universities and industries established during the first years of the 80s. Their sample of firms is made of 344 firms undertaking R&D activities, most of them represented by those engaged in chemicals, machinery and electrical and electronic productive sectors as well as research centres linked to some industrial groups.

Almost 60% of the firms surveyed considered their relationship with universities as satisfactory, even though recognising that such a relationship should be improved. However, only 25% of the firms - mainly involved with precision instruments, chemical industry, metal goods and research centres connected with industrial groups - considered their R&D agreements with universities as important for the development of their activities.

Regarding the university departments or schools with which firms establish co-operative R&D agreements, 45.3% operate in Engineering and Technology fields; other 23.4% relate to Medicine, while 15.8% relate to Chemistry. Disciplines more related to the development of basic research, such as Physics and Biology, count for a smaller proportion of linkages: only 6.2% and 3.6% respectively.

From the point of view of universities, the authors observe that, among all the institutions that replied their questionnaires, 47% established R&D agreements with companies prior to 1981 or during the first years of the 80s. 65% of these R&D agreements occurred within the Engineering and Technology fields, while 51% of linkages come from Chemistry and 44% from Physics. Academic disciplines such as Mathematics, Law and Economics presented a lower proportion of agreements: 29% and 24% respectively.

In the early 80's, Peters and Fufeld (1982) were commissioned by the National Science Board to undertake broad research to evaluate the state of the American University-Industry relationships, including the analysis of the extent and nature of their links focused on research programmes.

Due to the magnitude of such research, they concentrate their investigation on 39 major American research universities - 22 public and 17 private institutions - and 66 research based firms carrying out basic research. Since the development of basic research requires certain special conditions and implies a set of risks - as previously noted in this Chapter - the companies that participate in their research are represented by very large companies. However, the authors are aware of the fact that their sample of companies "does not permit in-depth treatment of the particular relationships that can exist between smaller companies and nearby universities" (Peter and Fufeld, 1982:11).

Peters and Fufeld (1982) note the diversity of links, both informal and formal, established between universities and companies in research programmes. They recognise that formal

research links are easier to identify and in their sample they notice 464 examples of University-Industry research links as listed in the Table 2.7 below.

Table 2.7 - University-Industry research links in the American context

TYPE OF INTERACTIONS	Number of Interactions in each Category	% of Interactions in each Category
All Categories of Interactions	464	100
General Research Support	54	11
U/I Cooperative Research	284	61
Knowledge Transfer	58	13
Technology Transfer	68	14
U/I Cooperative Research	284	100
Special Interest Liaison Programs	65	23
U/I Coop.Res.Centres/Institutes	71	25
Research Consortia	15	5
Grants & Contracts	128	45
Collaborative Interactions	5	2

Source: Peters and Fusfeld (1982:16)

Peters and Fusfeld (1982) observe that 61% of the links occurred under the broad heading of University-Industry co-operative research programmes, involving, among others, the establishment of joint collaborative research, contract research and research consortia. However, the authors point out to the difficulties encountered by partners in sharing common research interests since only 2% of those agreements could be considered real research collaboration. One of the facts they emphasise as being of importance to the establishment of links between academe and companies refers to the specific fields, and their multidisciplinary character, in which the collaboration is set up. As Peters and Fusfeld (1982:20) comment:

Industry generally supports [and commits itself to] the scientific and technical fields most closely allied to their interests. The nature and tradition of the field also determine the level and type of industrial funding [and collaboration]... Opportunities for cooperative university/industry research interaction frequently lie in subject areas at the interface of traditional academic disciplines, e.g., polymer science, biomedical engineering, materials science, robotics, very large systems integration

(VLSI). Of the 464 university/industry research ties we identified in our field study, 179 (approximately 40%) were programs covering two or more academic disciplines.

The limited relevance of academic research for the development of firms activities already observed in the previous studies are again confirmed by the results emerging from Mansfield's research (1991). This author also assesses the contribution of academic research to technological innovation in various American industries for a ten year period (1975-1985). In his study, Mansfield (1991) considers only recent academic research, whose definition is "[research] occurring within fifteen years of the commercialisation of whatever innovation is being considered" (Mansfield, 1991:1). The sample of firms investigated by Mansfield involves 76 major manufacturing industries, randomly chosen, in the following productive sectors: information processing (25 firms), electrical equipment (14 firms), chemical (15 firms), instruments (7 firms), drugs (6 firms), metals (6 firms), and oil (3 firms).

Mansfield observes that, on average, only 11% of the new industrial products and 9% of new industrial processes would not have been specially developed, without substantial delays, in the absence of support from academic research. The more sensitive productive sectors are drugs, instruments, metal and information processing for product innovation and drugs, metals and information processing for process innovation.

Mansfield also identifies many industrial innovations that have developed without the support of recent academic research even though they consumed greater financial resources and time in the respective companies. In this group of innovations, only 8% of product innovation (mainly those related to information processing and drugs) and 6% of process innovation (mainly information processing), on average, are detected.

As in Nelson, Klevorick and colleagues' research (Nelson, 1987, 1989; Klevorick et al, 1995), Mansfield's data show the limited, even though important, contribution of research

undertaken by universities for industrial innovation. Since product and process innovations require much more than research expertise to their development and implementation, he considers unrealistic to include universities "as a major player in this process". According to Mansfield (1994:12-13)

My findings do not support the view that universities are likely to play a central or direct role in the development of new products or processes. Most of the new products and processes that could not have been developed (without substantial delay) in the absence of academic research were not invented at colleges or universities; instead, academic research provided new theoretical and empirical findings and new types of instrumentation that were essential for the development of the new product or process, but not the specific invention itself.

In the Swedish context, Deiaco (1992) evaluates the contribution of universities to industrial innovation, covering a 5 year period (1984-1988). Making use of a sample of 101 firms, covering several productive sectors (e.g. food, beverages and tobacco; wood, pulp and paper; chemicals and pharmaceuticals; basic and fabricated metals; machinery and transport equipment; electronics, computers and instruments; electrical machinery; other manufactured goods), this author achieves similar results as those earlier mentioned.

He detects the low level of importance of universities on industrial innovation since only 23.9% of the firms investigated consider this source of knowledge and information as important to the development of their activities. As for the importance of academic research for single firms' technological innovation, Deiaco (1992) observes that academic research has been an important innovative input for only 13% of innovations undertaken by his sample of firms, being mainly concentrated in the chemicals and pharmaceuticals and electronics sectors.

As part of the effort in quantifying the economic benefits of academic scientific research, Gibbons and Johnston (1974) conducted research in order to explore "the various mechanisms by which scientific research and education contribute to industrial innovation" (Gibbons and Johnston, 1974:222).



In their analysis, Gibbons and Johnston (1974) consider the units of information used by British firms during the process of production of 30 "recent or on-going" industrial innovations. From the 887 units of information identified in those industrial innovations, the authors recognise that only 107 units (12%) can be classified as scientific information emerging from outside the firms.

In addition, Gibbons and Johnston are able to classify those scientific information according to the ways in which they are established. In other words, they establish certain categories that can be considered as channels through which scientific information flow to firms. Their results are as follows: 55 units (6%) from scientific literature (reports and original research work without any specific connection with the problem in question); 30 units (3%) from contact with university scientists and 18 units (2%) were obtained through contacts with scientists in government research laboratories; and 4 units (0.5%) were related to contact with scientists at conferences.

The results of Gibbons and Johnston's research confirms previous studies already described: university, as a source of knowledge or information, has a little direct impact on the development of the firms activities. Though little, Gibbons and Johnston consider the impact of research undertaken by universities as very important mainly in two distinct ways: the first relates to the increasing of the stock of knowledge per se. The second point refers to the constant improvement of scientists' capacity in dealing with topics that might directly contribute to the solution of industrial problems. In their words:

The first of these refers to the scientific knowledge resulting from research itself...The second major significance...is the maintaining the expertise of the scientist and his familiarity with a particular area of constantly changing knowledge...[because] the scientists can and sometimes does, play a vital role in perceiving the application of particular knowledge to specific problems, and translating and transforming the results of scientific research into a form in which they are directly usable in the industrial environment (1974:241).

More recently, Faulkner and Senker (1994, 1995), adopting an extension of the methodology developed by Gibbons and Johnston (1974), investigated the contribution of knowledge from Public Sector Research (PSR) - "government funded laboratories as well as laboratories in universities"¹¹ (1995:7) - to the innovative activity of firms. In such an enterprise, these authors make use of a sample of 31 companies from three technologies: biotechnology (4 firms based in the UK), advanced engineering materials (12 firms based in the UK) and parallel computing (15 firms, 7 based in the UK and 8 in the US).

Their analysis shows that the contribution of scientific and technological inputs from PSR varies depending on the sector of technology. For the three groups of technology, firms' internal sources of knowledge are more important than external ones. However, for biotechnology, PSR presents a higher relative contribution to the innovative activity of firms than other companies; for ceramics, PSR and other companies have similar impact on the firms' innovative activities and for parallel computing, other companies make a greater contribution to the innovative activity of firms than institutions linked to the PSR.

Table 2.8 - Channel use in Biotechnology, Advanced Ceramics and Parallel Computing*

Channel	Biotechnology	Adv. Ceramics	Par. Computing
Literature	55%	42%	23%
Personal Contacts	36%	49%	68%
Recruitment	11%	10%	10%

Source:- Faulkner and Senker (1995:183)

* Based on aggregated responses on the impact of STI obtained from PSR by these main channels

Regarding the channels through which scientific and technological inputs from PSR flow and have been accessed by companies, Faulkner and Senker (1994, 1995) observe that literature (through abstracts, textbooks and on-line databases, scientific and engineering

¹¹ Faulkner and Senker (1995:7) add that "The term "PSR" is slightly confusing in the US where universities may be public or private sector funded. In this setting, it therefore encompasses all universities (however funded) plus the various national laboratories. It will be appreciated that the boundaries between public and private sector research are becoming rather "porous" (on both sides of the Atlantic). Also, much of the research literature and policy discussion addresses the subject of public-private research links in terms of "university-industry relations".

journals) and personal contacts (consultants, collaborators, colleagues) are the most important links. As table 2.8 above shows, for biotechnology, literature comes first; for parallel computing, personal contacts are the main channel and for ceramics, both literature and personal contacts have a similar importance. Recruitment of skilled people does not represent an important channel of flow of knowledge from PSR to firms for the three technologies.

Summary

Though the above mentioned empirical studies adopt different methodologies, they share a common objective: to investigate and assess the importance and the ways in which universities, and particularly academic research activity, support innovative activity of firms. They emphasise that universities, through their academic disciplines, research activity and staff, make a marginal, but important, contribution to firms' innovative activity. Innovative activity, as has been emphasised in several parts of this Chapter, is a very complex activity in which research constitutes a small, but extremely important, input for its realisation. Because firms' innovative activity is dependent on several factors, the potential contribution of universities to its development must be contextualised within certain limits and as a complementary asset for firms. As Faulkner and Senker (1994:686) point out:

[Public Sector Research] PSR contributes to innovative RD&D in two distinct ways: (i) as a source of new knowledge in specialist fields of science and engineering; and (ii) as a source of practical help and assistance, including in the area of instrumentalities (except for parallel computing)...These findings confirm that the predominant role of PSR in innovation lies in the training of qualified scientists and engineers, and in its being a potent source of new knowledge - knowledge which either underpins industry's RD&D programmes or which, occasionally, offers new opportunities for exploitation.

2.2.2 - Factors Affecting the Strength and Significance of University-Industry Links

Several studies, including some of those outlined above, have focused on variations in the significance and effectiveness of links, and they have sought to identify the main reasons for such variations. The more important factors identified fall into three main categories: (i) organisational and cultural variables in the two kinds of institution, and in particular the degree of mismatch between them; (ii) characteristics of the firms and industries involved; and (iii) time, especially with respect to the degree of "maturity" of technologies and the space (geographical distance) separating the two institutions.

2.2.2.1 - Organisational And Cultural Aspects

The design and establishment of channels or mechanisms for fostering the U-I interaction is not a guarantee for the effectiveness of U-I links and consequent achievement of expected benefits. There is no prescription for the successful establishment of mechanisms. However, after analysing U-I links and mechanisms within the context of several of its member countries, the OECD report (1984) mentions that, under certain circumstances, the setting up of links and mechanisms between academe and firms would be facilitated, and the probability of success would be highly presented.

From the OECD' point of view, universities, for instance, must enjoy academic excellence in both research and training. Their scientific research agenda should be as diverse as possible "ranging from basic research through strategic and targeted research projects to the provision of consultative services" (OECD, 1984:7). Firms, on the other hand, must be able to clearly identify the needs and goals driving their linkages with universities. According to Rothwell (1991), they should also show willingness in accepting academic suggestions and orientation.



Both partners should strictly observe their cultural differences (Rothwell, 1991) as well as adopting a pro-active individual and institutional initiatives concerning their interaction. The setting up of a favourable environment between these partners is considered as an essential ingredient for fostering their links and interaction. Besides, a high level of flexibility - "institutional flexibility" - is necessary to pursue different modes and mechanisms of co-operation.

Complementing these observations, Governments should also demonstrate a pro-active attitude facilitating and stimulating U-I links and mechanisms through the creation of a favourable milieu. Thus several initiatives would take place and benefits would be achieved. As the OECD report (1984:9) puts it,

[the] adjustment of legal and regulatory constraints, provision of adequate incentives to all parties, development of national programmes to pull together scattered efforts. They can help in the creation of a milieu where initiatives multiply and bear fruit.

Moreover, Governments should promote, if necessary, intellectual property policy adjustments as well as undertake evaluative studies to overcome the lack of assessment of U-I links and mechanisms.

However, the establishment of links and mechanisms between university and industry do not occur uniformly. Several reasons underlie this diversity. Universities differ in their objectives, academic expertise and degrees of flexibility whereas industries, and even firms within a specific industrial branch, have different strategies and attitudes to the innovative process and research activity. The specific characteristics of firms - size, productive sector and ability to cope with technological advances - also influence the effectiveness of their links with universities. In this respect, the OECD report (1984:26) states the following:

...(i) both the extent and the nature of university/industry relations depend upon sector and firm size; and (ii) the objectives of such relationships - the function

which academic institutions can perform (more or less effectively) for industry similarly vary.

The next sub-section deals with three specific characteristics of firms: the size, productive sector and R&D activity that have, to some extent, influenced the firms' interaction with universities.

2.2.2.2 - Firms' Key Characteristics and the Links with Universities

Size of Firms

The OECD report (1984) recognises four types of relationship between university and industry from the point of view of size of firms:

- Large firms, intensively involved in R&D activities and dealing with high technology sectors, have a special interest in forging links with academe. These links are mainly considered as a way of accessing new ideas in specific technologies and recruiting highly qualified manpower.
- Large firms in traditional industrial sectors present two different attitudes concerning links with Universities depending on the dynamism with which their processes of technical change take place (e.g. more dynamic sectors such as chemistry, electrical and mechanical engineering; and less dynamic sectors such as shipbuilding, mining, automobile engineering). Consequently, less dynamic sectors have the tendency to have a weaker relationship with academe.
- Small and medium size firms (SMEs)¹² in high technology sectors are, generally, highly R&D intensive and work with specific niches of the market such as those related to micro-

¹² Particularly concerned with innovative small firms, Senker (1985:245) states that "some small firms help develop *new technologies*; other *newly established* firms and swarms of imitators develop the commercial applications of the new technologies; in established sectors dominated by large firms, small firms fill *market*

electronics and biotechnology. These companies have become a policy priority for governments due to their possibilities of producing value-added goods and services. However, the type of links they establish with academe varies enormously according to the activities they are engaged in. As the OECD report (1984:28) has stressed, "essential for all such firms appears to be close integration into the scientific community, national and international".

- Small and medium size firms (SMEs) in traditional industrial sectors appear to be in need of intermediaries bodies (e.g. Industrial Liaison Offices) in order to forge linkages with Universities. This specific segment of SMEs seems to be more sensitive to the traditional barriers encountered for the U-I interaction (e.g. rigidity of Universities structure; limited interest of academic staff in short-term industrial problems).

The empirical evidence related to the influence of size of firms and the establishment of linkages between firms and academe is not very profuse. Despite non existent empirical evidence, Parker (1992) states that the size of firms strongly influences the possibilities these latter have in collaborating with Universities. She emphasises that small firms, being more restricted to the solution of trivial problems and lacking adequate in-house research capabilities and financial resources, do not attract the interest of academic researchers in forging co-operation. The exception is small firms engaged in high technology productive sectors.

The results achieved by Corsten (1987a, b) confirm Parker's view. Corsten identified size of firms as the firms' total number of employees. He investigated the influence of the size of firms on the establishment of their links with universities through a sample of 317 companies (from Germany, France, the United Kingdom and the Netherlands). Table 2.9 below presents Corsten's main findings.

niches providing specialised products. From some of these market niche firms *new products* may emerge to create the mass markets of the future. In sectors not suitable for mass production, small firms keep their products competitive by applying new technologies as they emerge".

Table 2.9 - University-Industry Links and the Size of Firms

Size of Firms	% of Firms Investigated	% of Firms with Links with Universities
Small, Medium and Large Firms		
1 to 499 employees	71.0	23.6
500 to 999 employees	13.6	34.9
1000 to 1999 employees	9.1	65.5
2000 or more employees	6.3	75.0
Total	100.0	
Small and Medium-sized Firms		
1 to 19 employees	10.2	9.4
20 to 49 employees	24.9	20.7
50 to 99 employees	20.0	13.2
100 to 199 employees	16.0	26.4
200 to 499 employees	28.9	30.2
Total	100.0	

Source: Based on Corsten (1987a, b).

Column 1 shows the distribution of firms analysed according to their size. Column 2 shows the proportion of firms that had had links with universities during the period between 1977 and 1987. The two main pieces of evidence that emerge from the table, as part of the whole set of firms, certify that small and medium-sized firms (those with 499 or fewer employees) had much less interaction with universities than those with more than 500 employees. As a sub-group, SMEs did not present a higher proportion of commitments. It is, in fact, evident, from Corsten' research, that the bigger the companies, the higher the proportion of links established with universities.

Deiaco (1992), in his study previously mentioned, also investigates the adoption of R&D co-operation, as a technological strategy, for a sample of 101 Swedish firms. From the point of view of size of firms, the results achieved by Deiaco study confirm Corsten' findings. In the Swedish case, large firms have taken more advantage of branch institutes (72.2%) and universities (69.4%) than small and medium-sized companies. In particular, universities

have been drawn on much less frequently by small firms (38.1%) and medium firms (39.5%).

Corsten also assesses the problems firms have in establishing links with academe. Among them, those related to communication between academics and businessmen dominated the answers from firms with up to 1999 employees, with a specific effect on the group of small and medium-sized firms. Problems related to confidentiality and academic perfectionism were more important for bigger companies. SMEs also quoted as significant problems academic lack of concern for practical issues in dealing with firms' problems, as well as firms' lack of financial resources for joint ventures with academic groups. These results confirm some of the difficulties already mentioned about U-I interaction from the point of view of the size of firms (Rothwell, 1991; OECD, 1990).

Firms' Productive Sector

The productive sector of firms is another factor which can influence the potential for interaction between universities and industries. As already stressed, certain academic fields are more applicable to industrial activities. In the same way, some industrial productive sectors are closer to the research activities developed by universities.

Even though there is a high propensity of linkages between universities and firms engaged in high technology sectors, this does not signify that U-I interaction has been limited to those productive sectors. What happens is that most of the studies that have been undertaken on the links between university and industry have two different positions concerning the productive sector. On the one hand, one notes the studies (e.g. Deiacco, 1992; Mansfield, 1991) which consider the importance of the productive sector as one of the determining factors for U-I interaction linkages and analysis. However, apart from presenting some background information about the industrial activity of firms, no substantial investigation of



the productive sector influence on the establishment of links with academe have been developed.

On the other hand, if an investigation is completed, it is restricted to an examination of the so-called high-technology industrial sectors. This is due to the fact that the R&D activity developed by high-technology industries seems usually to be close to university research, representing an intellectual and attractive challenge for academic researchers. As a consequence, links established between these kind of firms and academe appear to be more visible to analysis.

The research conducted by Faulkner and Senker (1994, 1995), already mentioned, takes into consideration the PSR links in three different technologies (biotechnology, advanced engineering ceramics and parallel computing) and explore their differences. The authors observe that biotechnology has a higher propensity for linkages with PSR institutions than parallel computing companies; ceramics firms rate linkages with PSR institutions and with other firms in a similar way concerning their contribution to the development of their activities.

Companies from different sectors have a different approach to PSR institutions while PSR institutions and the technology itself influence firms' behaviour. Innovative activity in pharmaceutical companies (representing biotechnology sector), for instance, is strongly driven by knowledge, and, as a consequence, has a higher tendency of linkages with research developed in PSR institutions. On the other hand, ceramics and parallel computing companies have higher dependency on information coming from their users and suppliers of material and equipment than biotechnology firms.

Firms' R&D Activity

Several scholars (e.g. Freeman, 1994; Nelson, 1987) recognise that firms' R&D activity - or in-house R&D capability - is an essential ingredient for increasing the firms' ability in coping with technical progress. In fact, it has been argued that the most R&D intensive firms are, the fastest is their economic growth. According to Freeman (1994:83):

Empirical research...tends to show that very high R&D intensity is positively related to rapid growth, whilst at the opposite extreme lack of any R&D or very low R&D intensity is often associated with stagnation or decline of firms.

It has also been recognised that firms R&D activity not only expands the possibilities firms have in interacting with other research performers, such as universities, government laboratories and even other firms. It also allows firms to take more advantage from those interactions, which, per se, assume a complementary character to the firms R&D activities (Feller, 1989). Thus, it could be concluded that the most R&D intensive firms are, the higher their possibilities of establishing and taking advantages of links with universities.

Arora and Gambardella (1990), for example, investigate the complementarity and external links in large firms in biotechnology. They argue that knowledge is quite complex and multidimensional in this particular field. Consequently, firms presenting a higher level of R&D activity are better prepared to interact with external sources of knowledge and information. As Arora and Gambardella (1990:371) point out:

Firms with a higher level of internal knowledge are better equipped to evaluate and to exploit new knowledge generated outside their organizational boundaries...one might argue that the higher the level of internal knowledge (in biotechnology), the higher the incentives to undertake strategies of external interactions.

Also Mansfield (1991), in his investigation about the contribution of academic research to technological innovation in several industries, observes that at least part of the inter-

industries differences concerning the better exploitation of academic research is due to their different degree of in-house R&D capability. Mansfield (1991:2-3) suggests that:

...to a considerable extent...inter-industry differences with respect to new products can be explained by differences among firms in R&D intensity (percentage of its sales devoted to R&D)...one of the most important reasons why relatively R&D-intensive firms are more likely than others to carry out innovations based on recent academic research is that they tend to be more closely abreast of such research.

The few examples mentioned above emphasise the importance of R&D activity for firms undertake links with universities and, consequently, cope with innovative activity. However, it remains an open question how determinant is the existence of R&D activity - and its intensity - of firms for the establishment of their links with universities.

2.2.2.3 - Time and Geographical Distance

Time

The OECD report (1984) suggests that firms involved with high-technology industrial sectors present a higher propensity of interacting with universities than those dealing with more mature industrial segments. This reasoning emerges from the fact that high-technology segments, being close to research undertaken by universities, would attract the interests of academic researchers in interacting with them. Then, sectors like biotechnology, information and communication technologies and material sciences seem to constitute the focus of many of the links established between university and industry presently.

Biotechnology seems to be an "extreme" case, since it is still over dependent on university research as a source of basic know-how and recruitment of qualified scientists and researchers. As Arora and Gambardella (1990:363-364) point out:

Historically, biotechnology originated from fundamental scientific breakthroughs in the 60s, and especially in the 70s. Moreover, in biotechnology the distance between scientific advances and their commercial applications is relatively short. In many cases, a new scientific discovery is almost a new product...the agreements with universities tend to focus on more basic research objectives...

Faulkner and Senker (1995) detect, however, some changes concerning the pattern of links established between biotechnology companies and PSR institutions. These companies, supported by their stronger R&D staff, have, over time, increased their formal links and decreased the intensity of informal ones.

In fact, Faulkner and Senker (1995), based on empirical evidence emerging from their analysis of linkages between biotechnology, parallel computing and advanced ceramics companies and PSR institutions, point out that "the stage of development of a field" is an important factor that must be considered in relation to the establishment of these links (Faulkner and Senker, 1995:196). They also add that distinction must be made between technology development and product development. Quoting these authors:

Interviewees in all three technologies related intensity of PSR linkage to the stage of product development, pointing out that the scope for PSR inputs declines as product design stabilizes...Unlike product development, however, there is no singular pattern of technology development against which to assess any changes in public-private research linkage. Nor is there an unambivalent measure of age. Nevertheless, it seems fair to conclude, as a general statement, that the relative age of a field is likely to influence the use of PSR (Faulkner and Senker, 1995:196).

So far, one would understand that the maturity of a technology limits the possibilities firms (in more mature segments) have in interacting with academe. However, as Blume (1987) explains, from the point of view of Sociology of Science, many are the variables that intervene in the process of establishment of University-Industry interaction. These variables are related not only to the stage of development of certain fields of science and technology. They also refer to the different nature and objectives of partners, the "roles" that govern their specific activities and the socio-economic circumstances in a given period of time. According to Blume (1987), what governs the University-Industry interaction is the

existence of a "common social project" that can be based on "shared values", or "shared interests", or "shared sense of social structure" (Blume, 1987:34). As the author emphasises:

University-Industry relations are a special case...[of] common social project...common social projects are constituted when scientific and institutional conditions are favourable; they are not therefore a feature of all science (Blume, 1987:34).

Firms' innovative activity and scientific and technological possibilities represent so dynamic processes that there is always the possibility of doing "old things" in "new ways". As Stankiewicz (1986:10) says "what happens is simply that a genuinely new way of putting things together suddenly emerges". In other words, the dynamism of a field, that might be independent of its age as a technology, does influence the possibilities firms and academe have of establishing links.

From this perspective, the interaction between university and industry might occur in any stage of development of any specific field. What varies, however, is the way in which the links between companies and academe are established and the level of impact - more direct or not - the links have on the firms' innovative activity. For technologies in a more mature stage of development, the impact of university research may be more indirect, or less visible, than with high technology fields. However, as Stankiewicz (1986:14) points out:

...the apparent decrease in the direct R&D links between industry and universities in no way implies that the links between science and technology have weakened...Although the emphasis on the direct utilization of the academic research resources has diminished, contacts with universities continue to be regarded as very important.

Geographical Distance

It has been argued by many enthusiasts of the interaction between university and industry that the spatial concentration of scientific and technical resources, provided by universities,

and firms would facilitate their exchange of knowledge and information. In other words, the geographical proximity between these partners would increase the possibilities of linkages.

However, this perception, or belief, has not been confirmed by empirical evidence. Oakey (1985), believes that the geographical proximity between academe and firms does not eliminate other barriers to their relationship, mainly those related to their "organisational distance". According to this author:

...[the] close proximity [between universities and firms] may offer easy and frequent physical interaction. But this removal of barriers caused by the friction of distance does not eliminate a major barrier to the uninhibited interchange of information which stems from the "*organisational distance*" between the academic and industrialist...there are logistical and behavioural arguments that detract from the simplistic view that, because a potential provider of technical information is proximate to a potential user, useful interaction will take place (1985:59-60).

In order to test his argument, Oakey (1985) investigate the links that existed between a random sample of 102 British high technology firms (scientific instruments) and their close external research institutions (within a radius of 30 miles). From these 102 firms, 36 are located on the North West and 66 firms are located on South East regions of England. This author observes that 65 firms (63.7% of his sample) had some contacts with the close research institution. However, only 9 firms in this group (13.8%) considered those contacts as "locationally constraining significance" (Oakey, 1985:60).

Oakey's findings are confirmed by another study he conducted, involving a random sample of small high technology firms (instruments and electronics) located on the South East of England, Scotland and the Francisco Bay area of California. In this second study, the results Oakey achieves show that only 23.3% of firms located on the Francisco Bay area, 42.4% of firms located on South East England and 55.6 % of firms located on Scotland had important contacts with their close external research institution. Moreover, only few of these companies reported those links as very important for their internal R&D activities (6 firms located on Scotland, 4 located on South East England and 3 on Bay area). It is worth



mentioning that "75 per cent of the Bay Area firms were within 30 miles of Stanford University" (Oakey, 1985:61).

The empirical evidence provided by Oakey supports his view that "external research contacts of high technology firms [with their close research institution] are neither profuse, nor centrally important to the firm's internal innovation when they occur" (Oakey, 1985:60).

Similar results are presented by Aweduto et al (1988a) in their study concerning the interaction between university and industry within the Italian context. The authors observe that only 25% of the research collaboration links between a sample of 344 firms and universities were established with the local university (within a radius of 40 kilometres). Aweduto and colleagues (1988a:3) conclude that

...geographic distance [between firms and universities] does not appear to be a limiting factor: almost 60% of cooperative efforts is obtained outside contiguous territories, measured as a distance of about 40 kilometres.

2.3 - Conclusion

This chapter analysed the potential and limits of the University-Industry interaction and links. As was stressed, these possibilities and limitations have been dictated, among other things, by (1) broader national infrastructures, in which universities and industries are inserted, and the ways they have been set up over time; (2) the very nature of innovation, or innovative activity, with its diverse forms and sources of knowledge, information and technology and (3) the differences in the ways universities and firms present themselves as social institutions.

Particularly concerned with the specific roles of universities and firms within national innovation systems, sub-section 2.1.1 explained that they substantially differ in the nature,

objectives and outcomes of their activities. Universities have traditionally been involved with the training of qualified manpower and the increasing of the stock of knowledge through the development of independent basic research without any application in view, even though more applied research has also become the subject of several academic disciplines. Firms being much more pragmatic and profit-oriented, have sought to explore the available resources in society in order to improve their economic performance and maintain their market position.

It has been argued by policy-makers and governments, in general, that the U-I interaction still remains a sub-utilised scientific and technological resource. Apparently, the development of research activity - mainly that of a more basic character and whose domain has been attributed to universities in many countries - and the commercial exploitation of its results by firms seem to constitute the focal point of the University-industry debate.

However, as the history of the University-Industry interaction presented on sub-sections 2.1.2.1 and 2.1.2.2 has shown, the U-I interaction varies enormously not only over time but also between countries. Even though extremely important, the interaction between university and industry has made a modest and limited contribution to firms' innovative activity or search for technical solutions. Information emerging from the observation of industrial R&D investment in university/HEI confirms the above statement. This is not surprising if one takes into account the already mentioned differences and trends.

Empirical evidence emerging from the studies that have been carried out in order to assess the strength and significance of links established between academe and firms gives an account on how limited, even though important, has been these links to the development of firms activities. In fact, the importance of university to firms has been much more concerned to the development of their traditional activities - training of qualified manpower and increasing of the stock of knowledge through independent research - than to the application and commercial exploitation of its research results in the industrial environment.



The analysis of the factors that may affect the establishment of links between university and industry shows, once more, the limits that exist in the University-Industry interaction. On the one hand, the brief approach to the different organisational and cultural aspects of these distinct social actors emphasise that these differences really matter. In other words, a successful interaction between firms and academe does not happen under any condition.

This study has given special attention to three specific characteristics of firms that may influence the establishment of their links with academe: size, productive sector and firms' R&D activity and intensity. From the empirical evidence provided in sub-section 2.2.2.2, one may be persuaded to conclude that larger R&D intensive firms engaged in high-technology productive sectors would have a high propensity of establishing links with university than any other type of firms. However, generalisation must be done very carefully. This is because there is no empirical evidence about the establishment of links between university and industry in which these three firms' characteristics have been jointly analysed. Moreover, as was stressed, the technological maturity of certain productive sectors do not undermine the possibilities firms (in these more mature sectors) have in strengthening their links with university. Finally, the geographical proximity between firms and universities does not seem to be a determinant factor in the process of linkages between them.

Considering all the above comments and aiming to assess more empirical evidence about the University-Industry interaction and links, the next Chapter looks at the Science Park as a mechanism that has been designed for, among other objectives, forging and strengthening the links between university and industry.

CHAPTER 3 - SCIENCE PARKS

This Chapter reviews previous research about the interaction between university and industry in the context of Science Parks, mechanisms that are typically designed and planned, among other things, to strength the U-I links.

The Chapter is divided into four sections. The first (section 3.1) presents a brief review of the different concepts and definitions, participants and objectives that have driven the planning, establishment and management of Parks. Section 3.2 provides a historical outline of the establishment of Science Parks considering, initially, the American experience (sub-section 3.2.1) and followed by the European one, mainly through the observation of the British context (sub-section 3.2.2 and 3.2.3). Section 3.3 looks, in detail, at the establishment of links between firms and academe through the Science Park mechanism. Initially, based on available empirical evidence, sub-section 3.3.1 deals with the nature and the importance of these links. Then, sub-section 3.3.2 analyses the factors that might affect the establishment of links between firms located on Science Parks and the host university. Finally, section 3.4 presents a brief conclusion.

3.1 - Science Parks: Concepts and Definitions, Participants and Objectives

Science Parks seem to be the most celebrated and pro-active mechanism for setting up an infrastructure in which the interaction between university and industry might be forged and strengthened (Goddard et al, 1994; Bell, 1993).

The eagerness with which policy-makers, Governments, companies and university authorities, from both developed and developing countries, have sought to exploit this

mechanism can be observed through the bulk of research covering particular cases and experience all over the world. Castells and Hall (1994), for example, cross the map from the United States (Silicon Valley and Route 128) to Japan (Tsukuba and Kansai), passing through England (Cambridge), France (Sophia-Antipolis), South Korea (Taedok), Taiwan (Hsinchu), Siberia (Akademongorodok). Luger and Goldstein (1991) and Miller and Côté (1987) study the American experience. The OECD (1987), Aydalot and Keeble (1988) and Cohen and Simmie look at the European experience. The research undertaken by Monck et al (1988), Massey et al (1992) and Westhead and Storey (1994) particularly concerns the British experience.

Parks tend to have a huge diversity and heterogeneity concerning their patterns. The reasons for this diversity reside in the different motives and expectations that have driven the engagement of so distinct social agents in a common enterprise - the planning, implementation, operation and management of Parks. Also, as Massey et al (1992:10) point out:

...science parks take radically different forms, in terms of their relation to the local economy, the kinds of companies located in them, their political and financial purposes, and even the relation between public sector and private.

In spite of the broad context in which Science Parks have been planned and set up, several attempts have been made, at least, to identify certain common parameters in order to facilitate the understanding and emulation of this University-Industry mechanism of interaction.

Concepts and Definitions

The answer to a simple question like "What is a Science Park?" causes some conjecture about the terms commonly used to define similar undertakings such as Incubators,



Innovation Centres, Research Parks, Science Parks, Business/Commercial Parks, Industrial Parks, Technology Parks and even Technopoles¹ (Monck et al, 1988).

There is no concept of Science Park that is widely applied. This is due to the mix of different participants, different objectives and different socio-economic contexts in which they have been implemented. In reality, Science Parks and similar phenomena must accommodate a huge set of interests.

Currie (1985:1), for example, regards Science Parks as

real estate development associated with a university or other higher educational institution with the major objective of facilitating the transfer of technology between academic bodies and operational businesses.

In addition, Currie (1985) has also proposed the use of two basic distinctions - space and level of manufacturing activity - to categorise different Parks. According to him, space determines both the kind of firms to be located on Parks and the potentialities for expansion of the firms' activities. In this sense, Innovation Centres, built in limited (physical) areas, would be more adequate for housing small firms with restricted plans for expanding their activities. Science and Research Parks, occupying larger areas, present themselves as more flexible models.

Currie (1985) also considers the level of manufacturing allowed to be developed on sites as a useful variable to contrast Innovation Centres with Science and Research Parks. The scope of activities involved in Innovation Centres are strongly limited by the availability of physical space; hence, no manufacturing is allowed on site. On the other hand, Science

¹ Due to their broader dimension, Technopoles seem to constitute a different kind of undertaking. According to Gibson and his colleagues (1988:xvii) "The concept of the technopolis - the modern city-state linking technology and economic development - is relatively new. Sometimes referred to as a *technology center* or a *high tech corridor* or *triangle*, the technopolis appears to be an emerging world-wide phenomenon". However, in the lack of more precise or world-wide concept of Science Parks and similar phenomena, some researchers tend to see Technopoles in the same context as Science Parks.

and Research Parks, being larger than Innovation Centres and having more manageable planning permission, sometimes permit the development of light manufacturing (Science Parks) or, at least, the design of prototypes (Research Parks).

Another interesting definition of Science Park is that proposed by the United Kingdom Science Park Association (UKSPA). This Association, founded in 1984 for clustering the British Science Parks, defines a Science Park as a property-based initiative which:

- Has formal and operational links with a University, other Higher Education Institution or Research Centre;
- Is designed to encourage the formation and growth of knowledge-based businesses and other organisations normally resident on site;
- Has a management function which is actively engaged in the transfer of technology and business skills to the organisations on site.

More recently, the UKSPA has expanded its criterion for membership in order to accommodate parks whose firms, instead of establishing links with academic institutions, are supported by major research centres set up by large companies (Massey et al, 1992).

The OECD report on this subject suggests that:

Science Parks are **areas** varying from a few score to a few thousand hectares. Two common features of all these developments are: (i) they represent a concentration of high technological activity, and (ii) an essential component is at least one university department or other technological institute to which enterprises in the concentration have easy physical and intellectual access (OECD, 1987:1).

A common feature that emerges from these concepts of Parks is that they all stress the importance of a university, or a university department, near the Park to facilitate the forging and strengthening of links with firms located on the site.

Participants

According to the OECD report (1987), Science Parks and similar phenomena can be spontaneous or planned undertakings, depending on their promoters and participants and their different set of objectives. Participants are defined as "operators" and "promoters". Quoting the report, "operators"

...refer to all those organisations which are carrying on an activity itself intended to yield a product, whether material or intellectual, with a market or an application outside the confines of the spatial concentration...the term is being used to cover research laboratories...manufacturing plants...product development...ancillary [activities]...(OECD, 1987:8).

On the other hand, "promoters"

are organisations which are carrying out functions intended to facilitate matters for the operators, or to encourage the latter to set about their tasks, frequently in advance of the appearance of the operators. The most obvious activities of this kind are the assembly and physical development of sites, the construction of buildings, laying out the roads, installation of utility services. However, one could also include among the developers bodies which provide educational facilities or which undertake fundamental research, both without too much regard for direct commercially-exploitable consequences (OECD, 1987:9).

However, the OECD report (1987) advises that the distinction between "operators" and "promoters" is not easy to identify in practical terms because Parks and similar phenomena have a combination of spontaneity and planning.

In general, four main groups of participants, or groups of interests, are identified in the literature when the planning and establishment of Parks is discussed.

- Universities and research institutions - Due to the lack of sufficient financial support from traditional federal sponsors to undertake research, universities and research institutions have seen the industrial sector as a potential new source of financial resources. The



financial constraints faced by the academic sector have forced some academic staff to be in contact with industrialists, modifying sometimes the topics of research developed in these institutions to those more concerned with industrial needs and interests.

- Industrialists and the so-called academic-entrepreneurs - Despite the institutional and financial difficulties found by researchers, the proximity of scientific/technological and productive sectors has stimulated and encouraged some of them to become entrepreneurs and consequently explore the results of their academic research on a commercial basis. These researchers have usually been involved with small high-technology firms in quite specific areas such as microelectronics and biotechnology. From the industrialists' point of view, their interests in working with scientific institutions lay in using scientific expertise and resources to improve their productive activities (products, processes, managerial techniques) in order to achieve a better market position through the improvement of their economic competitiveness. The expectation of getting an improved economic result and increased profits have stimulated the interaction and the mutual work between academic staff and entrepreneurs.
- Bank financial agents and venture capitalists - This group aims to invest in new or growing high-technology firms presenting potential for rapid economic growth and rapid financial returns. Though involving a high rate of investment risk, the economic return can be higher than in any other kind of economic activity, as in the case for traditional sectors.
- Government officials, authorities, developmental agencies - Apparently, their purposes are a mixed combination of the purposes of the other groups of interest. However, an additional motivation is that they have the conviction that Science Parks can be used as a mechanism for the revitalisation of some depressed economic regions.

Objectives

Massey et al (1992) identify a broad set of objectives emerging from these major groups of interests. Some of them are explicitly related to Higher Education Institutions (HEIs) and aim at the promotion of their links with firms or the better exploitation of their resources. Others concern specifically the creation and support of technology-based firms. Another important set of objectives relates to regional development policy and the revitalisation of declined economic regions. Finally, there is a group of very general objectives. They are summarised below according to their main purposes.

Higher Education Institutions (HEIs):

- Encourage and facilitate links between higher education institutes (HEI) and industry;
- Facilitate technology transfer from academic institution to park firms;
- Commercialise academic research;
- Encourage spin-off firms started by academics;
- Give academic institutions access to leading-edge R&D in park firms;
- Create employment and consultancy opportunities for academic staff and students;
- Generate income for the academic institution;
- Increase the appreciation by academics of industry's needs;
- Improve the image of the academic institution in the eyes of central government.

Firms:

- Stimulate the formation of start-up new-technology-based firms (NTBFs);
- Encourage the growth of existing NTBFs;
- Create synergy between firms;
- Increase the "relevance" to industry of HEI research;

Regional economic development:

- Create new job for the region;



- Improve the performance of the local economy;
- Shift local/regional industrial base from declining to new industries;
- Counter the regional imbalance of R&D capability, investment, innovation;
- Attract inward investment, mobile R&D;
- Improve the image of the location, particularly for areas of industrial decline;
- Reproduce Silicon Valley, Hewlett Packard.

General character:

- Foster the technologies of the future;
- Stimulate science-based technological innovation;
- Provide an adequate and safe return on capital;
- Stimulate a shift in perceptions;
- Build confidence;
- Engender an entrepreneurial culture by example.

Before turning to the University-Industry links through the Science Park mechanism, the next section presents some historical information about the establishment of Science Parks.

3.2 - The Development of Science Parks: A Historical Outline

The literature concerning the Science Park mechanism has abounded since the 1980's and has concentrated more on exploring particular cases in the search for factors that might influence, or not, their implementation and later success, even though success is a very relative concept.

3.2.1 - The American Experience

There is a consensus in the literature on Science Parks that this mechanism has originated in the United States, Silicon Valley (California) and Route 128 (Massachusetts) being the two more famous American models. Their emulation has been tried not only within the American context but also all over the world. Both regions, for the economic dimension they have assumed within the American context, constitute something much more close to the concept of industrial complex or technopolis (Gibson et al, 1988) than to that of Science Park environments. The circumstances in which they were set up were so specific that their replication in any other place seems to be almost impossible. The next sub-section seeks to summarise the main factors contributing to their location.

3.2.1.1 - Silicon Valley and Route 128 - Key Factors for their Development

Silicon Valley, located in Santa Clara County, California, has been considered the heart of the world for producing advanced information technologies, whose main segments are semiconductors, microcomputers, computer peripherals and lasers (Larsen and Rogers, 1988). However, that region of California had no industrial tradition up to the forties and took advantage of the advent of World War II in order to stimulate its local economy (Saxenian, 1985 a, b).

On the other hand, at the same period of time, Massachusetts had industrial strengths in the machinery sector (mainly textiles) and other non-durable goods (Dorfman, 1983). After World War II, strongly supported by the Government and its contracts, sectors linked to defence and space activities - such as instruments, aircraft, missiles, space vehicles and electrical machinery - located their plants in Massachusetts. This successful undertaking brought economic revitalisation to that region, especially to the Boston area and Route 128.

In spite of the specificities of each case, the combination of certain key factors, summarised below, influenced the success of both regions.

- Infrastructure - Both economies (California and Massachusetts) were concentrated on well-established traditional sectors (agriculture and traditional industries). Despite the economic decline, both regions had a reasonable industrial infrastructure and some involvement with the electronics and computer sectors.
- Excellent universities and research centres were already located in the California and Boston areas. These academic institutions were responsible for the formation and training of highly qualified human resources (scientists, engineers and technicians). Moreover, such a high level of human expertise also involved the generation, absorption and spreading of a very positive entrepreneur spirit among their graduates and faculty units.

As for the Californian complex, Rogers and Larsen (1984)² have stressed that the University of California at Berkeley, more concerned with basic research and facing some administrative constraints, did not have, initially, strong participation in the process of the "creation" of Silicon Valley. However, Stanford University, well-endowed in the engineering field and with the stimulus of its Vice-president, Prof. Frederick Terman, had a critical and fundamental participation in its design and establishment. Terman encouraged the forging and strengthening of links between his University and the productive sector. He also founded the first American Science Park (at Stanford University) in order to attract and fortify science-based firms, stimulate young scientists to establish their own small companies and improve the university's income through tenancies in the Science Parks.

² Even though recognising the "availability of technical expertise" as an essential factor for the rise of Silicon Valley, these authors (1988:99-115), in more recent research, did not make any reference to the importance of local Universities for its establishment. In some sense, this reinforces the idea that the main function of Universities lies on the formation and training of qualified manpower.

On the other hand, in Massachusetts, despite the lack of explicit interest by the Massachusetts Institute of Technology (MIT) and Harvard University's administrators in encouraging local economic growth (Tödtling, 1994), both institutions, with different degrees of involvement, have been considered decisive components for the successful economic performance of the region. Before World War II, the MIT, which was traditionally more concerned with industrial links, had already an electrical engineering department of repute working at the frontier of electronics and computer technologies. The synergy between academic researchers and the productive sector started at that period and has had a mutual and profitable relationship over time.

- **Entrepreneurship** - On the case of Silicon Valley, Saxenian (1985a, b) has indicated that the "entrepreneur spirit" was a combination and consequence of the quality and quantity of graduates from the local universities. Initially stimulated by opportunities in the new semiconductor sector and their peripheral activities, they started their own companies, which are usually small high-tech ones. These scientists, technicians and employees of universities and other pre-existing companies were then responsible for the emergence of the particular dynamism that took place in Silicon Valley. Through their new start-ups, they initiated the enormous changes in information technology and increased the rate of employment. Larsen and Rogers (1988) consider small technology-based firms to be the backbone of Silicon Valley. In their account, they were able to identify 3100 electronics manufacturing firms located on the Valley in 1982. This number increased to 6000 when supporting activities (marketing, advertising, consulting, training, legal advice and so on) were added; and to 8000 if other 2000 companies dealing with non-electronics high-tech fields (chemicals, pharmaceuticals and biotechnology) are included.

- **Federal funds** - Silicon Valley and Route 128 consolidated after the World War II, depending heavily on the US military support and space programmes and on Government funds. The federal Government became a financial provider to a high degree and a very important client of the companies located in those regions.

- Venture capital - Larsen and Rogers (1988) define venture capital as "money placed in new or young high-technology companies with a high potential for rapid growth" (Larsen and Rogers, 1988:108). Venture capitalists have strongly contributed to the economic success of both regions. According to Rogers and Larsen (1984), Silicon Valley, with its potential for growth, represented (and still represents) a very good opportunity for venture capitalists undertake what know best: encourage the first steps of promising high-tech companies, provide financial resources and also management supervision and technical advice for market new-comers. Miller (1990) indicates that, for the period between 1982-1984, the participation of formal venture capital related to the total investment was 41.4% in California - the highest proportion in the US. - and 16.3% in Massachusetts.

These two American "models" have incorporated several factors considered as fundamental for the implementation of Science Parks. However, due to their broader economic dimension, they have also emulated some characteristic problems of older and traditional economic agglomerations (Rogers and Larsen, 1984; Saxenian, 1985a, b). The economic growth and massive job creation have provoked urban and environmental problems. As Larsen and Rogers (1988) diagnose "quality-of-life components have deteriorated" (Larsen and Rogers, 1988:110).

As a consequence, some legislative public controls have been imposed in order to contain the industrial growth. One of the first measures taken by major corporations in both regions was the separation of manufacturing activities and R&D units, driving the former ones to other parts of the country. On the one hand, the separation of R&D activities from manufacturing might cause a strong decrease in firms' competitiveness. On the other hand, it might also undermine Science Parks (or Technopoles) as an interactive mechanism, contradicting their initial objectives³.

³ Making reference to the British context, Goddard and colleagues (1994:27) point out that "the principle of separation of R&D from manufacturing is probably not a good model for the future competitiveness of UK industry".



3.2.1.2 - Other American Experiences

Besides Silicon Valley and Route 128, lots of other Parks have been planned, implemented and set up around the United States over time. Estimates of the exact number of American Science Parks range from one hundred (IPAC, Inc, 1988) to more than 150 (Van Dierdonck et al, 1991). Many of them have tried to emulate the early models and have acted as their branches incorporating some of the activities previously developed by them (Rogers and Larsen, 1984).

However, as Peters and Fusfeld (1982) caution, many are the differences existing between the first complexes and those founded more recently. Some important aspects that must be considered for current planning of parks relates to the different technical base, geographical pattern and financial support for business. Attention must be put on the greater maturity of several industrial sectors that previously collaborated with the emergence of Silicon Valley and Route 128. In addition, University-Industry relations have evolved over time and now require new institutional and business approaches.

The IPAC report (1988), based on a sample of 25 American Science Parks, made an analysis of this experience in the American context. Its main conclusions are:

- American Science Parks have had two main objectives. One refers to the promotion of the economic development of a particular region through the better utilisation of (local) scientific and technological resources. The second objective relates to the strengthening of links between academe and productive sectors and, as a consequence, the improvement of technology transfer.
- Parks have usually been involved with long-term R&D activities in high-tech disciplinary areas; links between the host university and Parks' tenants are considered as an essential factor for the success of this kind of development. Some restrictions on the level of tenants'

manufacturing activities have been imposed by promoters in order to maintain the Parks' environment and landscape.

- A mix of financial resources have been used to implement US Parks: university funds (including land sales and leases directly to the tenants or indirectly through private developers); state development funds, private banks, venture capital and federal grants. Also, infrastructure support has been provided through mutual arrangement from local, regional and state authorities and the promoters of the Parks.

3.2.2 - The European Experience

Lundvall (1988:364) argues that

The flourishing of "Silicon Valleys", characterised by a close interaction between "excellent" universities and high-technology firms in different parts of the world has given the [science and technology] debate further impetus. In most OECD countries the establishment of "science parks" and "technopolises" has become a part of industrial policy.

Several countries within the European context have, since the seventies, set up Science Parks and similar undertakings. The European Parks assume a huge diversity concerning their patterns. Part of such diversity is due to the different objectives and expectations of Parks' promoters and operators. However, the different national innovation systems and their specific policies within which Parks have been planned and established also explain the different patterns. The following paragraphs summarise some European experiences.

Germany

Germany, for example, lacking any strong segment of high-tech industries, has opted for the establishment of Innovation Centres and Science Parks in order to assist its group of

small and medium-sized firms - mainly those related to advanced technology. As Allesch (1985:59) points out:

Small and medium-sized firms have been recognized as an innovative motor for our economy...Setting up innovation centres and science parks is only a logical, albeit important step in this development...The target group of the innovation centres or science parks are preferably young firms in new areas of technology with a future, with microelectronics, computer software, control, metrology and environmental engineering predominating.

Other objectives imputed to those Centres include the revitalisation of older industrial areas, job creation, and validation of research undertaken in universities as a mechanism of technology transfer (Sunman and Lowe, 1986). However, as Sunman and Lowe (1986:71) emphasise:

...the links between universities and new companies seem to be fairly weak...In West Germany, the majority of centres have been sponsored by the local government, and frequently the university has little involvement in management beyond the initial screening of tenants. The university's involvement in West Germany is consequently much less which probably explains, at least in part, the disappointing technology transfer patterns.

On the other hand, the links forged among firms located on Parks and Centres seem to be more vigorous and even decisive not only for new-comers but also for the companies already established on Park sites.

France

France has, since the late 60's-early 70's, implemented large undertakings as Technopoles. According to Higgins (1989), the French Technopoles aim to create an innovative environment in which a set of high dense and diverse firms, research establishments and university work together in order to strengthen their interaction and, consequently, increase their capacity of transferring technology.

As a powerful instrument for regional development policy, the French Technopoles have been sustained much more through the greater involvement of large Government research laboratories and the attraction of large multinational companies, both related to specific technological segments, than through the support of French Universities, whose participation, in contrast to the British experience, has been reduced in those enterprises. More recently, support for small and medium sized enterprises related to new technologies, seems to have become the policy priority for French undertakings. This change of attitude might open more room to a greater involvement of French Universities with Technopoles companies.

Italy

Italy has set up Technopoles and Science Parks as a mechanism for the promotion of regional economic development. Even though there is a strong connection with the more traditional industrial sector, Italian Science Parks and Technopoles have a higher concentration in specific high-technology industrial segment in the North of the country. The importance of these enterprises within the Italian context has been recognised by Aweduto and Silvani (1988b), who have however alerted to the fact that the expectations concerning the Parks' results should be kept in a more realistic standard.

Sweden

Sweden has adopted Innovation Centres and Science Parks as a way of fortifying traditional industrial sectors, thus strengthening industrial competitiveness. Parks have been created much more to attend to local and regional needs than those of a more national character (Niblaeus, 1985). However, as Niblaeus (1985: 278) points out:

As to their roles and functions, it is obvious that the ambitions are rising; only a few years ago, contract research as such was the target, whereas today the ambition



often is to nurture the new ideas in incubators up until they are ready for production.

The strong financial support provided by the Swedish Government and the participation of research institutes and universities in the establishment of Parks has generated well-balanced development in the Swedish scenario.

Portugal and Spain

Portugal and Spain, although less-endowed economies within the European context, have also been engaged in the implementation of Science Parks. However, their potential is different.

In Portugal, the scenario is not so favourable to the implementation of Science Parks due to its weak economic performance. At the end of the eighties, there were three main objectives of the proposed Portuguese Technology Parks: to encourage foreign companies to invest in Portugal; to accelerate the development of indigenous Portuguese technological capabilities and to speed the diffusion of technology to traditional industries. However, the Luso American Development Foundation report (1988), which undertook broad research to scrutinise the Portuguese potential for the implementation of Parks, took a very realistic view: at that period, the Portuguese context was not favourable for the implementation of Parks.

On the other hand, Spain has a more optimistic scenario. Triana (1989) has emphasised that the main aims of the Spanish Science Parks are the modernisation of the industrial and services networks. Escorsa (1988) argues that Spanish Parks have been set up in a decentralised form by local and regional authorities taking into account a pro-active attitude on the part of universities and Research Institutes as well as from entrepreneurial associations and larger enterprises. Several Spanish Parks (e.g. Barcelona, Madrid and

Pais Basco) have been established in Zones of Urgent Reindustrialization (ZUR) and Government bodies have granted special incentives - such as subsidies and fiscal benefits - to attract firms to the Parks' site.

3.2.3 - The British Experience

The two most famous American experiences - Silicon Valley and Route 128 - decisively contributed to the inception of Science Parks in Britain (Massey et al, 1992). Within the European context, the United Kingdom is the country in which Science Parks have been established and analysed in a more systematic way. Several researchers have studied this phenomenon seeking to observe their implementation, diffusion as well as their social and economic impacts.

According to several British experts (Jones and Dickson, 1985; Monck et al, 1988; Massey et al, 1992), the development of British Science Parks has been a direct consequence of two main events. One refers to the reduction of financial support to British universities from traditional sources (Government), mainly during the 1970s and more sharply during the 1980s. The second relates to the lack of technological dynamism within the British industrial sector and, as a consequence, the increasing necessity of improving the industrial performance through the better exploitation of scientific and technological resources. Universities and other Higher Education Institutions are expected to fill at least part of such an expectation. As Massey et al (1992:7) point out

the gap between direct production and academia has been interpreted, from the 1960s of Harold Wilson to the recent decade of Margaret Thatcher, as a crucial problem which it is essential to resolve.

With the idea of placing firms and universities in the same physical space and expecting their closer linkages, Science Parks seem to represent at least a partial solution to the above mentioned problems. The next sub-section briefly describes the two initial British

experiences of Science Parks - Cambridge and Heriot-Watt Science Parks - and seeks to emphasise the main factors which contributed to their settlement.

3.2.3.1 - Cambridge And Heriot-Watt - Key Factors for their Development

Cambridge is the most famous British Science Park and has been considered as a model for other British Science Parks. Furthermore, other European countries have taken it as an example in their attempts to implement this mechanism. Established in 1973, it is located around Cambridge town as part of a broader high-tech industrial complex related to electronics and telecommunications, computing hardware and software, instruments, biotechnology, scientific and R&D consultancy.

Segal and Quince (1985) argue that the Cambridge Science Park was the first instance when Cambridge academic staff was considering University-Industry interaction. At that time, their purpose was the promotion of science-based industry in that region. According to these authors, the main characteristics of Cambridge Science Park are:

- Scientific research associated to industrial production;
- Light industrial production dependent on consultation with the tenant's own research staff or with the local scientific complex;
- Ancillary activities considered appropriate to a Science Park (e.g. social centre, patent agents, venture capitalists).

In spite of the multiplicity and complexity of factors supporting the establishment of the Park, Segal and Quince (1985) stress the special character of Cambridge as a place to house this kind of enterprise. Though a small town with limited industrial commitment, Cambridge has traditionally had a good performance in the financial, professional and business service sectors. In addition, the area has housed an exceptional network of qualified human resources due to the presence of a very well-endowed academic institution, Cambridge University. Besides its excellence in the sciences, engineering and



medicine fields, Cambridge University has also a flexible and decentralised administrative structure, allowing its academic staff to develop other functions besides their traditional academic responsibilities.

Trinity College, which is part of Cambridge University, had a special role in the process of the establishment of the Park. It owned some available land and, at the end of 1960's, when some key individuals/researchers from the Engineering and Science departments, stimulated by local authorities, decided to set up their own science-based companies, offered its spare land to house a Science Park (Segal and Quince, 1985).

The direct participation of Cambridge University in the Cambridge Phenomenon is measured by the number of small firms that have spun off from its departments. In this sense, the University's participation is not very expressive for not more than 10% of the companies located on the complex have come from the University. On the other hand, the University has indirectly been very important as a lure for enterprises. According to Segal and Quince (1985), by the middle/end of 1984, something like 350 small and young high-tech firms were located on the complex, and among them, 40 companies (12%) were installed in the Cambridge Science Park.

Heriot-Watt Science Park, set up in 1972, is located on the campus of the Heriot-Watt University, Edinburgh, Scotland. As its main objective, the Park has planned "encouraging the transfer of academic research into marketable industrial processes, products, and services" (Dalton, 1985:231). The planning brief of the Park involves research, development, design, engineering and also prototyping activities and its companies must maintain close linkages with university academic staff.

Heriot-Watt University has always presented a pro-active attitude concerning the process of establishing its Park. It is endowed with very good Science and Engineering departments,

initially concentrated in electronics, health care and precision engineering. From the 1950's onwards, the University started its involvement with off-shore technology, increasing the scope of its research/activities because of the exploration of gas and oil resources in the North Sea off Scotland. As a result, many large foreign (mainly American and Japanese) and domestic investors have come to the region.

Yet, the most important aspect concerning the University is that, in contrast to Cambridge, Heriot-Watt University has had a tradition of working and cooperating with the industrial sector since its foundation in the last century. This tradition has provided the University with a very flexible administrative structure which encourages and allows its academic staff to forge close relationships with the productive sector.

About the Research Park, Dalton (1985:233) points out

...it was decided that applied research and development was the most constructive sector in which the University could make a contribution to active collaboration with industry. It was realised, however, that production will often arise naturally from the result of research and development activities and it was decided that "the limited manufacture of sophisticated items containing a large element of development, not for sale to the general market, be allowed".

The financial support to the Park has been provided by the University and its private funds. In 1984, 18 companies were located in the Research Park, some from the University Technology Transfer Groups, others as spin-offs from the University departments and also some external companies. In general terms, these companies are interested in offshore/petroleum engineering and computer/electronics/electro-optic engineering.

The next sub-section presents some information about other British Science Parks.

3.2.3.2 - Other British Experiences

Science Parks have assumed different forms within the British context. Massey et al (1992:10) stress that:

science parks take radically different forms, in terms of their relation to the local economy, the kinds of companies located in them, their political and financial purposes, and even the relation between public sector and private.

Table 3.1 lists the British Science Parks established since 1972 according to their year of foundation. It also gives the number of tenants for 1986 and growth or reduction between 1988 and 1990.

The "first wave" of British Science Parks occurred at the beginning of the 70's, with the setting up of Cambridge and Heriot-Watt Science Parks. Ten years later the "second wave" took place, when 38 new Science Parks started operation and another handful have been planned.

Among the Parks established during the second phase, one can find the Surrey Research Park. This Park was chosen as the case-study for this research. As will be explained in more details on Chapter 4, the basic reasons for such choice are: (i) the maturity of the Park; (ii) its rational pattern of growth that can be observed through its stable pattern of tenantry; and (iii) the lack of specific regional development policies that could influence the ways in which the Park has been implemented and managed.

The distribution of British Science Parks over the British territory shows that "26 per cent of the parks, having 50 per cent of building area, 27 per cent of tenants, 55 per cent of buildings in construction and 49 per cent of employment" (Massey et al, 1992:54) are located in the south and east regions of the country.

Table 3.1 - British Science Parks established since 1972

PARKS	Year	Tenants 1986	Tenants 1988	Tenants 1990
Cambridge	1972	68	69	82
Heriot-Watt	1972	23	32	37
Merseyside	1982	12	15	13
Aston	1983	42	60	69
Bradford	1983	26	33	31
Glasgow	1983	15	21	24
Leeds	1983	11	8	5
East Anglia	1984	3	1	closed
Hull	1984	12	14	12
Loughborough	1984	17	16	13
Manchester	1984	11	17	22
Nottingham	1984	14	22	41
St. Andrews	1984	2	4	6
Southampton	1984	15	21	20
Surrey	1984	10	43	59
Warwick	1984	35	47	58
Aberystwyth	1985	6	10	14
Clwyd	1985	6	20	20
Durham	1985	5	25	23
South Bank	1985	36	50	77
Sussex	1985		14	16
Antrim	1986	2	6	7
Birmingham	1986	9	15	16
Bolton	1986	10	16	20
Brunel	1986	8	25	21
Kent	1986	2	5	6
Stirling	1986	5	17	21
Swansea	1986	6	20	22
Bangor	1987	1	5	4
Cardiff	1987		15	14
Keele	1987		10	15
St. Johns(Ca)	1987		31	62
Aberdeen	1988		6	19
Billingham	1988		30	36
Salford	1988		18	18
Sheffield	1988		32	35
Sunderland	1988		9	11
Wrexham	1988		5	16
Reading				12
Silwood Park				15

Source: Based on Massey et al (1992:18).

Information concerning the number of Park-tenants shows that between 1986-1990, one Park, located in the south, ceased activity (East Anglia). Some other 10 Parks had, in different degrees, their number of tenants reduced (Brunel and Southampton in the south



and, Bradford, Durham, Loughborough, Merseyside, Cardiff, Hull, Leeds and Bangor in the north). Two northern-Parks have kept the same number of tenants (Clwyd and Salford) and two other southern-Parks do not admit comparison (Reading and Silwood Park, linked to the Imperial College). For the remaining Parks, the rate of growth of tenants varies enormously: in some cases the proportion was 400% (in Durham and Bangor between 1986 and 1988) or 200% (as was the case of Wrexham between 1988 and 1990).

3.3 - University-Industry Links through the Science Park Mechanism

This section turns from the preceding broad perspective on Science Park mechanism, and reviews previous research about the links established between on-Park firms and host universities. The section is divided in two main parts. The first (sub-section 3.3.1) is concerned essentially with the nature and importance of links established between on-Park firms and universities. The better understanding of these issues also allow an evaluation about the importance of Parks as a mechanism of interaction between university and industry. Sub-section 3.3.2 is related to the factors that influence the establishment of links between on-Park firms and universities.

3.3.1 - The Nature and Importance of University-Industry Links through the Science Parks

Most of the research that have been carried out about Science Parks have focused on aspects related to regional economic development, such as the generation of jobs, the establishment of small technology-based firms and the revitalisation of local or regional economy. However, at least part of this research has also dedicated some attention to Parks as a mechanism of interaction between university and industry.

In the British context, for example, Monck et al (1988:167-168) suggest that links between on-Park firms and the local university might originate under the following broad headings:

- the transfer of people, including founder-members of firms, key personnel and staff into employment in firms;
- the transfer of knowledge (often embodied in the above personnel);
- contract or sponsoring research in the university by researchers and students;
- contract development, design, analysis, testing, evaluation, etc.;
- access to university facilities such as libraries, and especially journals;
- less formal interchange with academics which may lead to the important exchange of information, or provide access to a network of people and resources.

Based on these headings, Monck and colleagues (1988) establish two broad groups of links: (1) R&D and personnel, whose links are related to research activity, use of scientific equipment available at universities and recruitment of skilled people (students and researchers); and (2) non-research links involving several links related to the use of universities facilities.

In order to investigate the extent and nature of links established between companies located on British Science Parks and the local universities, these authors consider a sample of 284 similar firms. 183 of these firms were located on-British Science Parks and 101 firms were located off- Parks. The similarity of firms is based on their productive sector, age, ownership pattern and comparable economic areas of the United Kingdom. Table 3.2 summarises Monck and colleagues' main findings.

Interestingly, both on- and off-Park firms had very similar rates of response to R&D and personnel links. The exception was the higher proportion of on-Park firms accessing "informal contacts with academics" (60%) and "access to equipment" (38%) when compared to the sample of off-Park firms (45% and 30% respectively). However, it is worth emphasising that the generality embodied in the concept of "informal contacts with academics" makes evaluation very difficult.

Table 3.2 - Firms and their Links with the Local University - 1986 (proportion of firms)

Links	On-Park Firms	Off-Park Firms
R&D and personnel Links		
Informal contacts with academics	60	45
Employment of academics	28	28
Sponsor research/trials	14	15
Access to equipment	38	30
Test/analysis in HEI	12	13
Student projects	22	24
Graduate employment	30	30
Training by HEI	4	7
Teaching programme	5	10
Other formal links	1	
Non-Research Facilities		
Computer	19	7
Library	48	19
Recreation	30	7
Conferences	15	12
Dining	22	6
Audiovisual	10	4
University as a customer	15	16
Other	5	3

Source: Based on Monck et al (1988:171)

Regarding non-research links, on-Park firms used links to a higher degree compared to the sample of off-Park firms. This is due to the fact that as this group of links is related to the use of university facilities, the geographical proximity between on-Park firms and host universities, provided by Science Parks, facilitates the use of these facilities for firms located on the sites.

The analysis undertaken by Monck and his colleagues of U-I links within the context of Science Parks does not provide any further explanation to illuminate the reasons, intensity and importance of these relationships for firms and universities. Also, aspects related to specific firms' characteristics and the influence they might have on the establishment of links were not analysed in relation to the links.

On the other hand, what is clear from their investigation is that aspects related to the universities had only marginal importance for firms located in Parks. Only 24.9% of on-Park firms stated that proximity to the university was an important factor in their choice of location. In addition, reasons for their choices were mainly related to "prestige/image of site" (74% of firms) and "access to HEI facilities" (47% of firms). "Recruitment of new graduates" and "prestige of university links" received a much lower rating as a locational advantage⁴.

More recently, Westhead and Storey (1994) undertook another study in order to evaluate British Science Parks as a location for high-technology or knowledge-based companies. Part of their research was concerned with a comparative analysis of links between on- and off-Park companies and Higher Education Institutions. The data used in their analysis considered 251 firms: 130 located on British Science Parks and 121 similar companies located off Park. Of the 130 on-Park firms, 59 had been previously researched by Monck and his colleagues in 1986 (and described above) and 71 consisted of "new firms" which did not exist in 1986. Of the off-Park firms, 50 firms were part of the initial research and 71 were part of the new sample.

These authors also used the same categories of links as those of Monck et al (1988): R&D and personnel, and non-research links (Universities facilities). Their results, presented in Table 3.3, are compared to those of the previous research.

It is interesting to note that on-Park firms substantially increased their linkages, over time, with the local HEI in all the links. For the R&D and personnel group of links, "informal contacts with academics" showed, again, the highest score (76%). However, at the same time, the "employment of academics on part-time/consultancy basis" and "sponsor research trials or projects" - links more related to the development of firms' research - have

⁴ As Barden (1993:227) points out: "From the point of view of firms involved [in Science Parks] they get many property advantages in terms of high-class industrial estates, but...links with the university come well down the list of priorities that attracted them to the park".

had a considerable increase when compared with the previous results. Non-research links, meaning the use of university' facilities, had again a high rate of usage by on-Park firms.

Table 3.3 - Firms and their Links with the Local University - 1986 and 1992
(proportion of firms)

Links	On-Park Firms		Off-Park Firms	
	1986	1992	1986	1992
R&D and personnel Links				
Informal contacts with academics	60	76	45	45
Employment of academics	28	46	28	29
Sponsor research/trials	14	31	15	12
Access to equipment	38	39	30	22
Test/analysis in HEI	12	22	13	10
Student projects	22	51	24	31
Graduate employment	30	44	30	39
Training by HEI	4	10	7	6
Teaching programme	5	17	10	2
Other formal links	1	12	0	4
Non-Research Facilities				
Computer	19	22	7	4
Library	48	68	19	24
Recreation	30	32	7	4
Conferences	15	22	12	14
Dining	22	24	6	4
Audiovisual	10	14	4	2
University as a customer	15	37	16	14
Other	5	5	3	6

Source: Based on Westhead and Storey (1994:108, Main report)

Off-Park firms, on the other hand, did not perform in the same way concerning their links with the local HEI. Apart from "informal contacts with academics" that maintained the same level of linkages with HEI as in the former research, and was considered by this group of firms the most important link, only "student projects" and "employment of recent graduates" has a slightly higher rate. Related to the non-research links, off-Park firms maintained the same pattern for establishing these links as the previous study.

Westhead and Storey went further in their research and investigated the importance of HEI links for the development of firms' activities. They observed that both groups of firms consider these links as important for firms, even though links particularly related to the development of research activity are still not among the most important ones. However, as the authors stress:

For both groups of firms the single most important link reported was informal contacts with academics (29.8 per cent and 31.0 per cent of firms on Science Park and off-Park locations, respectively)...For Science Park firms the three other most important links were having the university as a customer (17.0 per cent compared with 3.4 per cent), employment of recent graduates (12.8 per cent compared with 17.2 per cent) and access to library facilities (12.8 per cent compared with 6.9 per cent). To a slightly greater extent, off-Park firms stressed the importance of the sponsorship of trials or research projects in the HEI (4.3 per cent with 10.3 per cent) (Westhead and Storey, 1994:110).

These results also confirm a previous study undertaken by Oakey (1985). In his analysis of the relationship between British Universities Science Parks and High Technology Small Firms, Oakey (1985:60) pointed out that

...empirical evidence on the extent of links between high technology firms and external research establishments tends to support...that research contacts of high technology firms are neither profuse, nor centrally important to the firm's internal innovation when they occur.

According to Oakey (1985), when such contacts occurred they usually played a supplementary function to the internal research departments of firms. He also considered that contacts between firms and suppliers of materials had a higher importance than those with academia for the innovative process of firms.

Though Westhead and Storey survey's did not provide substantial evidence about the importance of the establishment of research links to the development of firms' activities, in order to see whether their findings supported the final part of Oakey' statement, these authors found that for both groups of firms, over 52% would like to establish closer links



with the local HEI. It is worth mentioning that personnel interviewed were emphatic in stating that neither universities nor the Park management (in the case of on-Park firms) demonstrated at least interest in discussing and diffusing the universities facilities.

Westhead and Storey (1994) updated and further pursued the topics considered by Monck and his colleagues (1988). Their results clearly pointed out an improvement in linkages between firms and HEIs, mainly those related to the firms located on Science Parks. However, apart from "informal contacts with academics", the more important links continue to be those related to the use of universities facilities. So far, only *in this sense*, does the geographical proximity between firms and HEIs - as proposed by advocates of the Science Park mechanisms - seem to be an important mechanism for the promotion of U-I links.

The results presented by these studies (Monck et al, 1998; Westhead and Storey, 1994) about the links established between universities and industry through the British Science Parks were recently confirmed by a research conducted for Felsenstein (1994) within the Israeli context.

Felsenstein (1994) makes use of a sample of 162 similar high technology firms - 73 firms located on three Israeli Science Parks and 89 firms located off the Parks. This author is able to show how low is the interaction between on-Park firms and the host universities. His main findings are as follows.

High-level interactions, represented by joint research and industrial financing of research undertaken by university are responsible for only 13% and 9% of linkages respectively. Mid-level interactions, involving consultancy activities, accounts for no more than 20% of links. Firms' personnel involved in faculty positions presents a still lower proportion: only 8% of linkages. Low-level interactions, represented by links such as the recruitment of local university graduates and the use of universities, achieved the highest proportion among all the links: 28% and 24% respectively.

Quoting Felsentein (1994:107):

...the level of interaction between firms located on science parks and local universities is generally low. It is higher, however, than the level of interaction exhibited by companies that are not science park tenants...in common with other studies...the choice of a science park location is due as much to the status and prestige effect that these exclusive locations confer.

In the context of the American experience, Luger and Goldstein (1991) did not provide any illuminating evidence about the links established between on-Park firms and local HEIs, apart from that

the Park enhances the quality and stature of the University... by inducing the faculty member to accept the job offer...by helping to recruit researchers to the University...by helping to attract top graduate students...and by helping to increase the interaction between scientists and researchers in the University and Industry (Luger and Goldstein, 1991:165).

And Miller and Côté (1987), while recognising the university as an important factor in the success of (American) Science Parks, presented no substantial information about the links that emerged from the relationship between the host university and the particular set of on-Park firms.

3.3.2 - Factors Affecting the Establishment of Links between on-Park Firms and the Local University

The last sub-section reviewed previous research about the nature and importance of the U-I links through the Science Parks. It was possible to observe that some of the linkages have, at least within the context of the British Science Parks, presented some improvement over time. However, as Chapter 2 already emphasised, the establishment of links between companies and academe does not occur uniformly. Several reasons underlie this diversity. Among them, one can find: (i) the geographical proximity between the partners and (ii)

specific characteristics of firms that can influence the pattern and effectiveness of the links established with universities.

Geographical proximity

The expected close relationship between academic scientists and engineers and entrepreneurs is thought to be a key factor to sustain and validate Science Parks and similar phenomena as an interactive mechanism for University-Industry linkages. The implicit argument in this reasoning is that geographical proximity between universities and companies, as proposed by Parks, promotes the necessary synergy between the firms and academic institutions. Consequently, the exchange of knowledge, information and even technology between the partners is stimulated and improved.

Oakey (1985), for instance, identified that the great popularity of Science Parks within the British context has its roots in two main points. One refers to the encouragement, from the part of Government during the 80s, for initiatives that stimulate the establishment of links between university and industry. The second point concerns the potential positive effects on the links between academe and firms provided by Parks through the spatial concentration of scientific resources, on the one hand, and firms located on their sites, on the other hand.

Quoting Oakey (1985:58):

Much of the popularity of science parks stems from two important stimuli. First, a favourable British political climate has been created in the 1980s in which university contacts with industry are encouraged...Second, enthusiasm for the growth potential of Science Parks is based on circumstantial evidence from the United States of substantial high technology industrial growth in the vicinity of certain universities...American researchers [argue] that such growth is the product of some forms of "technological interaction" between technical universities and their local environment...However, while the *effect* of high technology industrial growth...is a simple fact, the *causality* for such developments is far less evident.

The studies previously mentioned in sub-section 3.3.1 have observed the geographical proximity between firms and universities from the point of view of on and off-Park firms and

their relationship with the host (or nearby) university. The observation show that for only certain kinds of link - mainly those related to the use of universities' facilities and some informal contact with academic staff -, the geographical proximity between the partners does matter.

Firms Characteristics

Chapter 2 (sub-section 2.2.2.2) dealt with three specific characteristics of firms that can, to some extent, influence the establishment and effectiveness of their links with universities: size, productive sector and R&D activity.

The next paragraphs approach the same firms' characteristics but in relation to the firms located on Parks. These information are mainly based on research conducted within the context of British Science Parks (as those mentioned in sub-section 3.3.1). Even though these research have indeed explored aspects such as the size of on-Park firms, their productive sectors and R&D activities, they have not, however, connected these characteristics of firms to the establishment of their links with universities.

Size of Firms

Empirical evidence that emerged from Chapter 2 (sub-section 2.2.2.2) emphasised that larger firms have committed a higher proportion of links with universities than smaller companies. In other words, the larger the firms, the higher their propensity of establishing links with academe.

However, data presented in Table 3.4 give an account of how small have been, on average, the firms located on British Science Parks: for 1990, "the average employment per tenant" was 14.5 employees/tenant. This evidence would then suggest that, from the point of view

of size of firms, these small on-Park firms have a low propensity of establishing links with universities.

Table 3.4 – British Science Parks: Tenants and Employment

Year	1985	1986	1987	1988	1990
Number of Parks	21	28	33	38	39
Number of Tenants	301	412	642	807	1012
Total Employment	3800	5300	7600	10540	14708
Average Employment per Tenant	12.6	12.9	11.8	13.1	14.5

Source: Massey et al (1992:20)

Productive Sectors

Firms operating in Information and Communication Technology (ICT) and related sectors seem to dominate, in different degrees, the British Science Park environment. In 1985, the UKSPA stated that 49% of all on-Park firms were related to computers, electrical goods and electronics, instrumentation and robotics; a further 10% were involved with chemicals, pharmaceuticals and biotechnology; 16% developed consultancy and testing and 23% were linked to other industrial sectors, financial and business services and other activities.

Information provided by Felsenstein (1994) concerning Science Parks in the Israeli context, confirm the general trends already observed in the British Science Parks. Israeli Science Parks have also presented a high concentration of firms engaged in electronics and software sectors (Tel Aviv area), biotechnology and chemical firms (in Rehovot area) and chemicals, electronics and electro-optics (Jerusalem).

Other important aspect related to the productive sector of on-Park firms that may somehow restrict the interaction of these companies with universities relates to the level of firms' manufacturing activity allowed in Parks. As Massey et al (1992) argue, Parks have, on the one hand, emphasised the importance of firms' R&D activity and brought firms near to one



of the sources of knowledge and information (universities). On the other hand, in excluding the firms' manufacturing activities in their planning permission, Parks may preclude several possibilities for linkages between these companies and universities. In this sense, as Massey and colleagues (1992) stress, Science Parks have been firmly connected to the concept of the linear model of technical change, a model that does not fit quite well with the contemporary view of the firms' innovation activity.

R&D Activity

The last characteristic of on-Park firms investigated here refers to their R&D activity. As Chapter 2 (sub-section 2.2.2.2) stressed, the existence of R&D activity within the organisational structure of firms has been considered as an essential asset for increasing their ability in coping with technical progress. In addition, several parts of Chapter 3 have also emphasised the importance of R&D activity for firms being located on Parks.

One way of measuring the on-Park firms' R&D activity is through their R&D staff (and their qualification) in relation to their total employment. Information concerning firms located on British Science Parks reports that most of the firms' employees have academic qualifications. According to the UKSPA-OU-CURDS survey (Monck et al, 1988), 40% of Park employees are qualified scientists and engineers, even though a high proportion of on-Park firms do not have them among their employees. A further 19% of Science Park jobs are related to clerical and administrative work; plus 17% to other professional and managerial posts; 17% accounts for manual workers and 8% for those with other qualifications (Massey et al, 1992).

Moreover, these studies (Monck et al, 1988; Massey et al, 1992) report that a high proportion of on-British Science Park firms are engaged on design and development and software production. Manufacturing activity, as expected due to restrictions imposed on firms by Parks planning permission, does not constitute their main strength. However, it is

interesting that a low proportion of on-Park firms have committed themselves to the development of research activity. Maybe this has its roots in the level of technological sophistication dominant in Park firms. According to Massey and colleagues:

...science parks establishments are relatively sophisticated technologically. But rather than being "leading-edge" in any absolute sense they appear to be more involved in new applications of relatively novel technologies, to be small innovators rather than involved in major innovative break-throughs, and indeed often to operate as diffusers rather than innovators *per se* (Massey et al, 1992:43).

3.4 - Conclusion

This Chapter investigated the links established between university and industry through the examination of the Science Park mechanism. The presentation of different concepts and definitions of Parks, their objectives and participants, was followed by historical information about their establishment based on the American and European experiences. This set of information do confirm how heterogeneous and multi-purpose the implementation of Science Parks and similar phenomena in various countries has been. However, a common point that emerges in all of these enterprises is the attributed importance of universities for the settlement of Parks. Acting as operators or promoters, universities have been considered essential participants in the process of the planning, implementation and management of Parks all over the world.

The results of the analysis of the establishment of links between firms and academe through Science Parks show that they are not very profuse. But, at least within the British context, it is possible to observe that there has been an increase in links between on-British Park firms and related universities over time. However, most of the links are still concerned with the establishment of informal contacts with academics and the use of universities' facilities. More formal links such as those related to some kind of application and

commercial exploitation of research activity undertaken by universities still present a low profile.

The pattern of establishment of links between on-Park firms and academe may have a straight connection with the type of firms that have been set up on Parks. Most of the Parks have housed firms that could be generally classified within the NTBFs (new technology based firms) category. They are small firms and have been engaged in specific niches of high technology productive sectors, such as information and communication technologies, and biotechnology. More importantly, their main activities - with different degrees of technological sophistication - are mostly in design and development and consultancy and not in research and development. In addition, it is evident that, from the firms' point of view, universities, other HEIs and even the Parks' management should have a more pro-active attitude concerning the establishment of links with firms (not only discussing but diffusing the potential facilities of universities).

However, several important issues concerning the U-I links and Science Parks have been neglected by current studies. One refers to the lack of a more systematic research about the characteristics of on-Park firms and their possible influence on the establishment of links - mainly those related to research - with the host university. Moreover, the scarcity of data about the university side of the U-I relationship, do not, at present, allow a proper evaluation of U-I links set up through the Science Park mechanism. The analysis of these topics and also of those related to the pattern of establishment of links, such as the frequency, outputs and importance of linkages for the development of the activities of the partners would broaden the current understanding about the links occurring between on-Park firms and universities. In addition, the exploration of these topics would facilitate the validity of the main argument embodied in the concept of Science Parks: that the geographical proximity between universities and firms, as proposed by Parks, would promote and strengthen the U-I links. These topics constitute the core of the empirical study of this thesis.

CHAPTER 4 - THE CASE STUDY: DESIGN, METHODOLOGY AND CONTEXT

This thesis concerns the links between industry and university R&D, and the expectation that Science Parks will strengthen these links. It concentrates on the analysis of these links through a case study of a single British Science Park. The research describes the technology-related links of the Science Park firms and the host university, assesses their "intensity" or "strength", and explores the factors affecting the strength of links. On the last issue, the research focuses on (i) the significance of selected characteristics of the Science Park firms and (ii) the importance of geographical proximity between the partners.

This Chapter is divided in two main parts. Section 4.1 presents a detailed description of the research design and methodology used in this study. Section 4.2 contextualises the object of investigation of this case study: the University of Surrey, its recent activities as well as the origins of its Research Park. The description of the Surrey Research Park occupies most part of this sub-section: firstly, exploring the Park management; then, presenting its tenants and their characteristics and R&D activities.

Finally, section 4.3 presents a brief summary.

4.1 - Research Design and other Aspects of Methodology

As indicated in Chapter 1, the objectives of this research are to complement the current studies about University-Industry interaction and Science Parks and illuminate some gaps still present in the literature. This thesis focuses on three broad questions:

- (1) What are the nature, frequency and outputs of linkages established between firms located on a Science Park and the host university?
- (2) What are firms' key characteristics that might influence the establishment of links with universities? To what extent do these characteristics determine the nature and intensity of the links?
- (3) To what extent does the geographical proximity between companies and universities, as proposed by the Science Park mechanism, facilitate the promotion and strengthening of their links?

This section provides information about the research design and methodology used in this study to answer these questions. It emphasises the main features of the research design, the reasons for choice of the Surrey Research Park as the object of this analysis, the taxonomy of links used to investigate the interaction between firms and university as well as a description of the interviews and questionnaires used during the field work.

4.1.1 - Research Design

Case study is the methodology approach used in this research. This methodology has been criticised by many social science researchers due to a supposed limited capacity it has in providing grounds for scientific generalisation. However, Yin (1994:10) stresses that "case studies, like experiments, are generalizable to theoretical propositions and not to populations or universes".

Case study was considered an adequate methodology for carrying out this investigation. This is because, through a detailed and in-depth exploration of part of a social phenomena that has been partially analysed - the links between university R&D and firms in Science



Parks -, it would add a better understanding of such a phenomena and would complement and illuminate the current studies in this topic of research.

As Stake (1994:237) emphasises:

In what we may call *instrumental case study*¹, a particular case is examined to provide insight into an issue or refinement of theory. The case is of secondary interest; it plays a supportive role, facilitating our understanding of something else. The case is often looked at in depth, its contexts scrutinized, its ordinary activities detailed, but because this helps us pursue the external interest...The choice of case is made because it is expected to advance our understanding of that other interest.

A special key feature of the design of this study is that it allows a completely new comparative approach about the links established between university and firms. As reported on Chapter 3, some studies have compared these links from the point of view of firms located on- and off-Science Parks and the host (or nearest) university. In this study, the comparison emerges from the perspective of firms located on the Science Park and their links with the host university as well as their links with other universities located elsewhere (detailed in Chapter 5). In addition, this research investigates the university side of this relationship. In this perspective, it observes the links established between the host university, represented by a sample of its researchers, and the links established between these researchers with firms located on the Surrey Research Park as well as their links with other companies located elsewhere (detailed in Chapter 7).

The sample of firms that took part in this research consists of 21 companies located on the Surrey Research Park and their main characteristics are described in sub-section 4.2.3. The sample of researchers from the University of Surrey is detailed in Chapter 7, sub-section 7.1.

¹ Besides *instrumental case study*, Stakes (1994:236-237) has identified two other types of case study: "*intrinsic case study*...is undertaken because one wants better understanding of this particular case...[and] *collective case study*...[in which] researchers may study a number of cases jointly in order to inquire into the phenomenon, population, or general condition".

4.1.2 - Choice of the Science Park

The Surrey Research Park, located at Guildford, in Southern England, with a sample of its firms and the University of Surrey as the host university, is the case-study for this research. The reasons for this choice were as follows.

- The Surrey Research Park started its operation in 1984. Because of different circumstances and external factors surrounding the implementation of British Science Parks, it is quite difficult to compare and evaluate their performance. However, as already stressed (Chapter 3, sub-section 3.2.3.2, table 3.1), the Surrey Research Park can be considered as a mature British Park. Data from the UKSPA, quoted by Massey et al (1992), give an account that the Surrey Research Park has had one of the highest rates of growth concerning number of tenants for the period between 1986-1988 (330% - from 10 to 43 tenants) and also a more moderate and stable rate for the period between 1988-1990 (37% - from 43 to 59 tenants).
- The Surrey Research Park is located in an economically well developed region of the country. As a consequence, the possibilities of some particular external factors, such as those related to regional development policies, interfering with the activities of the Park is smaller than with other Parks located in less favourable economic regions of the country. The observation of the university and industry links in the Surrey Research Park could be isolated from these factors.
- The Surrey Research Park is owned and run by the University of Surrey which had strong interests in facilitating links between its academic staff and firms located on its Park. Consequently, one might expect that some of the traditional barriers for the interaction between university and industry would be limited, and that there would therefore be a reasonable "density" of observable interaction permitting comparative analysis among sub-groups.

4.1.3 - Taxonomy of Links

One of the major questions involving the University-Industry interaction - whether it occurs inside or outside the Science Park "territory" - is the lack of appropriate definitions and parameters with which such interaction could be properly measured, monitored, analysed and evaluated. Although words such as interaction, links, linkages, relationships, connections or complexes have been extensively used by all researchers and policy-makers involved in this matter, difficulties related to the measurement of such an interaction continue to be a critical point in the University-Industry debate.

In order to delimit the scope of this thesis, it is worth making clear what kind of links this research is concerned with. This thesis is particularly interested in one of the several forms of transfer of knowledge, information and/or technology between two different social agents: that occurring between universities and firms located on Science Parks.

As already stressed in Chapters 1 and 2, both universities and firms make part of a broad national infrastructure for which the generation, diffusion, transfer and use of scientific and technological artifacts constitute an essential activity. On the one hand, universities and their scientists, researchers, specialised staff and equipment/instruments can generate and provide the productive sector with a bulk of specific knowledge and qualified professionals. On the other hand, companies might make use of such knowledge/expertise developed by universities to complement their internal technological effort and, consequently, increase their economic performance. Also, companies can provide universities with new challenging scientific problems, besides some financial resources and placement for students.

The interaction between university and industry presupposes the occurrence of links between them. A link, or linkage, refers to any form of contact or agreement by which the knowledge, information and/or technology, expertise, equipment and even new problems to be solved can be transferred among the agents involved in the process of interaction,

independent of their nature. The links can be specifically related to research, human resources and their improvement, the use of material and equipment or any combination thereof.

With the aim of exploring the university and industry links in Science Parks in a more accurate way, a taxonomy of links was constructed considering both sides of the interaction, represented here by a sample of firms located on the Surrey Research Park and researchers from the University of Surrey. This taxonomy also considered the formality of links, being based on the commitment of the agents involved (university and companies) as well as the payment, or not, of fees for such interaction. The links that emerged from these considerations are divided into three main groups - Informal links, Human Resources links, and Formal links - and are described in detail below².

Informal Links

Through this set of links, firms, in their search for technical solutions or in their attempt of implementing an innovation, establish contact with the pool of information and knowledge, expertise and equipment available at universities. On the other hand, universities establish contact with firms and their technical and scientific capabilities and needs. The establishment of these links does not imply formal contracts between the partners, even though small fees may sometimes be involved on an ad-hoc basis. The links that make part of this group are as follows.

1. Personal contact - This is a person-to-person contact, based on a previous relationship, friendship or indication of an associate. From the perspective of firms, the aim is to identify the feasibility of making use of the knowledge and information pool of the university for the solution of technical problems firms are facing. From the perspective

² Several links make part of each group of links. However, it is worth stressing that the interviewees that took part of the field work had the possibility of adding any other link they considered important.



of universities, the aims of this type of link are (1) to change ideas about the current research agenda underway at university or university department; (2) to be aware of technical or scientific problems of firms; (3) to discuss possible solutions for problems; and (4) to discuss future possibilities of partnership.

Name of Link: (a) Firms: *Personal contact with university academic staff*

(b) Researchers: *Personal contact with industrial staff*

2. Access to specialised literature and reports - To both firms and universities, this link aims to scrutinise and make use of the specialised literature (firms) and specialised industrial literature and technical reports (universities) in order to update information and improve the knowledge about a specific topic of research (in academe and industry).

Name of Link: (a) Firms: *Access to specialised literature*

(b) Researchers: *Access to specialised technical reports*

3. Access to research - From the perspective of firms, this link is strongly connected with personal contact with an academic at the university. Its aim is to make firms aware of the research agenda being developed at university departments concerning a specific area of knowledge. From the perspective of universities, this link is strongly connected to previous personal contact with the R&D staff of a firm. The aim is to be aware of the research agenda underway at firms concerning a specific topic of research.

Name of Link: (a) Firms: *Access to university department research*

(b) Researchers: *Access to industrial R&D*

4. Attendance at seminars and conferences - To firms, this link has as its main aims (1) changing and updating knowledge and information about a specific topic of research and (2) extending the contacts with academic staff expertise and specialists.

Name of Link: (a) Firms: *Attendance at seminars and conferences*

5. Access to equipment - To firms, this link, based on previous contact, represents the access to the university equipment and laboratories to be aware of advanced materials, new techniques and instrumentation in current use by academic researchers in a specific area of research. Vice-versa for universities.

Name of Link: (a) Firms: *Access to university equipment*

(b) Researchers: *Access to industrial equipment*

6. Attendance at general education/training programmes - Making use of the advantages held by universities, this link represents the participation of firms' staff in ordinary short-term courses promoted by universities, whose aim is to increase the general knowledge of a specific area of technology. These courses are not specifically designed to attend firms' needs.

Name of Link: (a) Firms: *Attendance at general education/training programmes*

7. Small industrial donation of gifts or capital to research - This link can be considered as a direct consequence of the establishment of any of the other informal links listed above and previously set up. It may or may not be a consequence of Government policy incentives to stimulate the interaction between university and industry. It represents a small financial contribution of companies to academics for the acquisition of books, material, and simple equipment for the development of their research activities (independent, or not, of the connections between the researcher's research agenda and the industrial research needs).

Name of Link: (a) Researchers: *Small donation of gifts or capital to research*

Human Resources Links

Human resources links are related to the improvement, training and recruitment and/or allocation of qualified manpower. Firms, for instance, may wish to strengthen their links with academe through the support to, or absorption of, qualified manpower. This group of links

also extends the possibilities of promoting technical and continuing education in specific areas of firms' interests. From the perspective of universities, individual researchers, departments or universities may wish to strengthen their links with companies aiming (1) to increase the offer of jobs for their qualified manpower; (2) to extend the educational basis and research portfolio of university research. This group of links also broadens the possibilities of providing more structured training to firms' employees and research staff. The links that make part of this group are as follows.

1. Students involvement in projects - From the firms' point of view, this link means the temporary absorption of students to support their internal R&D activities (or similar) in a specific topic of work. From the universities' side, this link, as part of the training programme of several universities or university departments, means the temporary allocation of students into firms to develop a specific project correlated with some disciplines of the students' curricula. Usually, the work is of common interest for both parties and monitored by an academic supervisor. This temporary experience of students can result in their permanent absorption by that firm after the conclusion of their courses.

Name of Link: (a) Firms: *Students involvement in projects*

(b) Researchers: *Students involvement in industrial projects*

2. Recruitment of recent graduates - From the firms' perspective, this link aims to support and improve the human resources capabilities of firms with qualified manpower.

Name of Link: (a) Firms: *Recruitment of recent graduates*

3. Recruitment of more experienced scientists and engineers - This link aims to strengthen the human resources capabilities of firms with higher qualified manpower.

Name of Link: (a) Firms: *Recruitment of more experienced scientists and engineers*

4. Industry supported fellowships - This link may or may not be a consequence of Government policy incentives to stimulate the interaction between university and industry. University researchers can receive industrial grants to carry out research at university even though the topic of research underway may or may not be related to the sponsor's research agenda or needs.

Name of Link: (a) Researchers: *Industrial fellowships*

5. Short-term internship in industry - Based on some form of contract and pre-defined rules, this link involves the temporary transference of a university researcher to the industrial laboratory and environment in order to carry out research of mutual interest.

Name of Link: (a) Researchers: *Short-term internship in industry*

6. Formally organised training programmes - In order to deepen understanding of a specific topic of research, firms can contract an academic (or academic team) to provide their employees (or R&D staff) with courses designed according to the specific interests and needs of firms. This firm-specific character of the design of the training distinguishes this type of link from the more informal participation in open education/training courses.

Name of Link: (a) Firms: *Formally organised training of firm's personnel in university*

(b) Researchers: *Formally organised training programmes for industrial personnel*

Formal Links

Through this set of links, firms, being aware of the resources available at universities - knowledge and information, human resources and equipment - may wish to contract the use of equipment or to contract research projects, in an individual or collective basis, or develop joint research to support and complement their internal technological effort. From the perspective of universities, after being familiar with the industrial environment and its



technical and scientific capabilities, universities, university departments or researchers may wish to use industrial equipment or to offer their scientific expertise to firms and consequently enlarge their income and broaden their research portfolio through the developing of contract research or joint research. Usually, these links presuppose the establishment of formal contracts between the partners, with both the commitment and the payment of fees previously established. The links that make part of this group are as follows.

1. Consultancy - This link means the contract of a researcher from a university department, on a temporary and pre-defined basis, to support the activities and/or the development of a specific project according to the needs of firms. Usually, this kind of link requires a follow-up exercise for monitoring the development of the research/activity.

Name of Link: (a) Firms: *Engagement of university academic staff for consultancy*
 (b) Researchers: *Consultancy*

2. Analysis and testing - This link represents the use of equipment or laboratories in/by universities or firms, in order to complement the own equipment and laboratory and relying upon advantages of universities/firms in their facilities and experiences. Firms and universities can make use of these equipment or laboratory on a contractual basis.

Name of Link: (a) Firms: *Analysis and testing in university departments*
 (b) Researchers: *Analysis and testing in industry*

3. Research contract - Firms (or universities, on the request of firms) establish and implement contract with a university research team (or a firm), on a temporary and pre-defined basis, with the aim of developing a specific research project related to the firms interests.

Name of Link: (a) Firms: *Establishment of research contract*
 (b) Researchers: *Participation in/Establishment of research contract*

4. Joint research - Both the R&D staff of a firm and a university team of researchers establish and implement a research agenda, of mutual interests, to be developed together on a temporary and pre-defined basis.

Name of Link: (a) Firms: *Establishment of joint research*

(b) Researchers: *Participation in/Establishment of joint research*

Tables 4.1 and 4.2 below summarise the set of links that are investigated for evaluating the interaction between firms located on the Surrey Research Park and researchers from the University of Surrey.

Table 4.1 - Taxonomy of Links for Firms located on the Surrey Research Park

Informal Links

1. Personal contact with university academic staff
2. Access to specialised literature
3. Access to university department research
4. Attendance at seminars and conferences
5. Access to university equipment
6. Attendance at general education/training programmes

Human Resources Links

1. Students involvement in projects
2. Recruitment of recent graduates
3. Recruitment of more experienced scientists and engineers
4. Formally organised training of firm's personnel in university

Formal Links

1. Engagement of university academic staff for consultancy
2. Analysis and testing in university department
3. Establishment of research contract
4. Establishment of joint research

Table 4.2 - Taxonomy of Links for Researchers from the University of Surrey

Informal Links	
1.	Personal contact with industrial staff
2.	Access to specialised technical reports
3.	Access to industrial R&D
4.	Access to industrial equipment
5.	Small donation of gifts or capital to research
Human Resources Links	
1.	Students involvement in industrial projects
2.	Industrial fellowships
3.	Short-term internship in industry
4.	Formally organised training programmes for industrial personnel
Formal Links	
1.	Consultancy
2.	Analysis and testing in industry
3.	Participation in/Establishment of research contract
4.	Participation in/Establishment of joint research

4.1.4 - Interviews and Questionnaires

The field work was based on personal interviews conducted through questionnaires addressed to (i) the Surrey Research Park management; (ii) University of Surrey management (Heads of Departments; Deans of Schools or Faculties; responsible person for the business area) and a sample of the host university researchers; and (iii) a sample of firms located on the Surrey Research Park.

Park Management

With the objective of collecting a broad set of information about the Surrey Research Park, a personal interview was carried out with the Manager of the Park. A pre-defined questionnaire was used covering topics related to the Park management, support for tenants and university, information about the tenants, and university and on-Park firms' links.

University of Surrey

This approach involved three different agents:

- University of Surrey Management Staff - This interview was performed with the person responsible for the Business Development Office. On the basis of an open-ended questionnaire which was recorded, it aimed to draw out the policies and strategies that have driven the interaction between the University of Surrey and industry at large and firms located on its Research Park. Also, some additional information about the University and, in particular, about the projects that have been supported by grants or contracts from external organisations were useful in complementing this set of information.
- Dean of Faculty/Head of Department - Two Faculties were chosen to take part in the fieldwork: the Faculty of Engineering which has traditionally been involved with the industry's needs at large, and the Faculty of Science, here represented by the Physics Department, whose formal involvement with industry has shown a substantial increase in recent years. These interviews, based on an open-ended questionnaire and also recorded, aimed to adduce the policies and strategies that have driven the interaction between those specific Faculties/Departments and both industry in general and on-Park firms.

- Researchers - The access to researchers was undertaken through a huge open- and closed-ended questionnaire covering issues related to (a) background information about the interviewee; (b) links that may exist between the researcher and firms located on the Surrey Research Park; (c) links that may exist between the researcher and firms located elsewhere; and (d) evaluation about the university and industry links and the Research Park. Items (b) and (c) took into consideration the taxonomy of links described at the previous sub-Section 4.1.3.

Firms located on the Surrey Research Park

The approach to firms was also done through personal interviews with the Managing Directors, R&D Directors or owners of a sample of on-Park firms. Again, a huge open- and closed-ended questionnaire was applied, addressing issues related to (a) the background information about the firm; (b) the R&D activities of the firm; (c) links that may exist between the firm and the host university; (d) links that may exist between the firm and any other Higher Education Institution; and (e) Research Park evaluation. Again, items (c) and (d) took into consideration the taxonomy of links described at the previous sub-Section 4.1.3.

In order to check the adequacy of the questionnaires used in this field work, some pilot interviews were undertaken at the University of Sussex. The pre-field work involved interviews with authorities of the University of Sussex and responsible person for its business area; interviews with the Dean and a researcher from the Cognitive Sciences Department; an interview with the R&D manager of a company located on the campus of the University of Sussex as well as an interview with the R&D manager of a company which was previously located on the same campus. The questionnaires, unanimously approved by all the interviewees during the pilot-project as being adequate for the purposes of this study, are reproduced in a summary form in the Appendix of the thesis. Where more detailed explanation of specific questions is required, this is provided in the relevant sections of the thesis where the data results are presented.



4.2 - The Context: The Park and its Tenants

This sub-section puts into context the University of Surrey, its recent activities and the origins of its Research Park. Also, it explores the Park management, the Park tenants and their main characteristics as well as their R&D activities.

4.2.1 - The University of Surrey and the Origins of the Surrey Research Park

The University of Surrey has traditionally been involved in teaching and research of relevance to industry and society at large. Founded in 1966, historically its origin dates back to 1891 as the Battersea Polytechnic Institute, with the specific objective of providing "greater access to further and higher education for the "poorer inhabitants" of London"³. The concentration on Science and Technology began in 1920 and in 1956 its status changed to Battersea College of Technology in recognition of its role as a specialist educational institution. In 1963, it was recommended by the Robbins Report⁴ that the College should become a University. Although the move to Guildford was decided in 1962, it was completed only in 1970. The current site of the University was acquired from the Guildford Cathedral, Guildford Borough Council and the Onslow Village Trust in 1965.

In order to complement and illustrate this brief profile of the University of Surrey, Tables 4.3, 4.4 and 4.5 provide some updated information.

³ University of Surrey, Calendar, 1992-1993:A/15.

⁴ "Robbins Report" refers to the Committee on Higher Education appointed by the Prime Minister under the Chairmanship of Lord Robbins in 1961-1963 and presented to the Parliament in October 1963. Its objectives were "to review the pattern of full-time education in Great Britain and in the light of national needs and resources to advise Her Majesty's Government on what principles its long-term development should be based. In particular, to advise, in the light of these principles, whether of institution are desirable and whether any modifications should be made in the present arrangements for planning and co-ordinating the development of the various types of institution" (Higher Education Report, 1963, pg. 1). The Report emphasised the complexity and plurality of the aims of the higher education system as well as its functions in order to attend to the demands of society at large. The strengthening of links between Universities, Government establishments and industry was also strongly recognised (Id.lb. pg. 128). One of the most important recommendations of the Report was concerned with the Colleges of Advanced Technology (among them the Battersea College of Technology) and the change of their status to University, as a recognition of their qualifications and excellence (Id.lb. pg. 130-1).

- Table 4.3 shows the University's current organisation according to its Faculties, Schools or Departments, as well as their number of undergraduate and post-graduate students for 1993. As the summary of the Table shows, in that year the Faculty of Human Studies accounted for the majority of both undergraduate and post-graduate students: 39.8% and 55.6% respectively. The Faculties of Engineering and Science had similar proportions of undergraduate and post-graduate students during the same period (about 30% of undergraduate and just over 20% of post-graduate students).
- Table 4.4 presents the number of projects undertaken by the University of Surrey that have been supported by grants or contracts from external organisations, for each Department or School, during the financial years of 1989/90, 1990/91 and 1991/92. The source of such data was the University's Register of Current Research and it is worth noting that as such a Register was introduced only in 1989, it is difficult to conduct any longer series analysis of such data. Also it does not list agreements involving less than £ 1,000 (interview with the Business Development Officer). Moreover, there is an overlap of projects when they are undertaken in the three different periods of time. In fact, the numbers in brackets (for the financial years of 90/91 and 91/92) represent the new projects of each period or the ones that were omitted in the preceding year. The list of the University's clients contains both public organisations such as ESRC, EEC, DTI and SERC, and private organisations like ICI, Ford Motor, Rolls-Royce, Varian Associates, and Wellcome Trust among others.
- Table 4.5 specifies the University's sources of Research Grants and Contracts for the financial years of 1989/90, 1990/91 and 1991/92. In spite of the fact that the proportion of such resources within total income has diminished through those years - from 23.37% to 17.09% - the participation of industrial resources has increased over the same period - from 13.43% to 22.03%.

Table 4.3 - University of Surrey - Organisation

Faculty	School/Departments	Underg	% (*)	Postg	% (*)
Engineering	Dept. Chemical and Process Engineering	171	15.3	10	2.6
	Dept. Civil Engineering	223	20.0	94	24.5
	Dept. Electr.and Electrical Engineering	393	35.3	166	43.3
	Dept. Materials Science and Engineering	69	6.2	54	14.1
	Dept. Mechanical Engineering	258	23.2	59	15.5
	Sub-Total	1114	100.0	383	100.0
Science	School of Biological Sciences	447	44.2	146	34.4
	Dept. Chemistry	140	13.8	37	8.7
	Dept. Math.and Comp.Sciences	211	20.9	11	2.6
	Nursing and Midwifery	87	8.7	61	14.4
	Dept. Physics	125	12.4	97	22.9
	Robens Institute	-	-	72	17.0
	Sub-Total	1010	100.0	424	100.0
Hum.Studies	Dept. Economics	206	14.7	35	3.5
	Dept. Educational Studies	-	-	453	44.9
	Dept. Linguistic and Internat.Studies	323	23.0	216	21.4
	Dept. Management Studies	338	24.1	116	11.5
	Dept. Music	149	10.6	35	3.5
	Dept. Psychology	194	13.8	79	7.8
	Dept. Sociology	194	13.8	74	7.4
	Sub-Total	1404	100.0	1008	100.0
	TOTAL	3528		1815	
SUMMARY	ENGINEERING	1114	31.6	383	21.1
	SCIENCE	1010	28.6	424	23.3
	HUMAN STUDIES	1404	39.8	1008	55.6
	TOTAL	3528	100.0	1815	100.0

Sources:- University of Surrey: (1) 1993 Entry, Postgraduate Prospectus and (2) Calendar, 1992-93.

(*) The percentages were calculated in relation to the total number of each category, by Department or School.

Table 4.4 - University of Surrey - Projects

Faculty	School/Department	89/90	%	90/91	%	91/92	%
Engineering	Dept. Chemical and Process Engineering	28	17.1	25 [05]	16.7	25 [08]	13.4
	Dept. Civil Engineering	18	11.0	17 [03]	11.3	116 [04]	8.6
	Dept. Electr. and Electrical Engineering	63	38.4	62 [18]	41.3	81 [34]	43.6
	Dept. Materials Sciences and Engineering	36	21.0	28 [06]	18.7	33 [13]	17.7
	Dept. Mechanical Engineering	19	11.6	18 [08]	12.0	31 [20]	16.7
Science	Sub-Total	164	100.0	150 [40]	100.0	186 [79]	100.0
	School of Biological Sciences	76	42.0	69 [20]	39.7	68 [31]	36.4
	Dept. Chemistry	19	10.5	15 [05]	8.6	22 [11]	11.8
	Dept. Math. and Comp. Sciences	9	5.0	11 [04]	6.3	11 [04]	5.9
	Nursing and Midwifery	5	2.7	5 [02]	2.9	5 [01]	2.7
Hum. Studies	Dept. Physics	34	18.8	33 [07]	19.0	40 [14]	21.2
	Robens Institute	38	21.0	41 [16]	23.5	41 [32]	22.0
	Sub-Total	181	100.0	174 [54]	100.0	187 [93]	100.0
	Dept. Economics	3	7.3	3 [02]	6.3	-	-
	Dept. Educational Studies	6	14.6	8 [04]	16.7	8 [02]	15.4
	Dept. Linguistic and Internat. Studies	1	2.4	5 [05]	10.3	10 [06]	19.3
	Dept. Management Studies	4	9.8	3 [01]	6.3	2 [00]	3.8
	Dept. Music	2	4.9	-	-	1 [01]	1.9
	Dept. Psychology	15	36.6	19 [08]	39.6	16 [04]	30.8
	Dept. Sociology	10	24.4	10 [04]	20.8	15 [09]	28.8
	Sub-Total	41	100.0	48 [23]	100.0	52 [22]	100.0
	TOTAL	386		372 [117]		425 [194]	
SUMMARY	ENGINEERING	164	42.5	150 [40]	40.3	186 [79]	43.8
	SCIENCE	181	46.9	174 [54]	46.8	187 [93]	44.0
	HUMAN STUDIES	41	10.6	48 [23]	12.9	52 [22]	12.2
	TOTAL	386	100.0	372 [117]	100.0	425 [194]	100.0

Sources: University of Surrey, Register of Current Research, 1989/90, 1990/91, 1991/92.

Note: The numbers in brackets (for financial years of 90/91 and 91/92) represent the new projects of each period or the new ones that were omitted in the preceding year.

Table 4.5 - University of Surrey - Income

Research Grants and Contracts	1898/1990	%	1990/1991	%	1991/1992	%
Research Councils	3,942	36.47	3,621	34.17	2,998	32.00
Charities	666	6.16	458	4.31	610	6.50
Government Departments	2,150	18.89	2,461	23.17	2,116	22.56
Local Authorities	29	0.27	28	0.26	22	0.23
Public Corporations	174	1.61	170	1.60	81	0.86
Industry and Commerce	10453	13.43	2,163	20.35	2,066	22.03
EEC (European Community)	10357	12.55	1,016	9.56	893	9.52
Overseas (excluding EEC)	540	4.99	626	5.89	542	5.78
Other	501	4.63	84	0.79	49	0.52
TOTAL	10812	100.00	10,627	100.00	9,377	100.00
SUMMARY:						
Research Grants and Contracts	10,812	23.37	10,627	20.82	9,377	17.09
Total Income	46,258		51,030		54,857	

Sources: Information obtained through the Office for Research and Commercial Services, University of Surrey.

The Surrey Research Park, owned and managed by the University of Surrey, was set up in 1984. It occupies an area of 70 acres of the University's land (Manor Farm) and has been built in several phases, providing the necessary flexibility for housing companies of different sizes and productive sectors. One of its major characteristics is its Surrey Technology Centre. Besides working as an "incubator" for up to 33 small high-technology research and development firms, the Centre also provides space (meeting rooms) and facilities (reception area, bar, restaurant, cash point and conference facilities) for the use of its tenants and other Park companies.

In the words of the Park's promoters (University of Surrey, 1990:5-7):

The Surrey Research Park offers a wide range of opportunities for high technology and research and development occupiers, with flexible lease terms...cost effective buildings which give these companies great scope for development, change and growth. The Research Park also offers a very high level of services and facilities with great importance being attached to effective site management...Good communications are an essential part of The Research Park, which benefits from the proximity to good air and rail services as well as easy access to the national motorway system.

In his book "Surrey: The Rise of a Modern University", Douglas (1991) sought to map the roots of the establishment of the Surrey Research Park. Although acknowledging that "the development of the University of Surrey in the 1980s was often dominated by financial questions" (Douglas, 1991:174) and by the search for new and additional sources of sponsorship for its activities besides the traditional Government resources, he has also strongly emphasised that the conception of the Park lies in the University's constant search for expanding its activities and strengthening its links with the industrial sector.

According to Douglas (1991:177):

"The Research Park idea appeared in a developed form in 1981, and some time before the "cuts"⁵ were announced it appeared in the Surrey County Structure

⁵ "Cuts" here are related to the new British Government funding policy on Higher Education Institutions, established mainly from 1976 but more critically around 1981. It was strongly suggested "that dependence of

Plan. It was proposed that a substantial area of Manor Farm...should be developed as a place where private corporations could conduct research...[The whole scheme would provide] a **fruitful interaction between (the companies) activities and those of the University**...[The overall effect would be] to turn academic ideas into marketable products which could form the basis of new British high technology industries". (emphasis added)

To summarise, in spite of the fact that the implementation of the Surrey Research Park was considered in part as a new source of finance for the University's activities, it has, at least from the point of view of its promoters (the University itself), been mainly regarded as expanding the activities of the University as well as complementing and strengthening its relationship with industry.

Massey et al (1992:23) quoted a small statement made by Dr. Malcolm Parry, General Manager and Marketing Liaison Director of the Surrey Research Park to the Financial Times (interview in 30 November 1985:xii) concerning the objectives of the Park:

...the "very clear aims" of the Park there: "to develop income from industrial sources for the university, **help further the strong links with industry already enjoyed by the university** and develop opportunities for people in the university to engage in consultancy work". (emphasis added)

It should also be stressed that, in aiming at such objectives and taking into account the nature of the University's activities and its needs for academic excellence, it was recommended by its promoters that the Park should be completely devoted to research activity (Douglas, 1991).

In the light of such a recommendation and with regard to the considerable extent of work required to establish and operate the Park, the University set up a full-time staff whose main task has been the management of the Surrey Research Park.



4.2.2 - The Park Management

During a personal interview with the Manager Director of the Surrey Research Park it was possible to identify what were the main activities undertaken by the Park management team (made up of 7 full-time employees at the time of the field work). Besides routine activities such as those related to the improvement and maintenance of the infrastructure of the Park, its promotion and financing, the more important aim here was to identify the effort that has been made by that team in order to support the fostering of links between the Park tenants and the University of Surrey.

Table 4.6 summarises the proportion of the work of the management team dedicated to two different sets of activities: the first concerning routine tasks; the second related to the support for tenants and their needs, their relationship with the University and other Institutions and firms.

Table 4.6 - Park Management Team - Main Activities

MANAGEMENT ACTIVITIES	% of the Team Work
Routine Activities	
Promoting/Marketing the Park and attracting new tenants	20.0
Property management/routine administration of the Park	10.0
Providing business services/facilities for tenants	7.5
Monitoring/evaluating the effectiveness of the Park's development	5.0
Public relations/general discourse (Promoting the University as a whole)	5.0
Raising finance and grants from Government and/or other agencies	2.5
Support for Tenants and University	
Legal advice to tenants and University (e.g. patents and licensing)	12.5
Fostering links between the University and Park tenants	10.0
General administration	10.0
Providing management expertise to tenants	5.0
Fostering links between tenants	5.0
Fostering links between on-Park tenants and off-Park firms	5.0
Providing financial/accounts advice to tenants	2.5
TOTAL	100.0

Source:- Personal Interview with the Manager Director of the Surrey Research Park.

The results presented in Table 4.6 suggest that activities connected with the fostering of links between the host university and firms located on the Research Park do not seem to constitute a priority among the several activities developed by the management team: only 10% of their time has been devoted to such a crucial task.

Links between tenants and between on- and off-Park firms have also been regarded as an important support for firms located on Research or Science Parks. Here again, both kinds of links have been accorded a low priority by the Management of the Surrey Research Park: only 5% of the work of the management team for each activity.

4.2.3 - The Tenants

The field work involving the firms located on the Surrey Research Park was undertaken between April and July of 1993. At that time, according to table 4.7, the Park accommodated 60 firms.

Table 4.7 - Surrey Research Park: Population and Sample of Firms

PARK	Population of Firms	Contacted	No Access	Refused	Final Sample of Firms
STC (*)	25	23	10	5	8
Other Buildings	35	34	5	15	13
TOTAL	60	57	15	20	21

(*) Firms located in the Surrey Technology Centre

As Table 4.7 above shows, 42% of the Park's firms (25 firms) were located in the Surrey Technology Centre and 58% of them (35 firms) in other buildings on the Park. Although nearly all of the firms (57 out of 60 firms) were contacted in order to take part in this research, the access to one quarter of those firms (15 firms) was particularly difficult because of their explicit lack of interest in participating in this research.

Apart from those 15 firms (mostly small), another 20 firms - one third of the firms located on the Surrey Research Park - refused to take part in this field work. Among the reasons for refusal can be quoted: (a) no time available for interviews (8 companies); (b) location on the Park due to its geographical convenience and not because of the proximity with the University (5 firms); (c) leaving the Park (1 firm); (d) personal and private office (1 person); (e) no special reason (4 firms). Also, one company fixed an appointment but nobody was there on the set date. Thus, the sample of firms that is worked in the main part of this study totalled 21 firms, representing 35% of the firms located on the Research Park.

It is difficult to assess the representativeness of this sample of the on-Park firms because it was not possible to obtain systematic information about the population of on-Park firms apart from those related to the firms' productive sector. However, the following points should be noted:

(1) Larger firms may be over-represented. Almost all of the larger firms (with more than 25 employees) that were contacted agreed to be interviewed. The majority of firms that refused or presented difficult access were small firms (with 5 or less employees).

(2) Firms with links to the university may be over-represented because a frequently stated reason for refusing to take part of the study was the lack of links with the host university or with other universities.

(3) According to the management of the Park, 90% of the on-Park firms were engaged in Information and Communication Technologies (ICT) related-sectors (such as computer related-hardware and software); the remaining 10% were involved with other industrial products and services. However, in the sample of firms that took part of this study, 49% were engaged in ICT related-sectors and 51% were related to other industrial products and services (productive sectors of on-Park firms is detailed on sub-section 4.2.3.1). The Park management must have exaggerated the number of firms primarily engaged in ICT-related

activities (or technologies), but it seems likely, nevertheless, that they are under-represented in the sample.

4.2.3.1 - General Characteristics of the Sample of the Firms

The aim of this sub-section is to describe the general characteristics of the sample of firms that took part in this research, considering aspects such as: advantages from being located on the Surrey Research Park, year of location, origin and status, size, productive sector, market and turnover.

Advantages from being located on the Surrey Research Park

The Managing Directors of on-Park firms were asked to state the main reasons that had driven their choice of location in the Surrey Research Park. In other words, they should evaluate a list of possible advantages they consider their firms derive from being located on the Park. Table 4.8 presents this set of results.

The first four items of the list were closely connected with the university and its relationship with the on-Park firms. As the table shows, a low proportion of the Managing Directors considered any of these four items as being a major advantage for their firms from being located on the Park (the highest score was 14% for "Access to university research and consultancy"). Adding to this group the scores attributed as "moderate advantage", the proportion of firms increases but does not exceed 38% (in the case of "Recruitment of specialised R&D staff"). It is evident that other items - not directly concerned with links to the host university - were considered as advantage in a higher proportion than those related to the university. For instance, "Environment of the region" and "Infrastructure and support offered by Park" scored 80% and 61% of firms in "moderate" and "major" advantages together.

Table 4.8 - Tenants' Advantages from being located on the Park (Proportion of Firms)

ADVANTAGES	NO ADV	LITTLE	MODER.	MAJOR
Access to univ. research and consultancy	29	38	19	14
Access to university equipment	38	38	19	5
Access to university facilities	14	57	19	10
Recruitment of specialised R&D staff	48	14	33	5
Interaction with other on-Park firms	38	33	19	10
Infrastructure and support offered by Park	29	10	47	14
Environment of the region	10	10	42	38
Access to business services outside Park	24	47	19	10
Special incentives offered by Government	90	10	-	-

Source:- Data based on 21 interviews with the Firms' Managing Directors

Categories:

No Adv no advantage at all

Little Little Advantage (indirect advantage for the development of the firm's activities)

Moder Moderate Advantage (significant advantage for the development of the firm's activities)

Major Major Advantage (crucial advantage for the development of the firm's activities)

Besides this list of advantages, some of the Managing Directors interviewed also quoted other items as important advantages from being located on the Park, such as: availability of transport and communication; credibility of the name of the Park; very pleasant place to work; duration of the licence; provision of parking services; and recruitment of students. The following statements made by some of the on-Park firms Manager Directors can illustrate some of the reasons for choosing the location on the Park:

The Park has a very nice environment and the rent price, at the beginning of our location here was very good...

...The communication and transportation benefits offered by the Park are very important to our activities

...The Park enjoys a very good reputation (prestige) and...moreover...it is located near our homes and families...

The location and nature of the Park and the commercial expectation are adequate for the company...



...Guildford has a very good network of services and it is easy to find R&D people...also the University provides us with very good sporting facilities...

It is geographically convenient (near our homes and families). Also, the central facilities provided by the Research Park are very useful. We have the opportunity to have a first class appearance without spent lots of money...

...The Park provide us with flexible accommodation arrangements and space for development and expansion...Because we are near the University, we have the opportunity of recruiting skilled people...

Year of Location

The Surrey Research Park started operation in 1984. At the time of this field work (April-July 1993), a substantial proportion (47%) of the firms investigated through this study had been located in the Park for a short period: between 1 and 3 years. Another 43% had been there for 4 to 6 years. Only 5% of those companies had been on the Park for less than 1 year and also only 5% for more than 7 years.

Origin of the on-Park Firms

The majority (56%) of the firms surveyed in the Surrey Research Park were existing firms relocated from elsewhere. Although 25% of the companies were start-ups, only 6% of them were classified as spin-offs from the host University. Among the remaining 19% were to be found, for example, branches of other companies such as R&D units of some Japanese companies.

Status of the Firms

Concerning the status of those companies, 38% of them were independent companies, 33% were branches of firms located abroad or subsidiaries of multinationals, and 29% were subsidiaries of British companies.

Size of the Firms

Size of the firm here is measured by the total number of firms' employees. As has been stressed in the literature concerning Science Parks, a substantial proportion of firms located in Parks is made up of small or very small companies. In this case, 9 companies (44% of the sample) had 10 or fewer employees (very small companies), among whom 34% of the total had 5 or fewer employees and 10% had between 6 and 10 employees. The remaining 56% of the firms had 11 or more employees, being divided as follows: 14% had between 11 and 15 employees; 14% between 16 and 25 employees; 14% between 26 and 50 employees and 14% (only 3 firms) had more than 51 employees.

Firms' Productive Sectors⁶

This item was related to the principal type of products the sample of firms investigated were mainly concerned with. Productive sectors such as Medical/Health related products and services and Other Molecular Biology/Genetic Engineering had no score among the firms surveyed. For other types of products, the scores were as follows: 34% in Computer related-software; 20% in Industrial Products; 10% in Consumer related products; 20% equally divided between Communications, Computer related-hardware, Other Electronics-related and Energy. Finally, 16% of the firms were concerned with bureaucratic services: Administration and/or Consultancy in general Engineering and infrastructure. If the productive sectors are classified in two broad groups, as previously done in sub-section 4.1.1, the results are: ICT related-fields cover 49% of the firms' type of products and other industrial and service sectors are responsible for the remaining 51%.

⁶ For "Productive Sector" this study meant the main type of products produced by the firms located on the Surrey Research Park. This research dealt with the following classification: (1) Communications; (2) Computer related-hardware; (3) Computer related-software; (4) Other Electronics related; (5) Medical/Health related products and services; (6) Other Molecular Biology/Genetic Engineering; (7) Energy; (8) Consumer related; (9) Industrial Products and (10) Other. It is worth noting that this classification, very similar to that adopted by the United Kingdom Science Park Association (UKSPA) in its "Tenants Directory", edited by Brian Worrall, 1987, is based on Venture Economics Inc and its Venture Economics Industry Codes, specially developed through their experience in the United States.

Market

Although a slight majority of the firms (52%) were focused on the national economy as their main market for their products and services, the international market represented a substantial proportion of the market for 43% of the firms.

Turnover

The Managing Directors of the sample of Park firms were asked about the turnover of their companies. Among them, only one was unable to provide such information. The results for the other 20 firms in regard to this topic are as follows: 35% of the companies had between £ 100,000 to £ 500,000 of turnover; 25% between £ 500,000 and one million pounds; 15% between one and five million pounds; 5% between five and twenty million pounds; 10% between twenty and fifty million pounds and 10% had more than fifty million pounds of turnover.

4.2.3.2 - R&D Activities of the Sample of Firms

Following the same steps as in the previous sub-section, the main objective now is to describe the R&D activities of this sample of on-Park firms.

In his interview, the Manager of the Surrey Research Park reported that all of the firms located on the Park were committed to R&D activity. Moreover, in the view of the Park's promoters, the Park should be exclusively devoted to research activity (Douglas, 1991). However, evidence emerging from data related to the primary activity and R&D activity of this sample of on-Park firms do not confirm such beliefs.

Primary Activity of on-Park Firms

The proportion of firms undertaking R&D activity as their primary activity was quite low, since only 19% of companies reported R&D as their primary activity. Other 24% of firms had their primary activity mostly concerned with Software Development; 19% with Sales and Distribution; 14% with other activities (mainly linked to administration); another 10% were connected with Consultancy, Analysis and Testing and 5% with Product Design and Engineering. 9% of the sample of firms (2 companies) had difficulties in classifying their primary activity.

The Presence/Absence of R&D Activity

7 out of 21 firms surveyed had no R&D activity (33% of the sample of firms). Among the other 14 firms, 13 of them (62%) supported a full-time specialised R&D division and one firm (5%) reported that part-time R&D activities were undertaken by staff with other responsibilities.

Firms' R&D Staff

Here only the firms which had a full-time specialised R&D division (13 firms) are considered. 31% of them had 5 or fewer employees in their R&D division; another 31% had between 6 and 10 employees in the same unit; 15% of the firms had between 11 and 15 employees; 8% had between 16 and 25 employees; and 15% had more than 26 employees in their R&D units.

Also, the low level of employment of highly qualified R&D staff among those 13 companies is worth noting. Only 4 of them (31%) included PhDs among their R&D staff. The majority of the R&D divisions of those firms (92%) were composed of employees with B.Sc. or

equivalent graduate staff. Also, the participation of specialised technicians was not very substantial - just 38.5% of the companies had such employees among their R&D staff.

Firms' R&D Intensity

Further interesting information related to the R&D activity of the firms can be gained by measuring their R&D activity intensity. Here, this value represents the proportion of R&D staff to total employment of the firms. Again, only the 13 firms with full-time specialised R&D divisions were considered. Such an indicator gave the following results: 23% of those firms (3 firms) reported between 0 and 20% of their staff involved with R&D activities, while 15% (2 firms) had between 21 and 50% of their staff committed to the R&D division. The highest share came in the next category with 38% of the firms (5 firms) having between 51 and 80% of their staff working in the R&D unit. Finally, 23% of the firms (3 firms) stated that between 81 and 100% of their staff worked in their R&D divisions.

Categories of R&D Activity developed by on-Park Firms

Table 4.9 - Categories of R&D Activities developed by on-Park Firms

CATEGORIES	% of Firms
Basic Research	10
Strategic Research	24
Development of a new product	47
Development of a new process	19
Improvement of an existing product	33
Improvement of an existing process	10
New Managerial Techniques	5
Other	5

Source:- Data based on 21 interviews with the Firms' Managing Directors

Table 4.9 above indicates the categories of R&D activity undertaken by the sample of firms located on the Surrey Research Park. The main category of R&D activity undertaken by this set of firms was that related to the development of a new product (47%), followed by the



improvement of an existing product (33%). Basic research, the kind of R&D activity that is generally carried out in academia or in R&D divisions of large corporations, was undertaken by only 10% of the firms located on the Park.

Firms' R&D Financial Sources

Among the set of firms which had a full-time R&D division (13 firms), two of them (15%) possessed two different sources of R&D financing: their own capital or Government grants plus "other" sources, meaning basically sponsorship from customers. All of the 11 remaining firms (85%) had just one source of R&D resources, the proportions being as follows: 55% resorted to their own capital; 27% had "other" sources (financing from the parent company, located abroad); 9% had venture capital and 9% had financial support from international institutions.

Summary of on-Park Firms Characteristics and R&D Activities

Table 4.10 summarises the main characteristics and the R&D activity of the sample of on-Park firms that took part of the field work.

4.3 - Conclusion

This Chapter, initially, presented a detailed description of important aspects and also the research design and methodology used in this empirical study. It is worth stressing again the key feature of the design of this study. It allows two types of comparison: between the links of on-Park firms with (i) the host university and (ii) with other universities; and also between the links of academic researchers from the host university with (i) on-Park firms and (ii) other firms. The study provides, in this way, a new approach to analysing the extent to which the geographical proximity provided by Science Parks may influence the interaction between firms and universities.

Table 4.10 - Summary of the on-Park Firms' Characteristics and R&D Activity

Year of Location	Origin of Firms	Status of Firms	Size of Firms	
			Employment	Turnover (*)
• 5% (< 1 year) • 47% (1-3 years) • 43% (4-6 years) • 5% (> 7 years)	• 56% (existing firms) • 25% (start-ups)* • 19% (companies' branches) * only one of these five start-ups were spin-offs from the University of Surrey	• 38% (independent) • 33% (subs. of multinationals) • 29% (subs. of British firms)	• 44% (up to 10 employees) • 14% (11-15 employees) • 14% (16-25 employees) • 14% (26-50 employees) • 14% (> 51 employees)	• 35% (£ 100 - 500,000) • 25% (£ 500 - 1 million) • 15% (£ 1 - 5 million) • 5% (£ 5 - 20 million) • 10% (£ 20 - 50 million) • 10% (> £ 50 million)
R & D				
Productive Sector (**)	Primary Activity	Existence of R&D Activity	R&D Activity Intensity (***)	Category of R&D Activity
• 49% (ICT-related productive sectors) • 51% (other industrial and service sectors)	• 24% (software development) • 19% (R&D) • 19% (Sales/Distribution) • 14% (Management) • 10% (Consult. + A&T) • 5% (Prod. Design + Eng.) • 9% (no information)	• 33% (no R&D activity) • 62% (full-time R&D) • 5% (part-time R&D)	• 23% (C-20% of R&D staff) • 15% (21-50% of R&D staff) • 38% (51-80% of R&D staff) • 23% (> 81% of R&D staff)	• 10% (Basic Res.) • 24% (Strategic Res.) • 47% (Dev. new prod.) • 19% (Dev. new proc.) • 33% (Impr. exist. prod.) • 10% (Impr. exist. proc.) • 5% (new man. tech) • 5% (other)

(*) Information related to 20 firms.

(**) ICT related fields involve Computer soft and hardware, other Electronics related and Communication; other industrial and service sectors also cover Energy.

(***) Only for firms with full-time R&D staff/activity

The second part of the Chapter provided information about the University of Surrey and the establishment of the Surrey Research Park within the context of the University's activities. Also, the Chapter described the main activities of the Park management, the on-Park firms main characteristics and their R&D activities.

In the view of the promoters and the Manager of the Surrey Research Park, the fostering and strengthening of links between the University of Surrey and industry is a paramount objective of this Park. However, through the description of the activities developed by the management of the Park, it was possible to observe that activities connected with the fostering of links between the Park tenants and the University or Research Institutions have not been considered, so far, as a priority for the management team. Also, such kinds of links do not seem to constitute a great advantage as seen from the perspective of the on-Park tenants. This observation coincides with previous analysis presented on Chapter 3 about British Science Parks: links with University seem not to be a focal point for choice of location of firms on Parks. Prestige of being located near a university, facilities provided by Parks management, pleasant environment and good communication and transportation networks are among the main reasons firms have mentioned for their location choices.

The main characteristics of the Park's tenants and also their R&D activities also confirm previous studies related to British Science Parks. Activities concerned with ICT related-productive sectors (Computer soft and hardware, other Electronics related and Communication) dominate the Park environment and account for almost 50% of the sample of on-Park firms investigated in this research. The size of the on-Park firms also conforms to a tendency already observed in other British Parks in which Parks seem to be a very adequate place for housing small companies. The development of R&D activities by no means constitute the only activity undertaken by this set of companies. Even though the promoters and the management of the Surrey Research Park do expect to house essentially firms for which the development of R&D activities is a priority, it was possible to observe that, at least within the context of this sample of on-Park firms, the development of



R&D activity has not still fulfilled such expectation. 33% of the firms that took part of this field work do not develop any R&D activity. Moreover, such activity is a primary activity for only 19% of the tenants and only 10% have been engaged in basic research activity, limiting, in this way, the possibilities of interaction with universities.

After this description concerning the on-Surrey Park firms characteristics and R&D activities, the next Chapter turns to the main topic of this research: the links that exist between this sample of firms and the host University and other university located elsewhere.

CHAPTER 5 - LINKS BETWEEN THE FIRMS LOCATED ON THE SURREY RESEARCH PARK AND THE UNIVERSITIES

This Chapter explores and describes the links that existed between the sample of firms located on the Surrey Research Park and universities. On the basis of the taxonomy of links previously developed (Chapter 4, sub-section 4.1.3), the Chapter consists of three main sections, as follows.

Section 5.1 concerns the links that existed between the sample of firms located on the Surrey Research Park and the University of Surrey, here also referred to as the local or host University. By considering each group of links separately - Informal, Human Resources and Formal - the section describes the kind of links, their frequency or intensity, the involvement of firms' departments as well as the outputs emerging from such interactions. In addition, it deals with aspects concerning the firms' location on the Surrey Research Park in order to assess its importance as well as the importance, or impact, of links with the local university for the development of the firms' activities.

Section 5.2 is concerned with the links that existed between the same sample of on-Park firms and other universities located elsewhere. Although presenting a more concise approach, the section follows the same steps as those previously done with the links with the local university. Moreover, this set of data allows a comparative analysis between both sets of on-Park firms links. The presentation of these series of data examines one of the strongest arguments related to the university and industry links in Science Parks: that the geographical proximity between universities and companies fosters and strengthens their interaction. Finally, section 5.3 concludes the Chapter.

Before starting Section 5.1, four general comments could be useful in order to clarify some points:

- This Chapter is related to the firms' side of the interaction between university and industry. Consequently, these data refer to a series of interviews conducted with the Managing Directors, R&D Directors or owners - here also referred to as interviewees - of the sample of 21 firms located on the Surrey Research Park.
- The data in this Chapter permit the use of only very simple statistics. Percentages have been rounded up or down to the nearest integer because of the small overall sample size. For this reason, totals in tables may not add to 100% because of the rounding.
- Several "answer categories" were created in order to facilitate and standardise the answers to the questionnaires. When necessary, the categories are defined and shown underneath each Table.
- The period of time considered in this research is between 1991 and 1993, mainly due to the fact that, as was stressed in Chapter 4, a high proportion of the sample of firms (47%) that took part of the fieldwork have been located on the Surrey Research Park for a very short period of time - between 1 and 3 years.

5.1 - Links between the on-Park firms and the University of Surrey

Table 5.1 summarises the links that existed between the sample of on-Park firms (21 firms) and the host university, during the period of 1991-1993. As the table shows, the great majority (95%) of firms located on the Surrey Research Park demonstrated some kind of links with the University of Surrey: 90% or 19 firms had one or more of the links in the Informal category; 52% or 11 companies had Human Resources links; and finally, 33%, representing 7 firms, were engaged in one or more of the links in the Formal category.

Table 5.1 - Links between the on-Park Firms and the Host University

LINKS	No. of Firms	% of Firms
Summary	21	100
Any Link	20	95
Informal Links	19	90
Human Resources Links	11	52
Formal Links	7	33
Informal Links	19	100
Personal contact with university academic staff	14	74
Access to specialised literature	11	58
Attendance at seminars and conferences	10	53
Access to university equipment	8	42
Access to university department research	4	21
Attendance at general education/training programmes	4	21
Human Resources Links	11	100
Recruitment of recent graduates	9	82
Students involvement in projects	8	73
Formally organised training of firm's personnel in university	3	27
Recruitment of more experienced scientists and engineers		
Formal Links	7	100
Analysis and testing in university department	4	57
Engagement of university academic staff for consultancy	3	43
Establishment of joint research	3	43
Establishment of research contract	1	14

5.1.1 - Informal Links

Through this set of links, firms, in their search for technical solutions or in their attempt to implementing an innovation, establish contact with the pool of information and knowledge, expertise and equipment available at universities. The establishment of these links does not

imply formal contracts between the partners, even though small fees may sometimes be involved on an ad-hoc basis.

Informal links have been considered by experts (among others, Monck et al, 1988; Massey et al, 1992; Westhead and Storey, 1994) as the most common kind of interaction between academics and entrepreneurs. In this research, as Table 5.1 detailed above, 19 firms, or 90% of the sample of on-Park firms, established at least one of the Informal links with the host university.

The first aspects explored during the interviews were concerned with the kind of Informal links the on-Park firms were involved in as well as their intensity, the firms' department which established the links and the outputs resulting from their interaction.

The links clustered within the Informal category of links are classified into two broad groups. The first, involving "Personal contact with university academic staff", "Access to specialised literature" and "Attendance at seminars and conferences" may be established through a less structured organisational approach from the firms' side. The second group, involving "Access to university department research", "Access to university equipment" and "Attendance at general education/training programmes" may require a more structured organisational approach for their establishment.

Taking the 19 firms that established any of the links included in this Informal category, it is evident that the less structured organisational approach the links require for their establishment, the higher is the number of firms committed to them. Links such as "Personal contact with university academic staff", "Access to specialised literature", and "Attendance at seminars and conferences" involved a higher number of firms participating in the interaction - 14 (74%), 11 (58%) and 10 (53%) respectively.

On the other hand, other Informal links such as "Access to university equipment", "Access to university department research" or "Attendance at general education/training programmes", whose establishment requires a more structured organisational approach or whose access would suggest some kind of previous commitment between the interested firms and the university departments, involved a lower number of firms interacting - 8 (42%), 4 (21%) and 4 (21%) in each of the quoted examples.

Table 5.2 shows information about the intensity of these Informal links. The intensity of links was measured in terms of the frequency with which the on-Park firms engaged in these types of informal interaction. Two aspects emerged from this Table:

- The great majority of links occurred around 3 - 6 times a year or less frequently, meaning that low frequency is the standard among Informal links.
- Even though the low frequency is the dominant one, the evidence, once again, shows that the less structured the organisational approach the links require for their establishment, the higher the possibility of their occurrence in a more intense way (medium or high frequency).

The results concerning the firms' departments that were involved in this category of links with the local University are described on Table 5.3. The main point to be stressed is that the majority of Informal links were committed by the firms' R&D departments. More than that, the links that require a more structured organisation approach for their establishment, such as "Access to university equipment" and "Access to university department research" had a higher involvement of the R&D department of firms than the others.

Table 5.2 - Informal Links established between the on-Park Firms and the Host University - Intensity (frequency)

Informal Links	Number of Firms	Low Frequency (%)	Medium Frequency (%)	High Frequency (%)	No Answer (%)
Personal contact with university academic staff	14	71.5	21.5	7.0	-
Access to specialised literature	11	64.0	18.0	18.0	-
Attendance at seminars and conferences	10	90.0	-	10.0	-
Access to university equipment	8	62.5	-	25.0	12.5
Access to university department research	4	75.0	-	-	25.0
Attendance at general education/training programmes	4	100.0	-	-	-

Categories:- **Low Frequency** links occurring around 3-6 times a year or less frequently

Medium Frequency links occurring about once a month

High Frequency links occurring about once a week or more frequently

Table 5.3 - Informal Links established between the on-Park Firms and the Host University - Firms' departments involved

Informal Links	No. of Firms	R&D (%)	D&PE (%)	P&M (%)	S&D (%)	Other (%)
Personal contact with university academic staff	14	43.0	14.0	-	7.0	36.0
Access to specialised literature	11	73.0	-	-	-	-
Attendance at seminars and conferences	10	60.0	-	-	9.0	18.0
Access to university equipment	8	75.0	12.5	-	20.0	20.0
Access to university department research	4	75.0	-	-	-	12.5
Attendance at general education/training programmes	4	25.0	25.0	-	-	25.0
Categories:-						50.0

R&D Research and Development

D&PE Design, Production Engineering and Implementation

P&M Production and Manufacturing

S&D Sales and Distribution

Other Other firms' departments



Other firms' departments such as Design, Production Engineering and Implementation, Production and Manufacturing, Sales and Distribution did not have any major level of interaction. Among other firms' departments engaged in Informal links, were quoted those related to Management, Marketing, Human Resources (Professional Development). Only one company made reference to a technical university department (in this case, the Geotechnical Department).

On the University side, a wide range of Departments were involved in these links. In the case of those links which require a more structured organisational approach (e.g. "Access to university department research", "Access to university equipment"), the university departments tended to be those more connected with "hard" sciences, such as Engineering, Chemistry, Computing Sciences.

On the other hand, Informal links which require a less structured organisational approach (e.g. "Personal contact with university academic staff", "Attendance at seminars and conferences"), tended to present connections with a more diverse spectrum of university departments. In addition to university departments linked to the "hard" sciences, departments such as Education, Marketing, Social Sciences and even the use of the library facilities demonstrated an increased participation.

The last aspect considered in this sub-section refers to the outputs which emerged from these Informal links. The results, summarised in Table 5.4, show that the most common outputs were those related to Verbal Advice/Provision of Information, with the "Attendance at seminars and conferences", "Personal contact with university academic staff" and "Access to specialised literature" being the main channels used by the firms in order to achieve such outputs (80%, 79% and 73% respectively). These results were expected in face of the informality of these links and their low frequencies, even though the firms' R&D departments were those most involved with the host university.

Table 5.4 - Informal Links established between the on-Park Firms and the Host University - Outputs of the Interaction

Informal Links	No. Firms	VA/PI (%)	AR (%)	PP (%)	DS/Pr (%)	Other (%)	N/A (%)
Personal contact with university academic staff	14	79.0	-	7.0	-	-	14.0
Access to specialised literature	11	73.0	-	9.0	-	-	18.0
Attendance at seminars and conferences	10	80.0	10.0	-	-	-	10.0
Access to university equipment	8	50.0	-	12.5	12.5	12.5	12.5
Access to university department research	4	50.0	-	25.0	-	-	25.0
Attendance at general education/training programmes	4	50.0	-	-	-	25.0	25.0

Categories:- VA/PI Verbal Advice/Provision of Information

AR Advisory Report

PP Implementation of a Particular Programme

DS/Pr Design Specification/Prototype

Other Any other output

N/A No Answer



5.1.2 - Human Resources Links

The Human Resources group of links concerns the improvement, training and recruitment of qualified manpower occurring between firms located on the Surrey Research Park and the University of Surrey. Firms may wish to strengthen their links with academe through the support to, or absorption of, qualified manpower. This group of links, as previously described, extends the possibilities of promoting technical and continuing education in specific areas of firms' interests.

Following the same steps as in the previous sub-section, the core of this sub-section is based on a set of information related to the kind of links and their intensity (measured by the number of programmes/students/graduates/scientists committed by the firms) as well as the firms' departments involved with these links. Table 5.5 below reproduces the information about the Human Resources links, emphasising the number of firms undertaking them in both ways absolute and relative numbers.

Table 5.5 - Number and Proportion of Firms Committed to Human Resources Links

LINKS	No. of Firms	% of Firms
Any of Human Resources Links	11	100
Recruitment of recent graduates	9	82
Students involvement in projects	8	73
Formally organised training of firm's personnel in university	3	27
Recruitment of more experienced scientists and engineers		

"Recruitment of recent graduates" scored the highest proportion among the links listed in this group - 82% of the firms, representing 9 companies, recruited recent graduates from the University of Surrey. The intensity of this link is as follows: 4 out of 9 companies (44%) recruited only one recent graduate/year; 2 other companies (22%) were restricted to 2 graduates/year and also the same proportion is registered for 3 graduates/year; only one company (11%) contracted 4 or more recent graduates/year.

"Students involvement in projects" refers to specific period of time the on-Park firms allow the participation of students from the University of Surrey in their activities or projects. 8 out of 11 firms established such a link.

It is important to stress that, particularly concerning the involvement of undergraduate students in industrial projects, the establishment of this link has been facilitated by the University of Surrey's own policy. Such policy requires that undergraduate students must attend, by the end of their courses, a training period in a company or industry as part of their graduation requirements. Consequently, the existence of the Park nearby the University has effectively contributed to the broadening of the students' opportunities.

Looking at the intensity of this link in some detail, one can observe that 4 firms committed 2 students/year; another 3 firms one student/year; only one had 3 students/year and none had 4 or more students/year.

Although it is not possible to establish a straightforward relation between "Students involvement in projects" and "Recruitment of recent graduates", some of the interviewees stressed that when the students involved in their projects are undergraduate students, both links could be considered as part of the same process. Initially, the undergraduate students could have their training period in some on-Park firms which, after their graduation, could absorb them as permanent staff.

Only 3 companies, or 27% of the firms engaged in this group of links, established "Formally organised training of firm's personnel in university" link with the host university. However, the interviewees were unable of giving details about the developed programmes.

Regarding the last link within this category of Human Resources links : "Recruitment of more experienced scientists and engineers" - it obtained no score. This result could cause some surprise due to the fact that more experienced scientists and engineers constitute the

"raw material" for certain kind of firms: those involved in innovative processes, R&D activities and located on Science Parks sites.

According to some of the interviewees, the absence of recruitment of more experienced scientists and engineers from the host university by their companies is due to the fact that the University of Surrey has not provided experts in areas where the firms' needs are concentrated.

The last aspect to be considered at this stage is that related to the firms' departments involved with the establishment of Human Resources links. Once again, as Table 5.6 shows, the firms' R&D departments appear to be centrally important for the establishment of any of the Human Resources links with the local University: 88% of the recent graduates, 56% of undergraduate students and 100% of formally organised training programmes were implemented with the participation of these departments. The importance of firms' R&D departments for the establishment of links with universities is explored in Chapter 6 in more details.

5.1.3 - Formal Links

Formal links refer to those arising under formal contract between on-Park firms and the local university, involving both the commitment of the partners to the planned project or activity as well as the payment of fees previously established. This group of links includes: (a) "Engagement of university academic staff for consultancy"; (b) "Analysis and testing in university department"; (c) "Establishment of research contract"; and (d) "Establishment joint research".

Table 5.6 - Human Resources Links established between the on-Park Firms and the Host University - Firms' Departments involved

Human Resources Links	No. Firms	R&D (%)	D&PE (%)	P&M (%)	S&D (%)	Other (%)
Recruitment of recent graduates	9	88.0	-	-	-	12.0
Students involvement in projects	8	56.0	22.0	-	-	22.0
Formally organised training of firm's personnel in university	3	100.0	-	-	-	-
Recruitment of more experienced scientists and engineers	0	-	-	-	-	-

Categories:- R&D Research and Development
D&PE Design, Production Engineering and Implementation
P&M Production and Manufacturing
S&D Sales and Distribution
Other



At the beginning of this section, Table 5.1 showed that the interaction between the sample of on-Park firms and the host University through Formal links attained a substantially lower score (33% of the total sample of firms) when compared to those demonstrated by Informal and Human Resources groups of links (90%, and 52% respectively). Table 5.7 below reproduces the number of firms engaged in the group of Formal links and their proportion in relation to this sub-sample of firms.

Table 5.7 - Number of Firms Committed to Formal Links with the Host University

LINKS	No. of Firms	% of Firms
Any of the Formal Links	7	100
Analysis and testing in university department	4	57
Engagement of university academic staff for consultancy	3	43
Establishment of joint research	3	43
Establishment of research contract	1	14

Analysis and testing in university department

Depending on the firms' activities, they may need to analyse and test their new or improved products and processes. Considering the high costs of some equipment and even of the implementation of their own laboratories, some on-Park firms may opt, through special agreements with the local university, for accessing and using those university tools.

Only 4 companies, representing 57% of this sub-sample of on-Park firms, were engaged in "Analysis and testing" link at the time of the fieldwork. Table 5.8 describes the main characteristics of this link.

The number of agreements between on-Park firms and the local university and their duration could not be considered as high: 50% of the firms established only 2 agreements between 1991 and 1993 and 75% of them lasted 2 months or less, meaning short-term commitments.

Table 5.8 - Main Characteristics of Firms' "Analysis and Testing" Links with the University of Surrey

Characteristics	Categories	Number of Firms Engaged in this Link	Proportion of Firms in each Category
a. No. of agreements	1 agreement	-	-
	2 agreements	2	50%
	3 agreements	-	-
	4 or more agreements	1	25%
	no answer	1	25%
b. Duration	less than 1 month	2	50%
	1 and 2 months	1	25%
	3 months and 1 year	1	25%
	more than 1 year	-	-
c. Firms' departments	R&D	3	75%
	D&PE	1	25%
	P&M	-	-
	S&D	-	-
	Other	-	-
d. Outputs	VA/PI	1	25%
	AR	2	50%
	PP	-	-
	DS/Pr	-	-
	Other (Analyt. Serv.)	1	25%

Categories:

Firms' Department R&D Research and Development
 D&PE Design, Production Engineering and Implementation
 P&M Production and Manufacturing
 S&D Sales and Distribution

Outputs VA/PI Verbal Advice/Provision of Information
 AR Advisory Report
 PP Implementation of a Particular Programme
 DS/Pr Design Specification/Prototype
 Other Any other output

The firms' departments involved with the establishment of "Analysis and testing" link once more reaffirms the importance of the firms' R&D departments: 75% of the firms forged this link through their R&D units. From the university side, the most active departments were the Chemistry Department (part of the Faculty of Science) and the Faculty of Engineering, through its Departments of Electronic and Electrical Engineering and Testing Laboratory.

An important question that was asked to the interviewees in relation to every link in all the categories but acquired a special meaning for those listed as Formal links is that concerning the outputs emerging from these interactions. This is because most of the links clustered within this category of links are potentially closer to the firms' innovative activity and, consequently, closer related to the research activity developed by universities. Then, it would be expected that the outputs emerging from the establishment of Formal links would have a stronger influence on the innovative activity of firms, generating more marketable products than the links clustered in the other categories.

Regarding "Analysis and testing" link, the main outputs emerging from this relationship were Advisory Reports (50% of the results) and Verbal Advice/Provision of Information (25% of the results). Then, contrary to the expectation, both outputs were closer connected to inputs to innovative activity of firms than to products to be commercialised in the market-place.

Finally, only two firms provided information about the financial costs they had to implement their "Analysis and testing" links. One of the firms spent less than £ 1,000 in 1991 and 1992. Another company answered that its costs, for 1992, were between £ 20,000 - £ 50,000, (representing between 1 - 2% of its turnover).



Engagement of university academic staff for consultancy

This link has been mainly restricted to a research relationship between companies and individual researchers, whose expertise is the corner-stone of the interaction. As the last report commissioned by the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom (1994:14) states: "Consultancy involves little in the way of new information gathering, but instead consists of advising firms on the basis of previous experience", being concerned with "the transfer of existing knowledge"

Table 5.9 describes the main characteristics of this link. According to it, only 3 companies, representing 43% of this sub-sample of on-Park firms (or 14% of the total sample of 21 firms), were engaged in "Consultancy" link with the host university researchers at the time of the fieldwork.

The characteristics of "Consultancy" link are quite similar to those presented in the previous "Analysis and testing" link. The number of projects varied between 1 and 3 for the 2 year period this research is concerned with. Only one project lasted more than one year; the other 2 projects (66%) did not exceed 2 months of interaction.

Besides the R&D department of one of the firms (1 project), the Design, Production Engineering and Implementation department (1 project) and a technical department of one of the companies (1 project) were those responsible for these Consultancy activities. The Faculty of Engineering, through its Chemical Engineering Department, plus the Testing Laboratory and the Geotechnical Department, represented the University side of this activity. Once again Verbal Advice/Provision of Information (66% of the results) and Advisory Reports (33%) were the main outputs resulting from this kind of linkage.

Table 5.9 - Main Characteristics of Firms' "Consultancy" Links with the University of Surrey

Characteristics	Categories	Number of Firms Engaged in this Link	Proportion of Firms in each Category
a. Number of projects	1 project	1	33%
	2 projects	1	33%
	3 projects	1	33%
	4 or more projects	-	
b. Duration	less than 1 month	1	33%
	1 and 2 months	1	33%
	3 months and 1 year	-	
	more than 1 year	1	33%
c. Firms' departments	R&D	1	33%
	D&PE	1	33%
	P&M	-	
	S&D	-	
	Other (Geotechn. Dept)	1	33%
d. Outputs	VA/PI	2	66%
	AR	1	33%
	PP	-	
	DS/Pr	-	
	Other	-	

Categories:

Firms' Department R&D Research and Development
 D&PE Design, Production Engineering and Implementation
 P&M Production and Manufacturing
 S&D Sales and Distribution

Outputs VA/PI Verbal Advice/Provision of Information
 AR Advisory Report
 PP Implementation of a Particular Programme
 DS/Pr Design Specification/Prototype
 Other Any other output

Finally, only one company stated its financial costs for establishing "Consultancy" links: it spent between £ 1,000 -£ 5,000 during the whole year of 1992, representing less than 1% of its turnover.

Establishment of joint research

This type of link presumes the collective research involvement of research teams from both the university and the interested on-Park firm in order to achieve and share mutual results and benefits. Table 5.10 presents the main characteristics of "Joint research" link.

The number of companies pursuing this link is the same as in the former sub-section ("Consultancy"). Only 3 out of 7 companies (43% of the sub-sample of firms committed to Formal links) implemented joint research projects during the period between 1991 and 1993.

Only one project was entered into by each of the 3 companies, their R&D departments being responsible for forging these collaborative research projects. The Faculty of Engineering, through its Electronic and Electrical Engineering and Chemical Engineering Departments, and Faculty of Science, through its Chemistry Department, signed these agreements. The number of qualified scientists and engineers employed by these common projects from both the university and the firms were equivalent (less than 5 researchers) and no other firm or University department shared in the projects developed by the principal partners. In addition, an Advisory Report was the type of output emerging from 2 out of the 3 agreements. The other output was related to the implementation of a particular programme.

Table 5.10 - Main Characteristics of Firms' "Joint Research" Links with the University of Surrey

Characteristics	Categories	Number of Firms Engaged in this Link	Proportion of Firms in each Category
a. Number of projects	1 project	3	100%
b. Date	before 1991	1	33%
	1991	1	33%
	1992	1	33%
	1993	2	66%
c. Stage of Develop.	in progress	2	66%
	finished	1	33%
d. Firms' Departments	R&D	3	100%
	D&PE	-	-
	P&M	-	-
	S&D	-	-
	Other	-	-
e. No. of researchers	from University side	less than 5	100%
	from Firm side	less than 5	100%
f. Outputs	VA/PI	1	33%
	AR	2	66%
	PP	1	33%
	DS/Pr	-	-
	Other	-	-

Categories:

Firms' Department R&D Research and Development
 D&PE Design, Production Engineering and Implementation
 P&M Production and Manufacturing
 S&D Sales and Distribution

Outputs VA/PI Verbal Advice/Provision of Information
 AR Advisory Report
 PP Implementation of a Particular Programme
 DS/Pr Design Specification/Prototype
 Other Any other output



Only for the year 1993 was it possible to access some financial information about "Joint research" projects. One of the companies was spending between £ 20,000 - £ 50,000, representing between 20 - 50% of its turnover. The second firm declared that its costs were higher than £ 50,000 in that year, without make any connection with its turnover.

Establishment of research contract

This link involves the development of some research activity developed by part of the local University research team, under formal arrangements set up with an interested on-Park firm. In this case, the objectives of the research are usually defined by the company which can also restrict the use and diffusion of the research results according to its point of view.

As already stressed (Table 5.1), only one out of the 7 companies that were involved in Formal links had developed this kind of link during the period between 1991 and 1993, but this single company had entered contracts for 4 projects. Table 5.11 details the main characteristics of these projects.

Two of the projects that started in 1992 were in progress at the time of the fieldwork. The other 2 projects (starting before 1991 and in 1991) were completed. The firm's R&D department approached the University teams. Although the main outputs resulting from these 4 projects were restricted to the presentation of Advisory Reports, the projects had a multidisciplinary character, involving 10 qualified scientists and engineers from two University departments: Material Sciences and Engineering (Faculty of Engineering) and Chemistry Department (Faculty of Science). The company informed that it has spent more than £ 50,000 (between 3 - 5% of its turnover) for implement these projects for both years 1991 and 1992.

Table 5.11 - Main Characteristics of Firm's "Research Contract" Projects with the University of Surrey

Characteristics	Categories	Number of Projects	Proportion of Projects in each Category
a. Number of projects		4	100%
b. Date	before 1991	1	25%
	1991	1	25%
	1992	2	50%
	1993	-	-
c. Stage of Develop.	in progress (extended)	2	50%
	finished	2	50%
d. Firm's department	R&D	4	100%
	D&PE	-	-
	P&M	-	-
	S&D	-	-
	Other	-	-
e. No. of researchers	from University side	10 researchers	100%
f. Outputs	VA/PI	-	-
	AR	4	100%
	PP	-	-
	DS/Pr	-	-
	Other	-	-

Categories:

Firms' Department R&D Research and Development
 D&PE Design, Production Engineering and Implementation
 P&M Production and Manufacturing
 S&D Sales and Distribution

Outputs VA/PI Verbal Advice/Provision of Information
 AR Advisory Report
 PP Implementation of a Particular Programme
 DS/Pr Design Specification/Prototype
 Other Any other output

Summary of Formal Links

Sub-section 5.1.3 described the pattern of interaction established between on-Park firms and the host university in relation to Formal links. This category of links includes "Consultancy", "Analysis and testing", "Research contract" and "Joint Contract".

Only 7 companies (or 33% of the total sample of firms) forged any of these links, but their proportion, individually, was much lower than that rate. The number of projects committed by these firms did not usually exceed four agreements during the period of 1991-1993. Also, the duration of such agreements did not exceed one year, being usually related to shorter periods (1-3 months). The firms' R&D department were responsible for the establishment of almost all the projects. The outputs generated through the establishment of these links - Verbal Advise/Provision of Information and Advisory Reports - were basically inputs to the firms' innovative activity and not innovations themselves.

5.1.4 - Firms' location on the Park and their Links with the Host University

This sub-section provides information about the importance of the links established between on-Park firms and the host university to the development of the firms activities as well as about the importance of the Science Park in stimulating these links.

In order to access these information, three main questions were addressed to the interviewees. One was related to the importance the establishment of these links had on the development of the firms' activities. Such an importance was measured in terms of the impact of links and their benefits to the firms' activities: low impact meant no or peripheral benefit for these activities and high impact meant direct or crucial benefit to the firms' activities.



Another important question was related to the pre-existence of the described links previously to the location of the firms on the Park. This was thought to be important due to the large number of firms that were re-located onto the Park from elsewhere (56% of the total sample of firms surveyed). The interviews, therefore, sought to identify whether firms already had links with the University of Surrey before they were located on the Park. Finally, it was assessed whether the location of the firms on the Park had been an important factor influencing the establishment of links with the host university.

The presentation of information on these issues considers each group of links separately.

Informal Links

Table 5.12 presents information about the importance the establishment of Informal links had on the firms' activities, the pre-existence of these links previously to the firms' location on the Park as well as the importance of the Park for the establishment of links in this category.

Overall, 19.5% of the firms had already established some of the Informal links previously to their location on the Park. The highest marks are those related to the links that required some structured organisational approach for their establishment within this Informal group. Particularly in regard to the "Access to university equipment" link (37.5%), some of the interviewees pointed out that their pre-interaction was mainly due to the well equipped Engineering laboratories of the University's Faculty of Engineering.

59% of the firms considered the establishment of Informal links as representing no or peripheral benefit for the development of their activities. The only exception was "Access to specialised literature", for it was considered as important for 63% of the firms. Broadly speaking, the majority of firms considered this group of links with the local University as not important (low impact) for the development of their activities.

Table 5.12 - Informal Links - Pre-existence of links, their importance for the firms' activities and the importance of being located on the Park for the establishment of these links

Informal Links	No. of Firms	Impact (%)		Pre-existence of links(%)	Importance of being located on the Park(%)
		Low	High		
Personal contact with university academic staff	14	57.0	43.0	21.5	43.0
Access to specialised literature	11	37.0	63.0	9.0	45.5
Attendance at seminars and conferences	10	80.0	20.0	10.0	40.0
Access to university equipment	8	62.5	37.5	37.5	37.5
Access to university department research	4	50.0	50.0	25.0	75.0
Attendance at general education/training programs	4	75.0	25.0	25.0	50.0
All Informal Links/All Firms	51	59.0	41.0	19.5	45.0

Categories:- **Low** **Low Impact** the link represented no or peripheral benefit for the development of the firms' activities
High **High Impact** the link represented a direct, or even crucial, benefit to complement the development of the firms' activities



Also, only 45% of the firms considered their location on the Surrey Research Park as important in order to establish Informal links with the local university. The exception was "Access to university department research": 75% of the firms engaged in this link considered important their location on the Surrey Research Park for forging this link.

Human Resources Links

Table 5.13 presents information about the importance Human Resources links had on the firms' activities, the pre-existence of these links previously to the firms' location on the Park as well as the importance of the Park for the establishment of links in this group.

Overall, 30% of the firms had already set up some of these links previously to their establishment on the Park. The highest score came through "Formally organised training of firm's personnel in university", for 67% of the firms had been involved with it before being located on the Surrey Research Park. "Recruitment of recent graduates" and "Students involvement in projects" achieved much lower scores: 22% and 25% respectively.

The importance of Human Resources links for the development of the firms' activities attained higher levels than those of the Informal group of links: 65% of the firms considered this group of links as important (high impact) for their activities. 100% of the companies engaged in "Formally organised training of firm's personnel in university", for instance, considered this link as a direct, or even crucial, benefit to complement the development of their activities. Here, the lowest mark came from

Data related to the importance of being located on the Park in order to establish Human Resources links was somewhat hampered because of difficulties in getting such information from the interviewees. The Table, therefore, only shows information for "Formally organised training of firm's personnel in university", for which 100% of the firms considered their location on the Park as important.

Table 5.13 - Human Resources Links - Pre-existence of links, their importance for the firms' activities and the importance of being located on the Park for the establishment of these links

Human Resources Links	No. Firms	Impact (%)		Pre-existence of links (%)	Importance of being located on the Park (%)
		Low	High		
Recruitment of recent graduates	9	33.0	66.0	22.0	
Students involvement in projects	8	50.0	50.0	25.0	
Formally organised training of firm's personnel in university	3	-	100.0	67.0	100.0
Recruitment of more experienced scientists and engineers	-	-	-	-	-
All Human Resources Links/All Firms	20	35.0	65.0	30.0	15.0

Categories:- **Low Impact** the link represented no or peripheral benefit for the development of the firms' activities
High Impact the link represented a direct, or even crucial, benefit to complement the development of the firms' activities

Formal Links

Finally, Table 5.14 presents information about the importance Formal links had on the development of the firms' activities, the pre-existence of Formal links previously to the firms' location on the Park as well as the importance of the Park for the establishment of links clustered in this group.

Overall, only 9% of the firms had established Formal links before their location on the Park. This low proportion, however, represents only the number of "Research contract" link committed by a company with the host university.

Regarding the importance of Formal links established with the local university, 73% of the companies considered this group of links as provoking a high impact - direct or even crucial benefit - on the development of their activities. Here again, "Research contract" showed the highest score (100%).

Data related to the importance of being located on the Park were, again, somewhat hampered. Some of the "Joint research" projects established between firms and the host university had just been implemented by the time of the fieldwork. Then, a more accurate evaluation was dependent of the results of those projects. Nevertheless, 27% of the companies considered, overall, their location on the Park as an important factor influencing the establishment of their links. Looking in detail, the firm which set up "Research contract" link with the local university considered its location on the Park as an important factor (even though it had previously forged this link).

Table 5.14 - Formal Links - Pre-existence of links, their importance for the firms' activities and the importance of being located on the Park for the establishment of these links

Formal Links	No. Firms	Impact (%)		Pre-existence of links (%)	Importance of being located on the Park (%)
		Low	High		
Analysis and testing in university department	4	25.0	75.0	-	50.0
Engagement of university academic staff for consultancy	3	33.0	66.0	-	-
Establishment of joint research	3	33.0	66.0	-	(*)
Establishment of research contract	1	-	100.0	100.0	100.0
All Formal Links/All Firms	11	27.0	73.0	9.0	27.0

Categories:- **Low Impact** the link represented no or peripheral benefit for the development of the firms' activities
High Impact the link represented a direct, or even crucial, benefit to complement the development of the firms' activities

(*) The only company which had finished its Joint research project considered as not important the location on the Park.

5.2 - Links between the on-Park Firms and other Universities located elsewhere

This section is divided into two sub-sections. Sub-section 5.2.1 briefly presents the links that existed between the sample of on-the Surrey Research Park firms and other universities during the period 1991-1993. Sub-section 5.2.2 relates to a comparative presentation of the links established between the on-Park firms and the host university and with other universities.

5.2.1 - Brief Description of the Links between the on-Park Firms and other Universities

Table 5.15 summarises the links that existed between the sample of firms located on the Surrey Research Park and other universities. 13 out of the 21 companies or 62% of the sample of on-Park firms established links with other universities located elsewhere. However, as one of those companies refused to answer the questions of that part of the questionnaire, the total number of firms computed for the following calculations considered the total research sample as 20 instead of 21 firms. The first results showed that 50% of the on-Park firms undertook Informal links; 35% had one or more of the links grouped in Human Resources links and finally another 35% were engaged in one or more of the Formal links.

Looking at the Informal links, the proportion of firms concerned with them varied between 20% for links such as "Access to university equipment" and "Attendance at general education/training programmes", where the geographical proximity could positively intervene, to 100% represented here by "Personal contact with university academic staff", the more usual link in this group. "Access to university department research" and "Attendance at seminars and conferences" with scores around 60% and 50% respectively, could suggest that what matters for their establishment are, instead of the physical proximity, the expertise and the quality and adequacy of the research developed by universities or other Higher Education Institutions.

Table 5.15 - Summary of Links between the on-Park Firms and Other Universities

LINKS	No.of Firms	% of Firms
Summary (*)		
Any Links	13	62
Informal Links	10	50
Human Resources Links	7	35
Formal Links	7	35
Informal Links	10	100
Personal contact with university academic staff	10	100
Access to university department research	6	60
Attendance at seminars and conferences	5	50
Access to specialised literature	4	40
Access to university equipment	2	20
Attendance at general education/training programmes	2	20
Human Resources Links	7	100
Recruitment of recent graduates	6	86
Students involvement in projects	4	57
Formally organised training of firm's personnel in university	3	43
Recruitment of more experienced scientists and engineers	-	-
Formal Links	7	100
Engagement of university academic staff for consultancy	6	86
Analysis and testing in university department	3	43
Establishment of research contract	2	29
Establishment of joint research	1	14

(*) Except for "Any Links" where 21 firms equals 100%, the Summary of the data considered 20 firms as 100%

The next paragraphs outline the main information about each group of links, starting with Informal Links, followed by Human Resources links and Formal links.

Informal Links

- Frequency of Informal links - The majority of links presented low frequency, meaning that they occurred around 3 - 6 times a year or less often. Only "Access to university equipment" (for 50% of the firms) and "Access to university department research" (for 33% of the firms) reached medium frequency (or occurrence), meaning about once a month.
- Firms' departments involved with such links were clear-cut: the firms' R&D departments were responsible for at least 75% of the Informal links with require a less structured organisational approach for their establishment ("Personal contact with university academic staff" and "Access to specialised literature") and 100% for those for which a more structured organisation approach is necessary (such as "Access to university equipment" and "Access to university department research").
- The main output emerging from this group of links was Verbal Advice/Provision of Information, whose scores varied between 50% and 100%. Besides that output, "Access to university equipment" also produced 50% in the form of Advisory Reports.
- Except for "Access to university equipment" whose impact on the development of the firms' activities represented no or peripheral benefit for the 2 firms engaged with it, the other Informal links obtained a rate of impact varying between 70% and 100%, meaning that they represented a direct, or even crucial, benefit to complement the development of the firms' activities.

Human Resources Links

Only 7 companies (33% of the total sample of firms surveyed) developed links related to Human Resources category with other universities: 6 companies (86% of this sub-sample of firms) recruited recent graduates; 4 firms (57%) had student involvement in projects and

3 firms (53%) established training programmes. The recruitment of more experienced scientists and engineers did not exist.

Other aspects regarding the establishment of this group of links are as follows.

- The frequency, or intensity, of these links, was measured by the number of students/graduates/scientists/programmes committed by the firms. Except for "Students involvement in projects" which was more intensive (3 or 4 students per company per year, excluding the lack of answers from 2 firms), the other links resulted essentially in one person or programme per company per year, representing a low frequency.
- Once again, the firms' R&D departments were responsible for the implementation of this group of links: 100% of the "Students' involvement in projects", 83% of the "Recruitment of recent graduates" and 66% of the "Formally organised training of firm's personnel in university" had their main channel of implementation or absorption through this department.
- The importance of establishing links in this group over the development of the firms' activities followed the same path as the scores achieved by the Informal ones. "Recruitment of recent graduates", "Formally organised training of firm's personnel in university" and "Students involvement in projects" recorded 83%, 66% and 50%, respectively, meaning that they represented a direct, or even crucial, benefit to complement the development of the firms' activities.

It is worth noting that among the universities or Higher Education Institutions with which the on-Park firms had established Informal as well as Human Resources groups of links, the great majority were located on the United Kingdom, the only example quoted from abroad referring to an American University. Also, it is important to emphasise that among the main reasons the firms had for such links, the interviewees strongly stressed the expertise and

technical competence in particular fields that universities possessed, the universities' facilities, the excellence of their graduates and also their ability in building and marketing links with industry.

Formal Links

According to Table 5.15, 7 companies (33% of the total sample) had linkages in the Formal group of links, 6 firms (86% of the sub-sample of firms) being committed to "Consultancy"; 3 firms (43% of the sub-sample of firms) to "Analysis and testing"; 2 companies (29% of the sub-sample of firms) established "Research contract" and only one firm (14% of the sub-sample of firms) had "Joint research" agreements.

The main finding concerning these Formal links are as follows.

- "Consultancy" - 3 companies or 50% of this sub-sample of on-Park firms set up 4 or more "Consultancy" projects during the period 1991-1993. Also, 2 companies were engaged in 2 projects and one company in another project in the same period of time. 83% of this activity was developed by the R&D department of the firms, whose results were mainly concerned with Advisory Reports (50%) and Verbal Advice/Provision of Information (33%). 83% of the firms evaluated their "Consultancy" activities as of high impact since the link represented a direct, or even crucial, benefit to complement the development of the firms' activities.
- "Analysis and testing" - The number of agreements established by the on-Park firms varied equally between one (33%), 3 (33%) and 4 or more agreements (33%) for the 2 year period. The firms' R&D departments were responsible for the implementation of 66% of this link, the remaining 33% being connected to the Design, Production Engineering and Implementation Department. Once again, the main outputs were Verbal Advice/Provision of Information (66%) and Advisory Reports (33%). 66% of the firms considered this kind of link very important for the development of their activities.



- "Research contract" - 2 firms set up this type of link: one of them developed 2 projects and the other one 4 or more projects during the 2 year time period. 100% of the links were carried out by the R&D departments of the firms and also 100% of the activity resulted in Advisory Reports. In both cases, the number of scientists and engineers involved with the development of the projects varied between 11 and 20 from the University side. This link recorded the highest value for the firms: both companies (100%) considered their "Research contract" a crucial link in order to complement the firms' activities.

- "Joint research" - Only one company, developing one project, presented this linkage. Once again, the R&D department of the firm carried out the collaborative research, whose main result was Verbal Advice/Provision of Information (100%) and the employment of qualified scientists and engineers, from both University and firm, was around 6 to 10 researchers. The firm considered this collaborative research as providing a direct benefit for the development of its activities.

As with Informal and Human Resources links, the majority of the Formal links occurred with universities located on the United Kingdom. Once again, for all the links in this group, the main reasons for their establishment were the expertise and higher technical ability those institutions possessed in particular areas. Consequently, as one of the interviewees emphasised, the possibility the firms have in changing information and research and also complementing their internal R&D is higher with institutions attaining high levels of qualification.

5.2.2 - Comparison between Links: Host University and Other Universities

The present sub-section aims to compare the links that existed between the sample of firms located on the Surrey Research Park and the University of Surrey and other universities located elsewhere. Table 5.16 summarises these information considering the three categories of links: Informal links, Human Resources and Formal links.

Table 5.16 - On-Park firms and their Links with the Host University and with Other Universities

LINKS	Host University (n=21)	Other Universities (n=20)
Informal only	7	2
Human Resources only	1	1
Formal only		1
Informal + Human Resources	5	2
Informal + Formal	2	2
Informal + Human Resources + Formal	5	4
No links	1	8
Total	21	20

As the table shows, most of the on-Park firms investigated in this research set up links with both the host University (95% of the sample) and other universities located elsewhere (60% of the sample). However, 8 companies did not commit any link with other universities while only one company did not establish links with the host university. Two broad conclusions can be drawn from this comparison.

First, concerning the establishment of only one category of links at the same time, 38% (8 companies) of the on-Park firms established links with the host university while only 20% (4 companies) developed linkages with other universities located elsewhere.

Second, however, the differences between the number of firms that committed a multiple combination of links (Informal plus Human Resources links; Informal plus Formal links and Informal plus Human Resources plus Formal links) with the host university and other universities, at the same time, are not so accentuated. In fact, 57% of the firms (12 companies) established these multiple combination of links with the local university while 40% had the same combination with other universities. It is interesting to note that the last

combination presented practically the same results: 5 companies (24% of the sample) with the host university and 4 companies (20% of the sample) with other universities.

These results suggest that the geographical proximity between the partners - as that provided by Science Parks - facilitates mainly the establishment of Informal and Human Resources links. For Formal links, strongly connected with the research activity developed by universities, what influences their establishment are other factors, such as the academic expertise and technical ability the universities possess, and not their geographical closeness to the firms.

5.3 - Conclusion

This Chapter explored the links that existed between the sample of 21 firms located on the Surrey Research Park and their links with universities.

Section 5.1 dealt with the links established between firms and the local university. It was possible to observe that the majority of these links were of low frequency, low absorption of more qualified human resources and a small number of agreements or projects, usually undertaken on a short-term basis. It was also evident the crucial importance of firms' R&D departments in order to implement and operate any of the links with the local university. Also interesting is that the main outputs emerging from this set of linkages were related to Verbal Advice/Provision of Information and Advisory Reports. These kind of outputs stressed that the contribution of universities to the development of firms' activities have been essentially related to provision of information to complement the internal technological effort of firms and not to the generation of innovation to be commercialised in the market-place.

Complementing these information related to links established between on-Park firms and the local university, it was possible to observe that the links that required a less structured organisational approach for their establishment were those with a high possibility of being established previously to the location of the firms on the Park. However, these links were considered as not important for the development of the firms' activities and attributed to the Park, as a location, a low level of importance as well. In fact, as Chapter 4 already reported, the choice of the firms' location on the Park has been strongly motivated by aspects such as the environment of the region and the location and infrastructure offered by the Park and not by those more related to the university.

Section 5.2.1 explored the links established between the same sample of on-Park firms and other universities located elsewhere. The majority of findings that emerged from these links were very similar to those obtained through the links with the local university. The exception came from the Formal category of links. The number of firms engaged in these links with other universities, though presenting variations according to the different links, is quite similar to that related to the host university. However, the number of agreements or projects established with other universities was larger and the importance of these links to the development of the firms' activities achieved higher scores. It is also meaningful to re-emphasise the importance assumed by the firms' R&D department as a vehicle for the establishment of any link with other universities. These results proved, once more, that the interaction between firms and universities must be regarded as a complement - and not a substitute - to the internal R&D capacity of the firms.

The links established with other universities have been motivated by aspects such as the expertise and technical ability those institutions possessed in particular areas, increasing, in this way, the possibilities of research interaction and exchange of information. Evidence that emerged from the brief comparative analysis between the links established with the local university and other universities (sub-section 5.2.2) showed that the number of companies involved in only one category of links, at the same time, was higher with the



host university than with other universities. However, regarding the establishment of a multiple combination of links, at the same time, on-Park firms had a similar pattern of linkage with both the host university and other universities located elsewhere.

Concluding, the different perspectives and results concerning the links established between on-Park firms and the host university as well as with other universities explored in this Chapter did not confirm the expected improvement of links between university and firms through the geographical proximity as proposed by the Science Park mechanism.

The next Chapter looks at the key characteristics of firms that may influence the establishment of links between firms and universities.

CHAPTER 6 - FIRMS' CHARACTERISTICS AND THE LINKS

Chapter 4, in its sub-sections 4.2.3.1 and 4.2.3.2, described the general characteristics and the R&D activities of the sample of 21 firms located on the Surrey Research Park. Then, Chapter 5 described the links these companies have established with the host university and also with other universities located elsewhere during the period 1991-1993.

The present Chapter analyses the relationship between these two sets of information. It examines whether particular characteristics of these firms have had any influence on the establishment of their links with the host university.

The Chapter is structured in three sections. Section 6.1 identifies the firms' key characteristics that are examined and briefly describes the method of analysis. Then, section 6.2, divided in six small sub-sections, shows the results according to each characteristic of firms in relation to the establishment of links with universities. Finally, section 6.3 concludes the Chapter.

6.1 - Key characteristics of Firms and Method of Analysis

Chapter 2 presented some of the key characteristics of firms that have been perceived in the literature as affecting the establishment of links between firms and universities. Also, during the field-work, some other factors emerged as possible inducement to these linkages, but now more related to the fact that the sample of firms investigated in this research have been located on a Science Park environment. As a result, the characteristics that are considered for the present analysis are as follows.

- Firms' R&D Activity - This is defined here simply in terms of whether or not R&D activity exists within the firms' organisational structure.
- Firms' R&D Intensity - This is defined in terms of the firms' R&D staff as a proportion of the firms' total employment.
- Size of Firms - This is defined in terms of the firms' total employment.
- Sector of the Firms' Activities - This is defined by the productive sectors in which the on-Park firms have been engaged.
- Firms' Ownership Status - This is concerned to the classification of the firms according to their ownership: if they are independent companies or if they are a section/subsidiary of a larger firm not located on the Park's site.
- "Age" of Firms - This is defined in terms of the number of years the firms have been located on the Park.

The sample of firms considered in this study is small: 21 firms for links established with the host university and 20 firms for those set up with other universities located elsewhere (as was explained in Chapter 5, one of the companies that had links with other universities located elsewhere refused to answer this part of the questionnaire). The number and frequency of the links established between the firms with both the host university and other universities are also quite limited. This severely constrains the statistical rigour with which the data can be analysed. Initially, an effort was made to use complex multi-variate methods (mainly through the discriminant analysis) to examine the relationship between firms' characteristics and their links with the host university. This, however, proved to be either inappropriate or impractical given the nature of the data. Consequently, the Chapter relies entirely on simple cross-tabulation. Even here, formal statistical tests of the significance of

differences between sub-groups of the sample are, usually, meaningless and are not used. In fact, the specificity of the data generated through this research does not allow the application of these statistical tests without causing violation in several of their principles. The conclusions reached through the cross-tabulation are therefore more in the form of "explorations" than "tests" of hypotheses.

6.2 - The Results

The results emerging from the data analysis are presented in six small parts, all of them related to the links set up between on-Park firms and the host or other universities. Each of the following sub-sections has been structured according to the six key firms' characteristics outlined under section 6.1 above and takes into account the main categories of link as previously defined: Informal links, Human Resources links and Formal links.

6.2.1 - Firms' R&D Activity and Links

In Chapter 2, it was argued that firms, in their search for solution for technical problems or in their process of implementing an innovation, would access external sources of knowledge, information and/or technology, such as universities, in order to complement their internal R&D capability. Implicit in this argument lies the assumption that firms' R&D activity constitutes an important, if not essential, asset for those firms' external relationship with universities.

The review of literature concerning Science Parks and similar phenomena (Chapter 3) has also emphasised the importance of the presence of R&D activity for firms being located on Parks. In the case of Research Parks, such a characteristic has been pointed out as an essential attribute for firms if they want to apply for any Parks-room.

However, the results presented in the previous Chapter 4 indicated that only 13 out of 21 on-Park companies had full-time R&D activity; one company had part-time R&D activity and 7 other firms had no R&D activity. Chapter 5, therefore, stressed two important aspects: (i) the R&D departments of the on-Park firms were very often the point of contact (or absorption) for links with universities; (ii) even those firms without R&D activity were able to establish links with universities.

This section examines the relationship between links and firms' R&D activities more systematically.

Table 6.1 below refers to the number of firms committed to links with the host university. It presents the information according to the existence of R&D activity within the firms' organisational structure (14 firms), the lack of such activity (7 companies), as well as for the whole set of firms.

Table 6.1 - Firms with and without R&D Activity and Links with the Host University
(number of firms in each category)

LINKS	Firms with R&D Activity (n=14)	Firms without R&D Activity (n=7)	Total Number of Firms with and without R&D Activity in each Category of Link (n=21)
Informal	13 (92.8%)	06 (85.7%)	19 (90.5%)
Human Resources	09 (64.3%)	02 (28.6%)	11 (52.4%)
Formal	05 (35.7%)	02 (28.6%)	07 (33.3%)

Table 6.2 shows the same kind of information but related to the links established with other universities located elsewhere.



Table 6.2 - Firms with and without R&D Activity and Links with other Universities
(number of firms in each category)

LINKS	Firms with R&D Activity (n=13)	Firms without R&D Activity (n=7)	Total Number of Firms with and without R&D Activity in each Category of Link (n=20)
Informal	07 (53.8%)	03 (42.8%)	10 (50.0%)
Human Resources	05 (38.5%)	02 (28.6%)	07 (35.0%)
Formal	04 (30.7%)	03 (42.8%)	07 (35.0%)

Both groups of firm - with and without R&D activity - set up links with universities. However, the main observation to be made is that firms with R&D activity have, for all categories of links with the host university and for Informal and Human Resources links with other universities, a slightly higher propensity to establish links than firms without R&D activity. Then, the existence of R&D activity within firms facilitates the communication and exchange of knowledge and information between firms and universities.

The propensity of forging Formal links is higher for firms with R&D activity in relation to the host university than for those without such resource. However, in relation to Formal links and other universities, firms without R&D activity present a higher propensity of links than firms with R&D activity. A possible explanation for such result can be the fact that among these companies without R&D activity are those which are consultant companies. These firms would, for instance, intermediate research contracts between their clients and universities' research groups according to previous indication by the clients.

The information presented on Tables 6.1 and 6.2 above are interesting. However, tables like these may distort the picture because firms may have links in more than one category of link at the same time. Therefore, Tables 6.3 and 6.4 present the same type of data in a more disaggregated form.

Table 6.3 - Firms with and without R&D Activity and Links with the Host University -
Disaggregated information (number of firms in each category)

LINKS	Firms with R&D Activity	Firms without R&D Activity	Total Number of Firms
Informal	4	3	7
Human Resources	1	-	1
Formal	-	-	-
Inf+HResources	4	1	5
Inf+Formal	1	1	2
Inf+HR+Formal	4	1	5
No Link		1	1
Total	14	7	21

Regarding the links with the host university, Table 6.3 shows that the number of firms with and without R&D activity committed to only one category of link at the same time is similar (proportionally, 36% and 43% respectively). However, the proportion of firms involved in multiple links is very much higher among firms with R&D activity (64%) than among firms without R&D activity (42%).

Turning to the links established with other universities, Table 6.4 shows that only firms with R&D activity established links in only one category of link at the same time. However, the proportion of firms without R&D that set up a multiple combination of links, at the same time, is slightly higher than those with R&D activity (43% and 38% respectively). Also, the proportion of firms without R&D that did not have any link with other universities is much higher than those with R&D (4 firms in each case, but representing 57% among the firms without R&D and 31% among those with R&D).

Table 6.4 - Firms with and without R&D Activity and Links with other Universities -
Disaggregated information (number of firms in each category)

LINKS	Firms with R&D Activity	Firms without R&D Activity	Total Number of Firms
Informal	2	0	2
Human Resources	1	-	1
Formal	1	0	1
Inf+HRResources	2	-	2
Inf+Formal	1	1	2
Inf+HR+Formal	2	2	4
No Link	4	4	8
Total	13	7	20

The remarkable differences between the two groups of firm (with and without R&D activity) are that firms with R&D activity present a higher propensity of establishing a multiple combination of links, at the same time, with the host university and only a slightly lower propensity with other universities, than firms without R&D. Also, firms with R&D have a higher propensity of having only one type of link, at the same time, with other universities than firms without R&D; such propensity is slightly lower in relation to the host university.

In sum, the data suggest that the presence of R&D activity within firms constitute an important asset for the firms to set up links with universities, even though the absence of this resource within the firms' organisational structure does not undermine their possibilities of engaging themselves in these linkages.

6.2.2 - Firms' R&D Intensity and Links

The presentation of R&D activity intensity of firms carried out in this sub-section considers only the firms which had full-time R&D staff (13 firms in the case of links with the host

university and 12 firms in the case of links with other universities). The data shown through Tables 6.5 and 6.6 below are clustered according to two broad groups: firms in which the number of R&D staff is 50% or less of their total employment and those for which such staff represents 51% or more of their total employees.

Table 6.5 - Firms R&D Intensity and Links with the Host University
(number of firms in each category)

LINKS	R&D Staff: 50% or less of Firms' Total Employment (n=5)	R&D Staff: 51% or more of Firms' Total Employment (n= 8)	Total Number of Firms (n=13)
Informal	05 (100.0%)	07 (87.5%)	12 (92.3%)
Human Resources	05 (100.0%)	04 (50.0%)	09 (69.2%)
Formal	03 (60.0%)	02 (25.0%)	05 (38.4%)

Table 6.6 - Firms R&D Intensity and Links with other Universities
(number of firms in each category)

LINKS	R&D Staff: 50% or less of Firms' Total Employment (n=4)	R&D Staff: 51% or more of Firms' Total Employment (n= 8)	Total Number of Firms (n=12)
Informal	03 (75.0%)	04 (50.0%)	07 (58.3%)
Human Resources	02 (50.0%)	03 (37.5%)	05 (41.6%)
Formal	02 (50.0%)	02 (25.0%)	04 (33.3%)

As the tables show, firms with 50% or less of their total employment engaged in R&D activity present a higher propensity of establishing linkages, in all categories, with both the host university and other universities, than those firms with 51% or more of their total employment involved in the same activity. In fact, the differences are more pronounced in relation to the links established with the host university: in this case, firms with a lower R&D activity intensity have set up twice or more Human Resources and Formal links than companies presenting a higher R&D activity intensity.

However, these figures may distort the picture for 2 reasons. First because firms may have links in more than one category of link at the same time. Second because the number of firms considered in the analysis is quite small, mainly in relation to those firms presenting a lower R&D activity intensity (R&D staff represents 50% or less of the total employment of firms). The presentation of data in a more disaggregated form may shed some light on this matter.

Table 6.7 - Firms R&D Intensity and Links with the Host University - Disaggregated Information (number of firms in each category)

LINKS	R&D Staff: 50% or less of Firms' Total Employment	R&D Staff: 51% or more of Firms' Total Employment	Total Number of Firms
Informal	-	3	3
Human Resources	-	1	1
Formal	-	-	-
Inf+HResources	2	2	4
Inf+Formal	-	1	1
Inf+HR+Formal	3	1	4
Total	5	8	13

Table 6.7 above shows that firms with higher R&D intensity present a higher propensity of forging only one category of link with the host university, at the same time, in contrast to the group of firms with lower R&D intensity (50% and 0% respectively). However, the propensity of establishing multiple links at the same time is more accentuated for firms with a lower R&D activity intensity than for the other group of firms (100% and 50% respectively). For instance, firms with a lower intensity of R&D activity had three times as many Informal plus Human Resources plus Formal links than those firms with a higher R&D activity intensity.

Regarding to the links with other universities, both groups of firms (with higher and lower R&D intensity) followed a similar pattern of linkages than that with the host university, as shown in Table 6.8 below.

Table 6.8 - Firms R&D intensity and Links with other Universities - Disaggregated Information (number of firms in each category)

LINKS	R&D Staff: 50% or less of Firms' Total Employment	R&D Staff: 51% or more of Firms' Total Employment	Total Number of Firms
Informal	1	1	2
Human Resources		1	1
Formal		1	1
Inf+HResources	1	1	2
Inf+Formal	1		1
Inf+HR+Formal	1	1	2
No links	1	2	3
Total	5	7	12

Thus, on the one hand, the existence of R&D activity within the organisational structure of firms does seem to be important. But the intensity of R&D undertaken by the companies does not. Indeed, some data about the firms' R&D intensity would indicate that less intensive R&D firms may be more closely linked to the host university.

6.2.3 - Size of Firms and Links

As explained in Chapter 2, empirical evidence relating size of firms and the establishment of links with academe has suggested that the larger the companies, the higher their propensity of linkages with universities. In addition, the literature concerning Science Parks (Chapter 3) has stressed that a substantial proportion of firms located on Science Parks is made up of



small or very small firms. It would be added that, in some cases, on-Park firms are so small that they could be named as "atomic" firms.

This sub-section investigates the influence of size of firms on the establishment of links with both the host university and other universities located elsewhere. The sample of firms is clustered in two broad groups, according to their total number of employees: smaller firms are those with 10 or less employees and larger firms are those with 11 or more employees. Tables 6.9 and 6.10 summarise the main findings for both links with the local university and other universities.

Table 6.9 - Size of Firms and Links with the Host University
(number of firms in each category)

LINKS	Smaller Firms (n=9)	Larger Firms (n=12)	Total Number of Firms (n=21)
Informal	08 (88.8%)	11 (91.6%)	19 (90.5%)
Human Resources	04 (44.4%)	07 (58.3%)	11 (52.4%)
Formal	02 (22.2%)	05 (41.6%)	07 (33.3%)

Table 6.10 - Size of Firms and Links with other Universities
(number of firms in each category)

LINKS	Smaller Firms (n=9)	Larger Firms (n=11)	Total Number of Firms (n=20)
Informal	05 (55.5%)	05 (45.4%)	10 (50.0%)
Human Resources	02 (22.2%)	05 (45.4%)	07 (35.0%)
Formal	01 (11.1%)	06 (54.5%)	07 (35.0%)

The results presented in both tables confirm those previously achieved through former studies: the group of larger firms present a higher propensity of setting up links, in almost all the categories, with both the host university and others, than the group of smaller firms. The only exception concerns the establishment of Informal links with other universities: smaller firms have presented a slightly higher propensity for those links than the larger ones.

Particularly concerning the establishment of Formal links, larger firms are almost twice as likely as smaller firms to have these links with the host university; and they were almost four times as likely to have Formal links with other universities.

Data in a disaggregated form, as in Tables 6.11 and 6.12, confirm the previous observation. Regarding the links with the host university (Table 6.11), in both cases - establishment of only one type of link or a multiple combination of links, at the same time - larger firms have a higher propensity of linkages than smaller companies (only one link at the same time: 42% and 33%; multiple links: 58% and 55%). This is particularly evident in relation to Informal plus Human Resources plus Formal links in which larger firms scored 4 against 1 smaller company (or 33% and 11% respectively).

Table 6.11 - Size of Firms and Links with the Host University - Disaggregated information (number of firms in each category)

LINKS	Smaller Firms	Larger Firms	Total Number of Firms
Informal	3	4	7
Human Resources	-	1	1
Formal	-	-	-
Inf+HResources	3	2	5
Inf+Formal	1	1	2
Inf+HR+Formal	1	4	5
No Link	1	-	1
Total	9	12	21

Regarding the links with other universities, Table 6.12 shows that the number of firms that did not forge any link is the same (4 companies in each case, representing 44.5% of the group of smaller companies and 36% of the group of larger firms). When the firms set up links, larger firms have a higher propensity of establishing a multiple combination of links, at the same time, than smaller ones (45% and 33% respectively). Smaller firms have,

however, a slightly higher propensity of setting up only one category of link, at the same time, than the larger ones (22% and 18% respectively).

Table 6.12 - Size of Firms and Links with other Universities - Disaggregated Information (number of firms in each category)

LINKS	Smaller Firms	Larger Firms	Total Number of Firms
Informal	2		2
Human Resources		1	1
Formal		1	1
Inf+HResources	2		2
Inf+Formal	1	1	2
Inf+HR+Formal		4	4
No Link	4	4	8
Total	9	11	20

A possible explanation for these results is that larger firms would be more likely than the smaller ones to have R&D department and the "size-effect" suggested here is actually connected with an "R&D effect". In order to check this explanation, Table 6.13 presents disaggregated information about the establishment of links with the host university and size and R&D activity of firms.

As the Table shows, the number of firms committed to Informal links only has been similar for both larger and smaller firms, with and without R&D activity. However, differences appear when multiple combination of links is observed. The number of smaller firms with R&D activity engaged in Informal plus Human Resources links is higher than that of larger firms (with or without R&D activity). However, the proportion of larger firms with R&D activity that have established Informal plus Human Resources plus Formal links is substantially

higher than that presented by the group of smaller firms with R&D activity (37.5% and 16% respectively).

Table 6.13 - Size of Firms plus R&D Activity and Links with the Host University
(number of firms in each category)

LINKS	Larger Firms with R&D Activity	Larger Firms without R&D Activity	Smaller Firms with R&D Activity	Smaller Firms without R&D Activity	Total Number of Firms
Informal	2	2	2	1	7
Human Resources	1	-	-	-	1
Formal	-	-	-	-	-
Inf+HResourc	1	1	3		5
Inf+Formal	1	-	-	1	2
Inf+HR+Form	3	1	1	-	5
No Link	-	-	-	1	1
Total	8	4	6	3	21

In sum, this set of data concerning size of firms and its influence on the establishment of links with universities do confirm previous studies in this area: larger firms have had a higher propensity of linkages than smaller ones. However, it should be added that the fact that larger firms have also shown a higher possibility of having a R&D department in their organisational structure, covering a broad portfolio of research, do increase their propensity of links with universities (mainly those related to the group of Formal links).

6.2.4 - Firms' Productive Sector and Links

Another very important characteristic of firms that can influence their interaction with universities is the productive sectors they are engaged. Chapter 2 also explored this topic and, in general, it has been argued that firms operating in the so-called "high-technology"

sectors are more prone to attract the interest of academics. Also, as Chapter 3 reported, Science Parks have been notoriously famous for housing in their space this kind of firms.

For the present analysis, the firms were clustered into only two broad groups: those involved in Information and Communication Technology (ICT) and those involved in other industrial products and service sectors. The ICT group includes those firms whose activities are related to communication, computer hardware and software and other electronics-related products, commonly associated to "high-tech" productive sectors. The "Industrial" group includes other industrial products and energy-related products, such as chemical, mechanical, geotechnical sectors - commonly associated to "traditional" productive sectors, and services, such as consultancy and administrative boards.

Tables 6.14 and 6.15 present the main finding concerning the establishment of links with the local university and other universities according to these broad groups of productive sector.

Table 6.14 - Productive Sectors of Firms and Links with the Host University
(number of firms in each category)

LINKS	ICT (n=10)	Other Industrial (n=11)	Total Number of Firms (n=21)
Informal	09 (90.0%)	10 (90.9%)	19 (90.5%)
Human Resources	05 (50.0%)	06 (54.5%)	11 (52.4%)
Formal	02 (20.0%)	05 (45.4%)	07 (33.3%)

Table 6.15 - Productive Sectors of Firms and Links with other Universities
(number of firms in each category)

LINKS	ICT (n=10)	Other Industrial (n=10)	Total Number of Firms (n=20)
Informal	03 (30.0%)	07 (70.0%)	10 (50.0%)
Human Resources	02 (20.0%)	05 (50.0%)	07 (35.0%)
Formal	02 (20.0%)	05 (50.0%)	07 (35.0%)



These Tables show that firms dealing with other industrial products and services have presented a higher propensity of forging all types of link with both the host university and other universities than the ICT companies. Regarding the host university, a more accentuated difference appears in relation to Formal links whose propensity of linkage is more than twice as high for firms in other industrial sectors and services than for those in ICT sectors. For links with other universities, firms in other industrial sectors have also presented a propensity of linkage more than twice as higher than ICT firms but for all types of links.

It is interesting to check this pattern of linkages through more disaggregated information. Table 6.16 present these information in relation to the host university. The number of ICT firms committed to the establishment of only Informal or only Human Resources links is higher than that of firms in other industrial sectors. However, information related to the forging of multiple links, at the same time, show that the proportion of firms in other industrial sectors have committed much more combined links than the other group of firms (72% and 40% respectively).

Table 6.16 - Productive Sectors of Firms and Links with the Host University - Disaggregated Information (number of firms in each category)

LINKS	ICT	Other Industrial	Total Number of Firms
Informal	5	2	7
Human Resources	1	-	1
Formal	-	-	-
Inf+HResources	2	3	5
Inf+Formal	-	2	2
Inf+HR+Formal	2	3	5
No Link	-	1	1
Total	10	11	21

Table 6.17 refers to the links with other universities. Again, the proportion of firms dealing with other industrial sectors and services engaged in multiple establishment of links, at the same time, is substantially higher (60%) than that of ICT companies (20%), mainly concerning the combination of Informal plus Human Resources plus Formal links. For the establishment of only one kind of link at the same time, ICT companies presented a higher propensity of linkages (30%) than the other group of firms (10%). Also, the proportion of ICT companies that did not establish links with other universities is higher than that in other industrial sectors (50% and 30% respectively).

Table 6.17 - Productive Sectors of Firms and Links with other Universities - Disaggregated Information (number of firms in each category)

LINKS	ICT	Other Industrial	Total Number of Firms
Informal	1	1	2
Human Resources	1		1
Formal	1		1
Inf+HResources	1	1	2
Inf+Formal	1	1	2
Inf+HR+Formal		4	4
No Link	5	3	8
Total	10	10	20

A possible explanation for these results is that firms involved with other industrial products and services would be more likely than the ICT ones to have R&D department and the "product-effect" suggested here is actually connected with an "R&D effect". In order to check this explanation, Table 6.18 shows disaggregated information about the establishment of links with the host university and productive sector and R&D activity of firms.

Table 6.18 - Productive Sectors and R&D Activity of Firms and Links with the Host University - Disaggregated Information (number of firms in each category)

LINKS	ICT with R&D Activity	ICT without R&D Activity	Other Industrial with R&D Activity	Other Industrial without R&D Activity	Total Number of Firms
Informal	3	2	1	1	7
Human Resources	1	-	-	-	1
Formal	-	-	-	-	-
Inf+HResourc	1	1	3		5
Inf+Formal	-	-	1	1	2
Inf+HR+Form	2	-	2	1	5
No Link	-	-	-	1	1
Total	7	3	7	4	21

The proportion of ICT companies, with and without R&D activity, committed to the establishment of only one category of link at the same time (57% and 66% respectively) is much higher than that of firms in other industrial sectors and services (14% and 25% respectively). Now, looking at the establishment of multiple links at the same time, both groups of firms with R&D activity presented a higher proportion of linkages than those without such a resource. However, the proportion of firms with multiple links is very much higher among other industrial and services firms with R&D activity (86%) than among ICT firms with R&D activity (43%).

In sum, this set of data related to the productive sector of firms and its influence on the establishment of links with universities do suggest that the companies engaged in other industrial sectors and services have presented a higher propensity of establishing multiple linkages, at the same time, with universities than companies linked to the ICT sector. The presence of R&D activity within the firms' organisational structure do increase the propensity of both groups of firms in establishing links with universities, especially among

Table 6.20 - Status of Firms and Links with other Universities
(number of firms in each category)

LINKS	Independent Firms (n=8)	Section/Subsidiaries (n=12)	Total Number of Firms (n=20)
Informal	02 (25.0%)	08 (66.6%)	10 (50.0%)
Human Resources	02 (25.0%)	05 (41.6%)	7 (35.0%)
Formal	02 (25.0%)	05 (41.6%)	7 (35.0%)

These Tables show that the group of sections/subsidiaries of firms have had a higher propensity of establishing all types of links with both the host and other universities than the group of independent companies. Particularly related to the establishment of links with the host university, independent firms did not set up any Formal link and had Human Resources links in a much lower proportion than the other group of firms.

Table 6.21 below presents disaggregated information about firms and their links with the host university.

Table 6.21 - Status of firms and Links with the Host University - Disaggregated Information
(number of firms in each category)

LINKS	Independent	Section/Subsid	Total Number of Firms
Informal	5	2	7
Human Resources	1	-	1
Formal	-	-	-
Inf+HResources	1	4	5
Inf+Formal	-	2	2
Inf+HR+Formal	-	5	5
No Link	1	-	1
Total	8	13	21

It is interesting to note that the group of independent companies present a much higher propensity of establishing only one type of link at the same time (mainly those related to Informal links) than the group of sections/subsidiaries companies (75% and 15% respectively). On the other hand, the group of firms that is made of sections/subsidiaries of firms has been much more concentrated on the establishment of multiple combination of links at the same time, than the group of independent companies (85% and 12/5% respectively).

Table 6.22 - Status of Firms and Links with other Universities - Disaggregated Information (number of firms in each category)

LINKS	Independent	Sections/Subsid	Total Number of Firms
Informal	1	1	2
Human Resources	1	-	1
Formal	1	-	1
Inf+HResources	-	2	2
Inf+Formal	-	2	2
Inf+HR+Formal	1	3	4
No Link	4	4	8
Total	8	12	20

Related to the links with other universities, Table 6.22 above shows the same pattern of linkages than those forged with the local university. Though the number of firms in each group that did not have links with other universities is the same (4 companies in each group), the group made of sections/subsidiaries of companies have had a much higher propensity of setting up a multiple combination of links, at the same time, than the group of independent companies (58.5% and 12.5% respectively). On the other hand, the group of independent companies have presented a much higher propensity of linkages in each category of links separately than the other group of firms (37.5% and 8.5% respectively).

Through this set of information, it is evident that the group of firms which are sections or subsidiaries of other companies have had a higher propensity of linkages with both the local university and other universities than the group of independent companies, mainly in relation to the establishment of multiple combination of links.

6.2.6 - "Age" of Firms and Links

The last firms' characteristics to be studied in this Chapter refers to the "age" of companies or the number of years the firms have been located on the Park. The present analysis considers two broad groups of firm: those which have been located on the Park for three years or less and those for which this period exceeds three years.

Table 6.23 - Age of Firms and Links with the Host University
(number of firms in each category)

LINKS	3 Years or less (n=10)	more than 3 Years (n=11)	Total Number of Firms (n=21)
Informal	09 (90.0%)	10 (90.9%)	19 (90.4%)
Human Resources	05 (50.0%)	06 (54.0%)	11 (52.4%)
Formal	03 (30.0%)	04 (36.0%)	07 (33.3%)

Table 6.23 above shows that both groups of firms have had a very similar propensity of establishing links with the local university in all categories of link. Data in a more disaggregated form, as in Table 6.24 below, confirm such a tendency. Firms which have been located on the Park for three years or less have a slightly higher propensity of forging a multiple combination of links with the host university, at the same time, than those located on the Park for more than three years (60% and 54% respectively). On the other hand, firms that have been on the Park for more than three years present a slightly higher propensity of setting up links in one category, at the same time, than the group of "younger" firms (45% and 30% respectively).

Table 6.24 - Age of Firms and Links with the Host University - Disaggregated Information
(number of firms in each category)

LINKS	3 Years or less	more than 3 Years	Total Number of Firms
Informal	3	4	7
Human Resources	-	1	1
Formal	-	-	-
Inf+HResources	3	2	5
Inf+Formal	1	1	2
Inf+HR+Formal	2	3	5
No Link	1	-	1
Total	10	11	21

In fact, the expectation that the longer a company is located on the Park, the higher their propensity of forging links with local university does not correspond to the reality. Both sets of firms present very similar pattern of interaction with the host university.

6.3 - Conclusion

This Chapter focused on an important aspect of the establishment of links between companies and academe: that related to the influence particular characteristics of the on-Park firms would have on the establishment of their links with universities. In this context, it was examined the following firms features: R&D activity, R&D intensity, size, productive sectors, status and age of firms.

The analysis of these aspects was based on simple cross-tabulation because the application of formal statistical tests would be impractical with such a small sample of firms.

As a consequence, the results, summarised below, must be understood much more within the limits of "explorations" than "tests" of hypothesis.

The main findings that emerged from this analysis are as follows.

- Firms' R&D activity - Firms with R&D activity presented a higher propensity of linkages in almost all the categories of link, with both the host university and other universities, than firms without this activity. The exception came through the firms without R&D activity that presented a higher propensity of forging Formal links with other universities. However, as was explained, such a result seems to be more related to the kind of activity developed by these firms than to the existence of R&D activity within their internal organisational structure.
- Firms' R&D intensity - Among the firms with full-time R&D staff, those with more than 51% of their total employment engaged in R&D activities presented a higher propensity of establishing only Informal and Human Resources links with the host university than those companies with less than 50% of their total employment committed to R&D activities. However, firms with a less intense R&D activity had a higher propensity of establishing multiple linkages, at the same time, with the host university than those more R&D intensive. Links with other universities presented the same pattern of linkage.
- Size of Firms - Smaller firms (10 or less employees) tended to have a lower propensity of linkages, with both the host university and other universities, than larger firms (11 or more employees). This is particularly evident for the establishment of Formal links. When the R&D activity of firms is added to this analysis, the results are, once more, confirmed. If smaller firms with R&D activity had a higher propensity of establishing Informal and Human Resources with the host university, larger firms with R&D activity had a higher propensity of forging Formal links with the local university.

- Firms' Productive Sector - Regarding the establishment of links with both the host and other universities, firms involved in ICT related-sectors had a higher propensity of establishing Informal and Human Resources links than firms dealing with other industrial and services sectors. Firms in other Industrial sectors and services had, however, a higher propensity of forging a multiple combination of links than the ICT group of firms. When the R&D activity of firms is added to this analysis, the results are: both groups of firms with R&D activity had a higher propensity of linkages with the host university than those without R&D activity. Moreover, firms engaged in other Industrial sectors and services and with R&D activity had a much higher propensity of combined links than those of ICT related-sectors.

- Status of Firms - Sections or subsidiaries of firms had a higher propensity of setting up multiple links, with both the host university and other universities, than independent companies. On the other hand, independent firms had a higher propensity of having only one category of link, at the same time, with both the host and other universities.

- Age of Firms - The expectation that the longer a firm is located on a Park, the higher its propensity of establishing links with the host university is not confirmed through this research. Both groups of firms - those that have been located on the Park for three years or less or more than three years - presented a very similar pattern of linkages with the host university.

As this analysis showed, each characteristic of the firms have presented some kind of influence on the pattern of linkages between firms and universities. However, the analysis does emphasise the importance of firms' R&D activity for the establishment of links with academe. Also larger firms as well as sections/subsidiaries of larger firms seem to be more prepared to forge links with universities than smaller independent companies. Concerning the firms' productive sector, those involved with other industrial and services sectors - rather than ICT related-fields - also showed potential for linkages with universities.



CHAPTER 7 - LINKS BETWEEN THE RESEARCHERS FROM THE UNIVERSITY OF SURREY AND THE FIRMS

The previous Chapters 5 and 6 dealt with the firms' side of the interaction between university and industry in Science Parks. Initially, Chapter 5 focused on the links that existed between the sample of 21 firms located on the Surrey Research Park and both the host university (University of Surrey) and other universities. Chapter 6 explored the firms' key characteristics that influenced the existence and strengths of such relationships.

Although the present Chapter follows a similar structure as that adopted in Chapter 5, it is related to the university's side of the University-Industry interaction, emphasising its more visible part: the individual researcher. The main objectives here are to explore and describe, in as much detail as possible, the links that existed between a sample of individual researchers from the University of Surrey and firms located on the Surrey Research Park as well as other firms located elsewhere. Besides some comparative analysis, these data allow further examination of the argument that geographical proximity is an important factor influencing the interaction between university and industry.

Making use of the taxonomy of links developed in Chapter 4 (sub-section 4.1.3), this Chapter is divided in four sections. Section 7.1 presents background information about the sample of individual researchers who took part of this study, exploring aspects such as their departments, first degree, degree of qualification and activities.

Section 7.2 deals with the links that this group of researchers had with firms located on the Surrey Research Park during the period between 1991 and 1993, seeking, initially, to describe the general characteristics of the firms and then focusing attention on the key features of their interaction.

Section 7.3 follows a similar path as that adopted in the previous section, but now looking at the links that existed between the same sample of researchers and other firms located elsewhere. The section thus makes a comparative analysis between the links established between the researchers and both set of firms (on-Park firms and other firms).

Finally, section 7.4 concludes the Chapter.

7.1 - Background Information about the Researchers

The field work involving the researchers from the University of Surrey was undertaken between August and September of 1993. It is important to note that the selection of the researchers was driven by the following steps:

(1) The researchers were selected from two Faculties of the University of Surrey: Faculty of Engineering (Departments of Chemical and Process Engineering, Electrical and Electronic Engineering and Materials Sciences and Engineering) and Faculty of Science (Department of Physics). The choice of these Faculties/Departments was based on information provided by the sample of firms located on the Surrey Research Park taking into account the University's units with which they had contacts. Also, official information from the University Register of Current Research related to the number of research projects undertaken by each Department during the period of 1989 and 1991 helped their selection. Thus, the selection of Faculties/Departments is almost certainly biased towards those with stronger links to firms on and off the local Science Park.

(2) The researchers from the Chemical and Process Engineering Department were indicated by the Head of that Department. The researchers from the other Departments were initially selected from a detailed list of the University of Surrey's staff (University of Surrey, Calendar, 1992-1993), according to two basic criteria: their degree of qualification

(PhD) and their relatively senior position within their Departments (Lecturer position or above). Thus the selection of researchers is almost certainly biased towards those with higher possibilities of establishing links with industry.

(3) The interviews were finally conducted with the researchers that, detaining a PhD qualification (except for one researcher) and at least Senior Research Fellow position within their Departments, were also available to be interviewed at the time of the field work. It is worth mentioning that the access to the researchers from the Department of Materials Science and Engineering presented some difficulties due to the lack of time of their researchers as a result of their undertaking activities outside teaching and research.

Table 7.1 presents information about the sample of researchers from the University of Surrey that took part in this study.

Table 7.1 - Sample of Researchers: Faculty of Engineering and Faculty of Science
Population and Sample of Researchers

FACULTIES/DEPARTMENTS	Sample of Researchers	Proportion of the Sample of Researchers in relation to their Departments' staff - Senior Research Fellow position or above	Proportion of the Sample of Researchers in relation to their Departments' total staff
Faculty of Engineering			
Chemical and Process Engineering Dept.	4	26.6%	15.4%
Electronic and Electrical Engineering Dept.	5	9.3%	6.0%
Materials Science and Engineering Dept.	1	8.3%	4.3%
Sub-total 1	10	12.3%	7.5%
Faculty of Science			
Physics Dept.	6	26.1%	14.3%
Sub-total 2	6	26.1%	14.3%
Total Sample of Researchers	16	13.9%	9.1%

In addition to the researchers, some interviews were conducted with Deans of Faculties (Faculty of Science and Faculty of Engineering) and Heads of Departments (Chemical and Process Engineering and Physics) aiming to assess specific policies of their Departments/Faculties concerning their activities with industries. However, such meetings did not add substantial information beyond that provided by the Business Development Office. Links with industry were considered natural, and even essential, for Engineering Departments and rather more circumstantial for the Department of Physics. The Deans/Heads of these Faculties/Departments considered their units as presenting a proactive attitude concerning the interaction with industry.

Faculties/Departments

Ten researchers (62.5% of the sample of 16 researchers) came from the Faculty of Engineering, representing three of its Departments: Department of Chemical and Process Engineering (4 researchers or 25% of the total sample), Department of Electronic and Electrical Engineering (5 researchers or 31.25% of the total sample) and Department of Materials Science and Engineering (1 researcher or 6.25% of the sample). The remaining 6 researchers (37.5% of the sample) were from the Department of Physics, part of the Faculty of Science.

Researchers' First Degree

The sample of researchers was made up of 44% who had graduated in Engineering; 38% in Physics; 6% in Applied Chemistry and another 6% in Mathematics. The remaining 6% had obtained a BSc in Technology. Also, 81% of the researchers opted for completing their graduation in British Universities. The year of their graduation suggests a reasonable level of seniority of the sample: 31% of the researchers graduated before 1960; another 31% between 1961 and 1970; 32% between 1971 and 1980 and only 6% after 1981.

Researchers' Degree of Qualifications

In this respect, the group of researchers was quite homogeneous because 81% of them held the title of PhD; and 13% held the DSc title. Only 6% of the interviewees in this study did not have a PhD qualification. Also, 94% of such titles were granted by British Universities.

Researchers' Position in the Departments

45% of the researchers were admitted into their Departments between 1981 and 1990, another 31% had been there since 1971 and 25% before 1970. Regarding their position within their Departments, the sample was composed of 6% that were Deans, 12% Professors, 25% Readers, 25% Senior Lecturers, 19% Lecturers and 12% Senior Research Fellows.

Researchers' Activities

Table 7.2 describes the activities developed by this group of researchers within their University Departments. All of them were highly involved with activities such as supervision (81%), teaching for undergraduates (75%) and applied research (75%). Also basic research (56%) and teaching for post-graduates (56%) achieved a reasonable score. 50% of the researchers had some Consultancy activity and 31% of them developed research classified as strategic research. Among the activities included in "Other Activities", administration was the one which absorbed the highest proportion of the researchers' time - 75% of the interviewees were involved in some kind of activity linked to administrative or bureaucratic functions, sometimes consuming 80% of their time.

Table 7.2 - Researchers' Activities within their Departments

ACTIVITIES	% of Researchers undertaking the activities (n=16)
Supervision	81
Teaching (Undergraduate)	75
Applied Research	75
Teaching (Post-graduate)	56
Basic Research	56
Consultancy	50
Strategic Research	31
Other (Administrative and bureaucratic activities)	75

7.2 - Links between the Researchers and Firms located on the Surrey Research Park

Table 7.3 summarises the links that existed between the sample of researchers and firms located on the Surrey Research Park. As the Table shows, 50% of the researchers kept some kind of links with the on-Park firms: 44% of them were committed to Informal links; another 44% engaged in Human Resources links and finally, 31% were involved in Formal links.

Table 7.3 - Links between the Researchers and on-Park Firms

LINKS	No. of Researchers (n=16)	% of Researchers (n=16=100%)
Any Links	8	50
Informal Links	7	44
Human Resources Links	7	44
Formal Links	5	31

In order to complement the information on Table 7.3, Table 7.4 considers the same links but now distinguished according to each group of researchers (engineers and physicists)

separately. The Table shows that researchers from the Physics Department attained a slightly higher level of linkage with the on-Park firms, mainly related to the establishment of Informal and Human Resources links, than their colleagues from the Faculty of Engineering. An explanation for the inter-group differences is the existence of a spin-off company from the Department of Physics located on the Surrey Research Park. The physicists have had extensive links with that company during the years of 1991-1993, such linkages being based mainly on friendship and not necessarily involving the payment of fees.

Table 7.4 - Links between each Group of Researchers and on-Park firms

LINKS	Engineers (n=10)	Physicists (n=6)
Any Link	4 (40%)	4 (67%)
Informal Links	3 (30%)	4 (67%)
Human Resources Links	4 (40%)	3 (50%)
Formal Links	3 (30%)	2 (33%)

The description of the data will be introduced following a similar pattern to that adopted in Chapter 5, namely: the interaction of the researchers and the on-Park firms through Informal links (sub-section 7.2.1), followed by Human Resources links (sub-section 7.2.2) and finally, Formal links (sub-section 7.2.3). These sub-sections explore the general characteristics of the firms with which the sample of researchers had contact as well as the more significant aspects of their linkages: their frequency, or intensity, the firms' departments involved in these links and their outputs. Sub-section 7.2.4 deals with three other aspects of the relationship between the researchers and the on-Park firms: the pre-existence of links with these companies before their establishment on the Surrey Research Park, the importance of these links for the development of the researchers' activities as well as the importance of the Park in fostering these links.

7.2.1 - Informal Links

As Table 7.5 shows, 7 researchers (44% of the total sample), were committed to Informal links with on-Park firms. All of this sub-group (7 researchers) carried out "Personal contact with industrial staff". Engineers attained higher participation rates than their colleagues from the Department of Physics, except for "Access to industrial equipment", where engineers had no contact. Only one link was added to the list of Informal links presented to the researchers: attendance at seminars, which was restricted to one physicist.

Table 7.5 - Researchers engaged in Informal Links with the Host University

LINKS	No. of Researchers	% of Researchers
Any Informal Link	7	100
Personal contact with industrial staff	7	100
Access to specialised technical reports	4	57
Access to industrial R&D	3	43
Small donation of gifts or capital to research	3	43
Access to industrial equipment	2	29

The majority of Informal links occurred between the researcher and only one on-Park company. A high proportion of these links were developed with small independent firms (25 or less employees) within both the ICT productive sector (mainly computer related software/hardware) and other industrial products and services sector (mainly medical/health related products and services). However, to a small degree, some large firms, represented by subsidiaries of British companies, were also represented in these interactions.

Table 7.6 presents the main findings related to the frequency, the firms' departments involvement and the outputs of Informal links established between the researchers and on-Park firms.

Table 7.6 - Informal Links established between researchers and on-Park firms: their frequency, firms' departments and outputs

Informal Links	No. of Links	Frequency	Firms' Department	Outputs
Personal contact with industrial staff	7	Low (72%)	R&D (72%)	VA/PI (72%)
Access to specialised technical reports	4	Low (100%)	R&D (75%)	VA/PI (100%)
Access to industrial R&D	3	Low (100%)	R&D (67%)	VA/PI (100%)
Small donation of gifts or capital to research	3	Low (100%)	R&D (100%)	VA/PI (33%)
Access to industrial equipment	2	Low (100%)	R&D (50%)	VA/PI (100%)

Categories: - **Frequency** **Low Frequency** links occurring around 3 - 6 times a year or less frequently
Medium Frequency links occurring about once a month
High Frequency links occurring about once a week or more frequently

Firms' Dept. **R&D** Research and Development
D&PE Design, Production Engineering and Implementation
P&M Production and Manufacturing
S&D Sales and Distribution
Other Other firms' departments

Output **VA/PI** Verbal Advise/Provision of Information
AR Advisory Report
PP Implementation of a Particular Programme
DS/Pr Design Specification /Prototype
Other Any other output

Almost all of Informal links were of "low frequency", with an occurrence of around 3 - 6 times a year or less. The only exception came from "Personal contact with industrial staff": although 72% of such links also occurred in such a low frequency, 28% of them presented medium or high frequency levels (14% for each level) meaning that they happened respectively about once a month or about once a week or more frequently.

The researchers had been mostly involved with the firms' R&D departments in this group of links. Their participation ranged from 50% ("Access to industrial equipment") to 100% ("Small donation of gifts or capital to research"). The other department also quoted by the interviewees was Design, Production Engineering and Implementation, whose participation was focused on "Personal contact with industrial staff" (28%), "Access to specialised technical reports" (25%) and "Access to industrial R&D" (33%).

The primary output originating from Informal links was Verbal Advise/Provision of Information for all the links. Besides such an output, both "Personal contact with industrial staff" and "Small donation of gifts or capital to research" links produced as a result Design Specification/Prototypes (28% and 33% respectively). The only link presenting Advisory Report/Publications as an output was "Small donation of gifts or capital to research" (33%).

Among the reasons the researchers had in carrying out Informal links with on-Park companies were found friendship with people in the companies, and the necessity of improvement and exploration, in a practical way, of their knowledge in specific areas.

7.2.2 - Human Resources Links

44% of the total sample, or 7 of the researchers investigated in this study, were committed to one of the Human Resources links. As Table 7.7 shows, 71% of this sub-group (5 researchers) had "Students involvement in industrial projects", 3 of them being from the Department of Physics. The other Human Resources links were carried out exclusively by

engineers whose participation was limited to one researcher (or 14% of the sub-group) for each link. Also, only one link was added to the list previously presented to the interviewees - advisory presentation of courses - being developed by only one engineer.

Table 7.7 - Researchers engaged in Human Resources Links with the Host University

LINKS	No. of Researchers	% of Researchers
Any Human Resources Links	7	100
Students involvement in industrial projects	5	71
Industrial fellowships	1	14
Short-term internship in industry	1	14
Formally organised training programmes for industrial personnel	1	14

Researchers generally developed only one project with only one on-Park company during the period between 1991-1993. The exception was found in "Students involvement in industrial projects" link which involved 2 projects for 60% of linkages during the same period of time. This higher scores could be explained by the nature of that link: it had usually involved undergraduate students and their need for a training period in firms as part of their graduation requirements at the University of Surrey.

Table 7.8 presents data concerning the frequency, firms' departments and outputs of Human Resources links established between the researchers and on-Park firms.

As the Table shows, most of the links in this category of Human Resources links presented a high frequency of occurrence, were carried out through the firms' R&D department and generated as the main output Verbal Advise/Provision of Information. The exception is "Short-term internship in industry" that had a low frequency, involved the Production and Manufacturing department of the firm and produced Advisory Report/Publications as output.

Table 7.8 - Human Resources links established between researchers and on-Park firms: their frequency, firms' departments and outputs

Human Resources	No. of Links	Frequency	Firms' Department	Outputs
Students involvement in industrial projects	5	High (60%)	R&D (60%)	VA/PI (40%)
Industrial fellowships	1	High (100%)	R&D (100%)	VA/PI (100%)
Short-term internship in industry	1	Low (100%)	P&M (100%)	AR/Publ (100%)
Form.organised training programmes for industrial personnel	1	High (100%)	R&D (100%)	VA/PI (100%)

Categories:- **Frequency** **Low Frequency** links occurring around 3 - 6 times a year or less frequently
Medium Frequency links occurring about once a month
High Frequency links occurring about once a week or more frequently

Firms' Dept. **R&D** Research and Development
D&PE Design, Production Engineering and Implementation
P&M Production and Manufacturing
S&D Sales and Distribution
Other Other firms' departments

Output **VA/PI** Verbal Advise/Provision of Information
AR Advisory Report
PP Implementation of a Particular Programme
DS/Pr Design Specification /Prototype
Other Any other output

Informal and Human Resources links presented a quite similar pattern of establishment. The proportion of researchers committed to them is the same (7 researchers or 44% of the sample in each case). Most of the links were implemented through the R&D department of firms and generated as their main output Verbal Advise/Provision of Information. The difference between these two groups of link is related to their frequency: Informal links tended to occur less frequently (3-6 times a year or less frequently), while Human Resources links occurred more frequently (once a week or more frequently).

7.2.3 - Formal links

Table 7.9 presents information about the number of researchers, and their proportion in relation to this sub-group that undertook Formal links. As the Table shows, only 5 researchers (31% of the total sample) were committed to any of the links in this group. Three researchers, or 60% of this sub-group, developed "Consultancy" activity during the period between 1991 and 1993, 2 of them being from the Department of Physics and one from the Faculty of Engineering. "Participation in/Establishment of research contract" and "Participation in/Establishment of joint research" links were set up by only one researcher from the Faculty of Engineering in each case (6% of the total sample). No researcher was involved in "Analysis and testing in industry" link.

Table 7.9 - Researchers engaged in Formal Links with the Host University

LINKS	No. of Researchers	% of Researchers
Any Formal Links	5	100
Consultancy	3	60
Participation in/Establishment of research contract	1	20
Participation in/Establishment of joint research	1	20
Analysis and testing in industry	-	-

Consultancy

The three researchers that developed "Consultancy" links had this link with only one on-Park company. Two of the links occurred between the researchers and small independent companies (with 25 or less employees) involved with ICT productive sector. The other link happened with a subsidiary of a British company employing more than 51 employees and involved with other Industrial products and services.

Table 7.10 describes the main characteristics of these "Consultancy" links. As it shows, two of the researchers carried out 3 projects with on-Park companies, while the third researcher had only one project. One of the projects lasted less than 1 month and the other two involved 3-12 months. Also, 2 of the projects involved the firms' R&D departments. The outputs of these links were related to Verbal Advise/Provision of Information (1 project), Advisory Report/Publication (1 project) and Design Specification/Prototypes (1 project).

One of the researchers who undertook three "Consultancy" projects had no financial return because the projects were developed based on friendship. One other researcher, whose project was in 1991, earned less than £ 5,000 in that year, but did not share such an amount with his Department or University. Finally, the third researcher earned less than £ 5,000 per year, but shared his earnings with his Department, on a 50%-50% basis.

Participation in/Establishment of research contract

Only one researcher from the Faculty of Engineering established a "Research contract" link. This was with a small subsidiary of a multinational (25 or less employees), involved with the other Industrial products and services sector. As Table 7.11 details, 2 projects, lasting more than 1 year each one, were carried out between that researcher and the company's R&D department. Both projects had finished by the time of the interview and generated as output Advisory Report/Publications.



Table 7.10 - Main Characteristics of Researchers' "Consultancy" links with on-Park Firms

Characteristics	Categories	Number of Researchers Engaged in this Link	Proportion of Researchers in each Category
a. No. of projects	1 project	1	33%
	2 projects	-	-
	3 projects	2	67%
	4 projects or more	-	-
b. Duration	less than 1 month	1	33%
	1 and 2 months	-	-
	3 months and 1 year	2	67%
	more than 1 year	-	-
c. Firms' departments	R&D	2	67%
	D&PE	-	-
	P&M	-	-
	Other	-	-
	no answer	1	33%
d. Outputs	VA/PI	1	33%
	AR/Publ	1	33%
	PP	-	-
	DS/Pr	1	33%
	Other	-	-

Categories:

Firms' Departments R&D Research and Development
 D&PE Design, Production Engineering and Implementation
 P&M Production and Manufacturing
 Other

Outputs VA/PI Verbal Advise/Provision of Information
 AR/Publ Advisory Report/Publication
 PP Implementation of a Particular Programme
 DS/Pr Design Specification/Prototype
 Other

Table 7.11 - Main Characteristics of the Researcher's "Research contract" links with the on-Park firm

Characteristics	Categories	Number of Projects	Proportion of Projects in each Category
a. No. of projects		2	100%
b. Starting	before 1991	2	100%
	after 1991	-	-
c. Duration	less than 1 year	-	-
	more than 1 year	2	100%
d. Stage of develop.	in progress	-	-
	finished (1991)	2	100%
e. Firms' departments	R&D	2	100%
	D&PE	-	-
	P&M	-	-
	Other	-	-
f. Outputs	VA/PI	-	-
	AR/Publ	2	100%
	PP	-	-
	DS/Pr	-	-
	Other	-	-

Categories:

Firms' Departments	R&D	Research and Development
	D&PE	Design, Production Engineering and Implementation
	P&M	Production and Manufacturing
	Other	

Outputs	VA/PI	Verbal Advise/Provision of Information
	AR/Publ	Advisory Report/Publication
	PP	Implementation of a Particular Programme
	DS/Pr	Design Specification/Prototype
	Other	

Regarding the financial benefits the researcher had with those "Research contract" projects, the interviewee stated that although both projects resulted in more than £ 50,000 per year, the benefits came straight to his department, helping it in buying materials and equipment. Even though those activities had slightly altered the research agenda of the researcher, his participation was supported by the overlapping of research interests.

Participation in/Establishment of joint research

Here again, only one researcher, from the Faculty of Engineering, had developed this type of link. As Table 7.12 details, the interaction took place with the R&D unit of a small division of a company located on the Park (25 or fewer employees), whose main activity was related to other Industrial products and service sector. At the time of the fieldwork, the project had been set up between the agents. As the research was in progress, it was expected that, depending on the results, the contract could be extended for more than the initial period of 2 years. The preliminary results were presented as Verbal Advise/Provision of Information. The financial benefits to the researcher's department were up to £ 50,000 in the initial year, and should be employed to satisfy its research purposes.

Overall, then, Formal links with the on-Park firms were carried out for only 5 researchers (31% of the total sample). The firms involved in these links were represented by small on-Park firms (less than 25 employees) and the number of projects executed did not exceed 3 projects in each case. Most of the projects were set up with the R&D department of the firms and their main results were Verbal Advise/Provision of Information and Advisory Report/Publications. Only one "Consultancy" project resulted in Design Specification/Prototype. The financial returns of these links were modest for "Consultancy" projects (less than £ 5,000) and more substantial for "Research contract" and "Joint research": in both cases, the financial benefits exceeded £ 50,000 and were employed by the University' Departments in order to complement their research resources.

Table 7.12 - Main Characteristics of the Researcher's "Joint research" links with the on-Park firm

Characteristics	Categories	Number of Projects	Proportion of Projects in each Category
a. No. of projects		1	100%
b. Starting	before 1991	-	-
	after 1991 (in 1993)	1	100%
c. Duration	less than 1 year	-	-
	more than 1 year	1	100%
d. Stage of develop.	in progress	1	100%
	finished	-	-
e. Firms' departments	R&D	1	100%
	D&PE	-	-
	P&M	-	-
	Other	-	-
f. Outputs	VA/PI	1	100%
	AR/Publ	-	-
	PP	-	-
	DS/Pr	-	-
	Other	-	-

Categories:

Firms' Departments R&D Research and Development
 D&PE Design, Production Engineering and Implementation
 P&M Production and Manufacturing
 Other

Outputs VA/PI Verbal Advise/Provision of Information
 AR/Publ Advisory Report/Publication
 PP Implementation of a Particular Programme
 DS/Pr Design Specification/Prototype
 Other

7.2.4 - Researchers' Assessment of their Links with the on-Park Firms

This sub-section provides information about the importance, from the point of view of the researchers, of the links they established with firms located on the Surrey Research Park, as well as about the importance of the Park in stimulating these links.

In order to assess these issues, three main questions were addressed to the interviewees. One was related to the importance the establishment of these links had on the development of the researchers' activities. Such an importance was measured in terms of the impact of the links and their benefits for the researchers: low impact meant no or peripheral benefit for the development of the researchers' activities and high impact meant direct or crucial benefit for the researchers.

Another important question was related to the pre-existence of the described links prior to the companies' location on the Park. As was already explained, this was thought to be important due to the large number of firms that were re-located onto the Park from elsewhere (56% of the total sample of firms surveyed). The interviews, therefore, identify whether the researchers already had links with those companies before they were located on the Park. Finally, it was assessed if the Park has been important to foster linkages between the researchers from the local University and the on-Park firms.

As in Chapter 5, the presentation of these information consider each group of links separately.

Informal Links

Table 7.13 concerns the Informal links. Overall, a large proportion (52.5%) of the Informal links had already been established between the researchers and the firms by the time of the firms' location on the Park. The highest marks were those related to "Access to

Table 7.13 - Informal Links - Pre-existence of links, their impact on the researchers' activities and the importance of the Park for the establishment of these links

Informal Links	No. of Researchers	Impact		Pre-existence of links	Importance of the Park for establishing links
		Low	High		
Personal contact with industrial staff	7	57.0%	43.0%	29.0%	29.0%
Access to specialised technical reports	4	50.0%	50.0%	75.0%	-
Access to industrial R&D	3	67.0%	33.0%	67.0%	-
Small donation of gifts or capital to research	3	33.0%	67.0%	67.0%	-
Access to industrial equipment	2	50.0%	50.0%	50.0%	-
All Informal Links/All Researchers	19	52.5%	47.5%	52.5%	10.5%

Categories:- **Low** **Low Impact** the link represented no or peripheral benefit for the development of the researchers' activities

High **High Impact** the link represented a direct, or even crucial, benefit to complement the development of the researchers' activities

specialised technical reports" (75%) and "Access to industrial equipment" and "Small donation of gifts or capital to research" (67% for each link). The main exception was "Personal contact with industrial staff", whose score was only 29%.

Regarding the importance of the Park for the establishment of these links, overall, only 10.5% of the researchers considered it as an important vehicle for the promotion of their Informal linkages. As the interviewees stated, either their Informal links with these companies already existed before their location on the Park, or their occurrence was completely independent of it.

Finally, concerning the importance of these links for the development of the researchers' activities, overall, 52.5% of the researchers considered their Informal links as provoking low impact (no or indirect benefit) on their activities. The exception was "Small donation of gifts or capital to research", for 67% of the researchers considered the establishment of this link as important to their activities.

Human Resources Links

Table 7.14 refers to the Human Resources links. Overall, only 12.5% of the links in this group had already been established between the researchers and the firms when those companies set up on the Park site. In fact, besides "Students involvement in industrial projects", none of the other links were set up previously to the firms' establishment on the Park.

Concerning the importance of the Park for the establishment of Human Resources links between the researchers and firms located on the Park, 62.5% of the researchers considered the Park as an important instrument for forging their linkages. All the researchers attributed a high importance for the Park, with the exception of those involved in "Students involvement in industrial projects", whose score was 40%.

Table 7.14 - Human Resources Links - Pre-existence of links, their impact on the researchers' activities and the importance of the Park for the establishment of these links

Human Resources Links	No. of Researchers	Impact		Pre-existence of links	Importance of the Park for establishing links
		Low	High		
Students involvement in industrial projects	5	20.0%	80.0%	20.0%	40.0%
Industrial fellowships	1	-	100.0%	-	100.0%
Short-term internship in industry	1	-	100.0%	-	100.0%
Form. org. training programmes for industrial personnel	1	-	100.0%	-	100.0%
All Human Resources Links/All Researchers	8	12.5%	87.5%	12.5%	62.5%

Categories:- **Low Impact** the link represented no or peripheral benefit for the development of the researchers' activities
High Impact the link represented a direct, or even crucial, benefit to complement the development of the researchers' activities

In relation to the importance of Human Resources links for the development of the researchers' activities, overall, a high proportion (87.5%) of the researchers regarded these links as important to their activities.

Formal Links

As Table 7.15 shows, only 40% of the links grouped as Formal links were set up between the researchers and the companies previously to the companies' location on the Park. The highest score within this group of links came from "Research contract" link (100%), since this links had already been previously established with the company.

Also, overall, 60% of the researchers regarded the Park an important vehicle for stimulating the establishment of their Formal links with firms located on the Surrey Research Park. The Park was particularly important for the establishment of "Research contract" and "Joint research" links (both researchers attributed the highest score -100%- for the Park as an important instrument for setting up their links).

Finally, overall, 80% of the researchers considered the establishment of Formal links as important for the development of their activities. Such links have been particularly important for those researchers involved in "Research contract" and "Joint research" - both achieved the highest score (100%).

Overview: Links with on-Park Firms

The researchers from the University of Surrey established 19 Informal links with firms located on the Surrey Research Park. Overall, 52.5% of these links were set up with the companies previously to their establishment on the Park site. Moreover, 52.5% of them had a low impact (importance) on the development of the researchers' activities and only 10.5%

Table 7.15 - Formal Links - Pre-existence of links, their impact on the researchers' activities and the importance of the Park for the establishment of these links

Formal Links	No. of Researchers	Impact		Pre-existence of links	Importance of the Park for establishing links
		Low	High		
Consultancy	3	33.0%	67.0%	33.0%	33.0%
Participation in/Establishment of research contract	1	-	100.0%	100.0%	100.0%
Participation in/Establishment of joint research	1	-	100.0%	-	100.0%
Analysis and testing in industry	-	-	-	-	-
All Formal Links/All Researchers	5	20.0%	80.0%	40.0%	60.0%

Categories:- **Low Impact** the link represented no or peripheral benefit for the development of the researchers' activities
High Impact the link represented a direct, or even crucial, benefit to complement the development of the researchers' activities



of the researchers attributed importance to the Park as a channel for forging these informal links.

Also, these researchers established 8 links within the category of Human Resources links. Only 12.5% of these linkages were already committed with the researchers with these firms before their location on the Park. Contrary to the group of Informal links, 87.5% of these links were regarded as important for the development of the researchers' activities and 62.5% of the researchers considered the Park as a important vehicle for forging links in this category.

Finally, the researchers established 5 links within the category of Formal links. 40% of them were set up previously to the establishment of the firms on the Park. Moreover, 80% of the links generated a direct or even crucial benefit for the development of the researchers' activities and 60% of the researchers considered the Park as being important for the implementation of these Formal links.

It is interesting to quote some problems the researchers have detected for establishing their links with the firms located on the Park. According to the interviewees, the economic recession and consequently the pressures from the Government on researchers for improving their links with industry have forced them to consume much of their time in getting money instead of doing creative work. As the competition with other research institutions and universities for the establishment of research contracts with companies, both in the UK and overseas, have substantially increased in the recent years, it is paramount the researchers keep themselves at the leading-edge of research in order to carry out industrial links.

In addition, the researchers stated that the distinction and lack of formal guides running academic and commercial activities have generated problems of confidentiality and patent rights among others. The inflexibility of the University's roles, the lack of adequate

communication between the agents and, sometimes, a not very pro-active attitude of the researchers and firms concerning closer relationship between them have made more difficult their interaction and the generation of mutual benefits.

7.3 - Links between the Researchers and other Firms located elsewhere

This section is divided in two sub-sections. Sub-section 7.3.1 briefly presents the main findings related to the links that existed between the same sample of researchers and other firms not located on the Surrey Research Park. Sub-section 7.3.2 compares the links established between the researchers and on-Park firms and other firms.

7.3.1 - Brief Description of the Links between the Researchers and other Firms

Since one of the researchers refused to answer the questions in this part of the questionnaire, the total number of researchers covered here is 15 instead of 16. Table 7.16 shows that 14 researchers (93% of the sample) had established links with other firms located elsewhere: 73% of them were committed to Informal links; 80% were engaged in Human Resources links and another 80% were involved in Formal links.

Table 7.16 - Links between Researchers and other Firms located elsewhere

LINKS	No. of Researchers (n=15)	% of Researchers (n=15=100%)
Any Link	14	93
Informal Links	11	73
Human Resources Links	12	80
Formal Links	12	80

Table 7.17 presents the same categories of link but now distinguished according to each group of researchers (engineers and physicists) separately. As the Table shows, 89% of the engineers and 33% of the physicists committed to Informal links; 89% of the engineers and 50% of the physicists engaged in Human Resources links as well as in Formal links.

Table 7.17 - Links between each Group of Researchers and other Firms

LINKS	Engineers (n=9)	Physicists (n=6)
Any Link	9 (100%)	4 (67%)
Informal Links	8 (89%)	2 (33%)
Human Resources Links	8 (89%)	3 (50%)
Formal Links	8 (89%)	3 (50%)

Informal Links

As Table 7.18 shows, 10 researchers (8 from the Faculty of Engineering and 2 from the Faculty of Science) established, at least, one of the links listed in the group of Informal links. The main finding concerning these links are as follows.

Table 7.18 - Researchers engaged in Informal Links with other Firms

LINKS	No. of Researchers	% of Researchers
Any Informal Link	10	100
Personal contact with industrial staff	10	100
Small donation of gifts or capital to research	6	60
Access to specialised technical reports	5	50
Access to industrial R&D	5	50
Access to industrial equipment	3	30

- 57% of the researchers had links with 3 or more companies; in 40% of the cases, these companies were independent companies and another 27% were departments or divisions of firms.

- 50% of the links were established with large companies (more than 1500 employees) and none of them with smaller firms (less than 50 employees). Moreover, only 23% of the links happened with companies engaged in ICT productive sector.
- 96% of the links were developed between the researchers and the firms' R&D departments; the remaining 4% were involved the Production and Manufacturing departments of firms.
- The main outputs resulting from these links were as follows: 54% of Advisory Reports/Publications and 37% of Verbal Advise/Provision of Information. The remaining 10% provided materials, equipment and discussion about future co-operation and absorption of students.
- Finally, 90% of the researchers considered their Informal links with other companies located elsewhere as important for the development of their activities (direct or crucial benefit to the researchers).

Among the reasons stimulating the establishment of Informal links with firms located elsewhere, the interviewees emphasised their need to make their research industrially relevant, to use certain equipment, and to get financial support for their research. Also, as was stressed by one of the engineers, "we need to be creative and this happens outside [the University]"

Regarding the main obstacles the researchers had faced in order to implement these links, there was quoted their lack of time and their lack of knowledge of the right people with whom to discuss at the industrial level.

Human Resources Links

As Table 7.19 shows, 11 researchers (8 from the Faculty of Engineering and 3 from the Faculty of Science - established at least one of the links listed in the group of Human Resources links. The main finding concerning these links are as follows.

Table 7.19 - Researchers engaged in Human Resources Links with other Firms

LINKS	No. of Researchers	% of Researchers
Any Human Resources Link	11	100
Students involvement in industrial projects	9	82
Formally organised training programmes for industrial personnel	5	45
Industrial fellowships	1	9
Short-term internship in industry	1	9

- 53% of the researchers established Human Resources links with 3 or more companies.
- These links were developed with companies involved in a variety of productive sectors. So, for example, 60% of the links were connected to Industrial products and services sector (including here Molecular Biology/Genetic Engineering). ICT related-companies accounted for 12% of the linkages.
- 65% of Human Resources links occurred between the researchers and the R&D department of firms. Also, 18% involved the Production and Manufacturing divisions of the companies.
- The main outputs emerging from these interactions were as follows: 41% of Verbal Advise/Provision of Information; 29% of Advisory Report/Publications; 12% represented by teaching/seminars and 6% of Design Specification/Prototypes. Two of the researchers were not able to specify the outputs of their links.

- 71% of these links were considered important for the development of the researchers' activities (direct or crucial benefit). The remaining 29% of links received a low rate of importance, resulting in no or only indirect benefit for the researchers.

Formal Links

Table 7.20 shows that 11 researchers (3 from the Department of Physics and 8 from the Faculty of Engineering) were committed to Formal links with off-Park firms. 64% of the interviewees carried out Consultancy activities with off-Park firms; 55% had "Participation in/Establishment of research contract"; another 45% had "Participation in/Establishment of joint research"; 45% were engaged in "Analysis and testing in industry" link.

Table 7.20 - Researchers engaged in Formal Links with other Firms

LINKS	No. of Researchers	% of Researchers
Any Formal Link	11	100
Consultancy	7	64
Participation in/Establishment of research contract	6	55
Participation in/Establishment of joint research	5	45
Analysis and testing in industry	5	45

- "Consultancy" - Data related to this type of link show that the 7 researchers committed to this link interacted with 2 or 3 firms in 71% of the cases, implementing one project (57%) whose duration was greater than one year (57%). Smaller firms (50 or less employees) did not attract the interests of the researchers, for 100% of the links were established with firms having 51 or more employees. The firms' R&D department were responsible for 71% of the linkages whose main outputs were Advisory Report/Publications (57%) and Verbal Advise/Provision of Information (43%). Related to the financial benefits the researchers had had with their Consultancy activities, the researchers informed that in 1991, 100% of the links generated less than £ 5,000. For 1992, the financial return for 29% of the links were

around £ 5,000 and £ 15,000; the remaining 71% of links involved less than £ 5,000. Finally, 86% of the researchers considered "Consultancy" link as important for the development of their activities.

Among the reasons the researchers had for the establishment of their "Consultancy" links, they mentioned their need to broaden their experience in new areas of research, to get more money to develop their research and to make the results of academic work socially and industrially relevant.

- "Participation in/Establishment of research contract" - The number of links which researchers had with off-Park firms presented a variation between 1 to 4 projects and 67% of them lasted for more than one year. Although 17% of the links were carried out with small firms (25 or fewer employees), 84% of the them involved large companies with 600 or more employees. Here again, the R&D department of companies were responsible for 100% of the links, whose main outputs were Verbal Advise/Provision of Information (50%) and Advisory Report/Publications (50%). 83% of the researchers involved with this link informed that the financial benefits emerging from these linkages were the main reason for such an involvement: for both years (1991 and 1992), 40% of the links generated less than £ 5,000; 20% were related to £ 5,000 to £ 15,000 and finally, 40% were around £ 15,000 and £ 30,000. Finally, 67% of the researchers considered their "Research contract" projects as important for the development of their research activities.

- "Participation in/Establishment of joint research" - 80% of the researchers established this type of link with 3 or more companies and in 60% of the cases, only one project was developed at time. 60% of the projects occurred with large firms (600 or more employees), whose R&D departments were involved in 100% of the links. 60% of the outputs related to Advisory Report/Publications and 40% to Verbal Advise/Provision of Information. This link could be considered the more profitable one in this group of Formal links: 40% of the linkages generated between £ 5,000 and £ 15,000 of financial benefits; 20% around

£15,000 and £ 30,000; 20% between £ 30,000 and £ 50,000 and finally another 20% more than £ 50,000. Among the reasons the researchers had for participating in or establishing of "Joint research" were found: financial support for research; mutual technological benefits and advance of the research per se. All of the projects were considered as important for the development of the researchers' activities.

- "Analysis and Testing in industry" - Five researchers developed this link, most of them involved with 2-3 companies and carried out 3-4 projects. The lack of specific equipment and, consequently, their availability in companies, was the main reason for which the researchers implemented this link with companies located elsewhere. This type of link was considered important for the development of the researchers' activities (direct or even crucial benefit).

7.3.2 - Comparison between Links: on-Park Firms and other Firms located elsewhere

Section 7.2 covered the links that existed between a sample of researchers from the University of Surrey and their links with the firms located on the Surrey Research Park. Then, sub-section 7.3.1 dealt with the links that existed between the same sample of researchers and other firms located elsewhere.

The present sub-section aims to compare both set of links. Table 7.21 summarises these information considering the three categories of links: Informal links, Human Resources links and Formal links.

From the comparison between these two set of data, it is evident that the proportion of researchers that established links, in all the categories, with other companies located elsewhere is much higher than those that set up links with companies located on the Park. Moreover, this proportion is higher, the more structured organisational approach the links require for being set up (Formal and Human Resources links). The main point to be

stressed here is that the geographical proximity between the researchers (universities) and firms does not seem to be affecting their interaction with firms.

Table 7.21 - Researchers and their Links with the on-Park Firms and other Firms

LINK	ON-PARK FIRMS		OTHER FIRMS	
	No.Researc. (n=16)	% Researc.	No.Researc. (n=15)	% Researc.
Any Link	8	50	14	93
Informal Links	7	44	11	73
Human Resources Links	7	44	12	80
Formal Links	5	31	12	80

The following Table 7.22 presents the same kind of information but in a more disaggregated form.

Table 7.22 - Researchers and their Links with the on-Park Firms and other Firms

LINKS	On-Park Firms (n=16)	Other Firms (n=15)
Informal only	1	0
Human Resources only	0	1
Formal only	0	2
Informal + Human Resources	2	1
Informal + Formal	0	0
Human Resources + Formal	1	0
Informal + Human Resources + Formal	4	10
No links	8	1
Total	16	15

As Table 7.22 shows, the researchers from the University of Surrey set up links with both the on-Park firms and other firms located elsewhere. However, they were much more likely to have links with off-Park firms: half of researchers had no links with on-Park firms, whereas only one researcher (6.5%) of the sample had no links with off-Park companies.

Looking at the researchers who established only one category of link at the same time, the Table shows that researchers were slightly more likely to have these links with off-Park firms than with on-Park firms: only one researcher (6% of the sample) had Informal links with the on-Park firms while three had Human Resources or Formal links with off-Park firms (20% of the sample).

The difference is much more striking with respect to researchers with multiple links at the same time. Seven of the researchers (44% of the sample) established multiple linkages with on-Park firms, but eleven of them (73% of the sample) had multiple links with off-Park firms. In particular, the number of researchers engaged in Informal plus Human Resources plus Formal links with off-Park firms is much higher than that with on-Park firms (10 X 4 researchers or 62.5% X 25% of the total sample).

This comparative analysis do indicate that, so far, the establishment of links between researchers and on-Park firms has been modest when compared to those set up with off-Park firms.

7.4 - Conclusion

This Chapter explored the links that existed between the sample of 16 researchers from the University of Surrey and their links with firms located on the Surrey Research Park as well as with other firms located elsewhere.

Section 7.1 presented a set of information concerning the background of these researchers. Most of them have been on the University for a long time, occupying a senior academic position and developing a large spectrum of activities.

Section 7.2 dealt with the links established between the researchers and the on-Park firms. Both Informal and Formal categories of links showed a low frequency and a small number of agreements. The exception was the Human Resources links which had a high rate of frequency. It was evident the importance of the R&D departments of firms as a point of contact for the researchers in their linkages with companies. Also interesting is that the main outputs emerging from this set of Informal linkages were related to Verbal Advise/Provision of Information and Advisory Report/Publications rather than Implementation of a Particular Programme or Design Specification/Prototypes. These kind of outputs, as was in the case of the firms' links described in Chapter 5, stressed, once more, that the contribution made by universities to the development of firms' activities reside mostly on the provision of information to complement the firms' technological effort.

Sub-Section 7.3.1 explored the links established between the same sample of researchers and other firms located elsewhere. Most of the companies with which the researchers have been connected were represented by larger firms. Once more, the importance of the R&D departments of firms for the establishment of these linkages were stressed: R&D units do represent the point of contact between academics and firms. The outputs that resulted from this set of links were mainly Verbal Advise/Provision of Information and Advisory Reports/Publication).

However, the striking difference between the two set of linkages established by the researchers refers to the much higher proportion of links established between researchers and off-Park firms in relation to those set up with on-Park firms. It could not be said that the geographical proximity between researchers and firms, as within the Science Park territory, does not have any influence on the establishment of their links. Researchers from the



University of Surrey do have committed links with the on-Park firms. However, most of these links have been established previously to the location of the firms on the Park site. More importantly, the links established with on-Park firms have been much more related to the groups of Informal and Human Resources links than to the group of Formal links, closer than the former ones to the research activity developed by academics.

CHAPTER 8 - SUMMARY AND CONCLUSIONS

This research was concerned with the links established between industry and university R&D, and the expectation that Science Parks would strengthen their links. The structure of the thesis aimed to provide as much detailed information as possible in order to illuminate and deeply understand the links occurring between companies and university within the Science Park milieu.

Chapter 2 analysed the potential and limits of the University-Industry interaction and links. It stressed that these possibilities and limitations have been dictated, among other things, by (1) broader national infrastructures, in which universities and industries are inserted, and the ways they have been set up over time; (2) the very nature of innovation, or innovative activity, with its diverse forms and sources of knowledge, information and technology and (3) the differences in the ways universities and firms present themselves as social institutions.

It showed that the U-I interaction varies enormously not only over time but also between countries and has made a modest and limited, even though important, contribution to firms' innovative activity or search for technical solutions. More than that, it emphasised that the importance of universities to firms has been much more concerned with the development of their traditional activities - training of qualified manpower and increasing of the stock of knowledge through independent research - than to the direct application and commercial exploitation of its research results in the industrial environment.

In addition, it stressed that a successful interaction between firms and academe does not happen under any condition: in fact, larger R&D intensive firms engaged in high-technology productive sectors seemed to have a higher propensity of establishing links with universities than other types of firms. However, such a generalisation must be considered

very carefully due to the lack of empirical evidence about the establishment of links between university and industry in which firms' characteristics have been properly analysed. Also, the technological maturity of productive sectors did not seem to undermine the possibilities firms (in these more mature sectors) have in strengthening their links with university. Finally, the very limited available evidence raises questions about whether the geographical proximity between firms and universities is a determining factor in the process of setting up linkages between the partners.

Then, Chapter 3 investigated the links established between university and industry through the Science Park mechanism. Universities have been considered essential participants in the process of the planning, implementation and management of Parks all over the world. However, the results observed through previous research have shown that these linkages have not been very profuse. They have been mostly related to the establishment of informal contacts with academics and the use of universities' facilities than to those related to the research activity undertaken by universities. However, these results might have a straight connection with the kind of firms that have generally been set up on Parks: small firms engaged in specific niches of high technology productive sectors, and mostly involved in design and development and consultancy than in research and development activities. The lack of a more systematic analysis about the firms' characteristics and their possible influence on the establishment of links with university, and the scarcity of data about the university side of this relationship still present in previous research, does not allow a proper assessment of U-I links set up through the Science Park mechanism. More consistent information about these topics would, in addition, facilitate the validation of the main argument incorporated in the concept of Science Parks: that the geographical proximity between universities and firms would promote the strengthening of links.

Chapter 4 detailed the research design and methodology used in thesis. Such a design sought to allow two types of comparison: first between the links of on-Park firms with (i) the host university and (ii) with other universities; and second between the links of academic

researchers from the host University with (i) on-Park firms and (ii) other firms. The study provided, in this way, a new approach to analysing the extent to which the geographical proximity between the partners may influence their interaction.

The Chapter also provided information about the University of Surrey and the establishment of the Surrey Research Park within the context of the University's activities. It described the main activities of the Park management. This description showed that, from the point of view of the management of the Park, activities connected with the fostering of links between the Park tenants and the University or Research Institutions have not been considered, so far, as a priority.

Moreover, the Chapter described the steps followed in order to select the sample of on-Park firms investigated in this study as well as the main characteristics and R&D activities of this sample of firms. The main characteristics of the Park's tenants and also their R&D activities confirmed previous studies in this area. Activities concerned with more sophisticated technological sectors, such as those developed by ICT companies, dominated the Park environment and accounted for almost 50% of this sample of firms. The size of the on-Park firms also confirmed the tendency already observed: Parks seem to be a very adequate place for housing small companies. Interesting to observe the small proportion of spin-off companies located on the Park. Only one among the companies in this sample was a spin-off company from the local University. This observation contrasts with the high expectations generated in relation to Science Parks as an adequate place for stimulating the establishment of small companies from the university. The development of R&D activities did by no means constitute the only activity undertaken by this sample of companies: 33% of the firms did not develop any R&D activity. Indeed, R&D was the "primary activity" of only 19% of the tenants; and only 10% had been engaged in basic research activity, perhaps limiting, in this way, the possibilities of interaction with universities.

Chapter 5 explored and described the links that existed between this sample of 21 firms located on the Surrey Research Park and their links with universities. Concerning the links established with the local university, it was possible to observe that most of them presented a low frequency, low absorption of more qualified human resources and a small number of agreements or research projects, usually undertaken on a short-term basis. Also, most of the links were set up through the R&D department of firms: in fact, these departments constitute the point of contact, or absorption, of links with academe. The outputs emerging from this set of linkages related basically to Verbal Advice/Provision of Information and Advisory Reports rather than more immediately implementable outputs like Implementation of a Particular Programme or Design Specification/Prototypes. The importance of the links for the development of the firms' activities varied: Formal links had a higher rate of importance than Informal and Human Resources links. Also, the importance of the Park as a mechanism for strengthening firms' links with academe was low. In fact, as Chapter 4 reported, the choice of firms' location on Parks has been strongly motivated by aspects such as prestige, the environment of the region and the infrastructure and common administrative services provided by the Park.

Regarding the links established between on-Park firms and other universities located elsewhere, most of the findings were similar to those obtained through the links with the local university. However, the establishment of research links (Formal category) with other universities occurred in a slightly higher proportion than those established with the host university.

Chapter 6 focused on one important aspect of the establishment of links between companies and academe: that related to the influence particular characteristics of the on-Park firms had on the establishment of their links with universities. The firms' characteristics considered for analysis were: R&D activity, R&D intensity, size of firms, productive sectors, status of firms and their "age" (number of years the firms have been set up on Park's site). Such an analysis, based on simple cross-tabulation,

emphasised that, among these characteristics, the existence of R&D activity within the organisational structure of firms influenced the establishment of their links with universities. The intensity of R&D within the firms did not seem to determine the propensity of linkages. The analysis of the size of firms confirmed previous studies: the larger the firms, the higher their propensity of linkages, mainly if the firms have R&D activity. Also, firms engaged in non-ICT industrial sectors showed a higher propensity of linkages than firms in ICT sectors (particularly if the companies had R&D activity). Sections or subsidiaries of larger firms had a higher propensity of links, in all the categories, with both the host university and other universities, than independent companies. Finally, the assumption that the longer a firm is located on a Park, the higher its propensity of establishing links with the host university was not confirmed through this research.

Finally, Chapter 7 explored the links that existed between the sample of researchers from the University of Surrey and their links with firms located on the Surrey Research Park as well as with other firms located elsewhere.

Regarding the links established between the researchers and the on-Park firms, Human Resources links occurred more frequently than Informal and Formal links. These last groups of links also showed a small number of agreements. It was again stressed the importance of the R&D departments of firms as the main point of contact with universities. The main outputs emerging from this set of linkages were, again, related to Verbal Advice/Provision of Information and Advisory Report/Publications rather than more immediately implementable outputs such as Implementation of a Particular Programme and Design Specification/Prototypes.

The main findings that can be drawn from the links established between the same sample of researchers and other firms located elsewhere are as follows. The kind of companies with which the researchers have been connected were represented by larger firms, and,



here again, the importance of the R&D departments of firms for the establishment of these linkages were emphasised. Also, the same kind of outputs resulted from this set of links (mainly Verbal Advice/Provision of Information and Advisory Reports/Publication). However, within the total of all their links, researchers had a higher proportion with off-Park firms than with on-Park firms.

The next paragraphs highlight the main conclusions and limitations of this research as well as its main contributions to understanding Science Parks. Some topics for future research in this area are also presented.

As was already stressed, this thesis was concerned with the links established between industry and university R&D, and the expectation that Science Parks - mechanisms that have been typically designed and planned for, among other things, strengthening the U-I links - would, in fact, strengthen those links. The research addressed three broad questions:

- (1) What are the nature, frequency and outputs of linkages established between firms located on a Science Park and the host university?
- (2) What are firms' key characteristics that might influence the establishment of links with universities? To what extent do these characteristics determine the nature and intensity of the links?
- (3) To what extent does the geographical proximity between companies and universities, as proposed by the Science Park mechanism, facilitate the promotion and strengthening of their links?

The attempt to answer these questions generated a set of very illuminating and interesting results or conclusions. They must, however, be understood within certain limitations

imposed, on the one hand, by the method of analysis chosen. In this sense, the case-study approach did allow an in-depth exploration about the links that existed between firms and universities through a specific mechanism of U-I interaction. It also made possible the analysis of the geographical proximity between the partners as an important variable for the promotion of links. On the other hand, the mechanism chosen for analysis - a Science Park within the British context - has also specific features that strongly influence the performance of the partners and their linkages. In this sense, the Surrey Research Park may not be representative neither of all British Science Parks nor of other modalities of mechanism also planned with similar purposes but with different design, such as Innovation Centres or Technopolis. Moreover, the sample of on-Park firms and researchers from the host university may not even be representative of the whole population of firms located on the Surrey Research Park and researchers from the University of Surrey.

Then, given the above mentioned limitations, the possibilities of making broad generalisations from the results of this study are a bit reduced. On the other hand, however, as some of the conclusions emerging from this research do confirm some results already presented in previous research about the interaction between university and industry and Science Parks, the particularities of this case-study do not preclude that its results support some general conclusions, as follows.

(1) The strengthening of links between academe and on-Park firms does not constitute, so far, a paramount objective either for the Park management or for the firms located on Parks' sites.

The planning, implementation and operation of Science Parks involve several groups of interests such as universities and research institutions, industrialists, bank financial agents and venture capitalists and Government officials, authorities and developmental agencies. These different groups of interests have also a huge set of mix objectives - among them, those related to the promotion and strengthening of links between on-Park firms and the

host university, which would require, from the Park management, a substantial effort for their achievement. However, as was observed through this research, only 10% of the time of the Park' management team have been devoted to the promotion of U-I links. Moreover, from the point of view of the on-Park firms, the reasons that have driven their locational choice on Parks have been much more concerned to the availability of transport and communication in the region, the provision, by the Park, of a pleasant work environment and facilities and credibility of the name of the Park than the possibilities of fully explore the research resources available at universities.

(2) Science Parks have been an interesting vehicle for fostering the establishment of Informal links between on-Park firms and the host university. The main evidence that support this conclusion are as follows:

(2.1) A high proportion of on-Park firms (95% of the total sample) have established links with the host university within the category of Informal links. This group of links represents the contact with the pool of information and knowledge, expertise and equipment available at universities. However, the establishment of Human Resources links (related to the improvement, training and recruitment and/or allocation of qualified manpower) and Formal links (related to research agreements and contracts) have presented a much lower proportion of linkages (52% and 33% respectively). Overall, these linkages have shown a low intensity (or frequency of occurrence) and have generated, as their main outputs, Verbal Advice/Provision of Information and Advisory Report/Publications rather than more immediately implementable outputs such as Implementation of a Particular Programme and Design Specification/Prototypes.

(2.2) Concerning the links established between on-Park firms and other universities located elsewhere, the results that emerge from the field-work show a similar pattern of linkages as that observed through the links established between the on-Park firms and the host university. Even though in this case the establishment of Informal and Human Resources

links presented a lower proportion of commitments (50% and 35% respectively), the establishment of Formal links (those related to the research activity) had a slightly high proportion when compared to the first set of results (with the host university).

(2.3) On the researchers' side, their linkages with firms located elsewhere were substantially higher than their linkages with firms located on the Park, for all categories of links. For instance, the proportion of Informal links established between the researchers with other firms scored 73% against 44% with on-Park firms and the proportion of Human Resources links was 80% against 44% . In relation to the establishment of Formal links, the researchers had 80% with other firms and only 31% with on-Park firms. As in the case of the firms' side, here again the main outputs that emerge from these links were Verbal Advice/Provision of Information and Advisory Report/Publications rather than more immediately implementable outputs such as Implementation of a Particular Programme and Design Specification/Prototypes. The main difference observed on the researchers' links with the on-Park firms and other firms located elsewhere refers to the kind of firms with which researchers have been in contact: they have explicitly been connected to large firms presenting a broad portfolio of research agenda.

As Chapter 3 showed, previous research in this area have been restricted to the exploration of the nature of linkages between on and off-Science Park firms and the host, or nearby, university. Moreover, their scope of analysis have not considered the university' side of this relationship, represented by the linkages established between the researchers from universities and firms located on and off-Parks. Even though presenting these limitations, the results achieved by these previous research undertaken within the context of the British Science Parks (such as those presented by Monck et al (1988) and Massey et al (1992) and updated by Westhead and Storey (1994)) and that overlap with part of the present study, do confirm that there has been an improvement in the linkages established between firms and HEIs through Science Parks, over time. Their results, as those presented in this research, clearly pointed out to an improvement in linkages between on-

Park firms and the host university, mainly those related to the Informal category of links (such as "Informal contacts with academics") and the use of the universities facilities.

(3) The results emerging from this study, considering both sides of the interaction - firms and the researchers - do emphasise the crucial importance of R&D departments within the organisational structure of firms in order to allow the implementation and operation of any kind of link between these partners. In fact, the R&D department of firms has been the point of contact between the firms and researchers from universities when linkages were set up.

From the point of view of the on-Park firms, and taking into consideration the establishment of Informal links, it was possible to observe that the R&D department of firms was responsible for the implementation of a substantial proportion of links in this group, mainly those which required a more structured approach for their establishment (e.g. "Access to university equipment" and "Access to university department research", both with 75% of involvement of the R&D department of firms). Also, within the group of Human Resources links, this firms' department was strongly engaged in the recruitment of recent graduates (88% of the links) and training programmes (100% of the cases). However, it is within the group of Formal links that the R&D department did have a decisive participation: the establishment of 75% of the analysis and testing agreements, 100% of the joint research and 100% of the contract research projects happened under the umbrella of this unit of firms.

From the point of view of the researchers, the R&D department of firms was engaged in the establishment of most of their Informal links (e.g. 72% of the "Personal contact with industrial staff", 75% of "Access to specialised technical reports" and 100% of "Small donation of gifts or capital to research"). In relation to the Human Resources links, 100% of "Industrial fellowships", "Short-term internship in industry" and "Formally organised training programmes for industrial personnel" also occurred through the R&D department of firms.

Moreover, all the agreements established through "Consultancy", "Research contract" and "Joint research" were set up between the R&D unit of companies and the researchers from universities.

The importance of the R&D department of firms for the establishment of their links with academe emphasised in this study also confirms previous research in this area. As Chapter 2 demonstrated, several scholars (e.g. Freeman, 1994; Nelson, 1987) indeed recognise that the firms' R&D activity is an essential ingredient for increasing the firms' ability in coping with technical progress. Moreover, it has also been recognised that firms R&D activity (or departments) not only expands the possibilities firms have in interacting with other researchers performers, such as universities. It also allows firms to take more advantage from those interactions, which, per se, assume then a complementary character to the firms R&D activities (e.g. Feller, 1989).

For instance, Arora and Gambardella (1990), investigating the complementarity and external linkages in large biotechnology firms, argue that in this particular field, knowledge is quite complex and multidimensional. In this case, firms presenting a higher level of R&D activity are better prepared to interact with, and take full advantage of, external sources of knowledge and information. Mansfield (1991) also observes that at least part of the inter-industries differences concerning the better exploitation of academic research is due to their different degree of in-house R&D capability. As this author points out "one of the most important reasons why relatively R&D-intensive firms are more likely than others to carry out innovations based on recent academic research is that they tend to be more closely abreast of such research" (Mansfield, 1991:3).

The research linkages between academe and companies must then be understood within the context of complementing, and not substituting, internal R&D effort of firms. Hence, the existence of R&D departments is an essential asset for firms in terms of interaction with universities.

This evidence has also important implications in relation to the Science Park mechanism, mainly in situations where it has been expected that this mechanism would strengthen the research links between university and firms that undertake little or no R&D of their own,. This is a typical situation observed in developing countries.

As was emphasised in Chapter 1, developing countries have also been strongly motivated - by the same reasons and expectations as those presented in developed countries - to strengthen the interaction between their universities and industry. In these countries, the establishment of mechanisms as Science Parks has, in recent years, acquired a greater importance. However, as Balazs and Plonski (1994) argue, the industrial structure of that set of countries has not been driven to the promotion of innovative activity. Moreover, when their universities and Research Institutions do generate a relatively strong science base, such a base has been completely disconnected from the productive sector. In addition, the economic and social demands presented in developing countries also differ substantially from those presented by developed economies. Hence, the implementation of Science Parks in developing countries must be considered with some caution. The simple emulation of models based in other realities and that do not consider the differences above mentioned must be taken carefully in order to avoid the waste of scarce resources and the generation of false expectations and inadequate results.

(4) The contribution of universities to the development of firms' activities have been essentially related to provision of information to complement the internal technological effort of firms and not to the generation of innovations that are then final or even "semi-processed" goods to be "commercialised" by firms.

The results emerging from this research indeed identified that Verbal Advice/Provision of Information and Advisory Report/Publications are the main outputs emerging from the linkages established between firms and universities, for all kind of links (Informal links, Human Resources links and Formal links).

This conclusion confirms previous observation made through Chapter 2 about the interaction between universities and industry. As was emphasised, universities and firms are different social entities. They differ considerably in the nature and objectives of their activities (e.g. Pavitt, 1993). Moreover, their research activities also have different purposes, outcomes and reward procedures. These differences provide them with specific comparative advantages and also define the scope of action they can take concerning each other. To these factors, it must be added that innovation within firms is a very complex process and research is only one of the possible inputs for firms in their search for technical solutions or implementation of product or process innovation.

As a consequence, it has been recognised that the best contribution made by universities to the development of firms' innovative activity still remains on the development of universities' traditional functions, namely: the provision of qualified human resources and the increasing of the stock of knowledge, through the development of independent research.

These results were confirmed by several research undertaken by experts (e.g. Gibbons and Johnston, 1974; Nelson, 1987; Mansfield, 1991, 1994; Klevorick et al, 1995, Faulkner and Senker, 1994, 1995) in their attempts of assessing, mainly from the point of view of firms, the contribution of university research to the development of industrial innovative activity. These studies vary quite widely in the level of detail at which they assess such a contribution. However, they have stressed that the contribution of the research undertaken by universities have a marginal, though very important, contribution to the firms' innovative activity. Such an importance resides on the capacity universities have in providing to firms (and society at large) qualified human resources and increase the stock of general knowledge. It is worth re-state here the findings achieved by Gibbons and Johnston (1974), According to these authors, university, as a source of knowledge or information, has a little direct impact on the development of the firms activities. Though little, Gibbons and Johnston consider the impact of research undertaken by universities as very important

mainly in two distinct ways: the first relates to the increasing of the stock of knowledge per se. The second point refers to the constant improvement of scientists' capacity in dealing with topics that might directly contribute to the solution of industrial problems. In their words:

The first of these [contribution of research university] refers to the scientific knowledge resulting from research itself...The second major significance...is the maintaining the expertise of the scientist and his familiarity with a particular area of constantly changing knowledge...[because] the scientist can, and sometimes does, play a vital role in perceiving the application of particular knowledge to specific problems, and translating and transforming the results of scientific research into a form in which they are directly usable in the industrial environment (1974:241).

(5) The results emerging from this study, considering both sides of the interaction - firms and the researchers - do suggest that the physical proximity between companies and academe, as proposed by the promoters of the Science Park mechanism, is not confirmed by this thesis. In fact, such a proximity has favoured the establishment of Informal links and, under certain circumstances, the establishment of links grouped in the Human Resources category (mainly concerning the involvement of students in industrial projects). However, in relation to the Formal links, the geographical proximity between the partners does not have any influence on their establishment. In the case of research links (Formal links), evidence show that firms had almost the same proportion of research links with the host university and other universities (33% and 35% respectively). Looking at the researchers' side, it is possible to observe that 31% of them committed themselves with any of the Formal links ("Consultancy", "Research contract" and "Joint research") and firms located on the Park in contrast to 80% of commitments established with other firms located elsewhere. These data suggest that the interaction between universities and industry has been driven by the expertise and technical ability the institutions possess in particular areas rather than by their geographical proximity.

These results again confirm previous research undertaken in this area. Oakey (1985), for instance, does believe that the geographical proximity between academe and firms does

not eliminate other barriers to their relationship. Through his investigation, this author concludes that

...[the] close proximity [between universities and firms] may offer easy and frequent physical interaction. But this removal of barriers caused by the friction of distance does not eliminate a major barrier to the uninhibited interchange of information which stems from the "*organisational distance*" between the academic and industrialist...there are logistical and behavioural arguments that detract from the simplistic view that, because a potential provider of technical information is proximate to a potential user, useful interaction will take place (1985:59-60).

This research did not intend to cover all the topics related to the interaction between University and Industry and Science Parks. In addition, the method of analysis - a case-study of a single British Science Park- does not allow, as previously mentioned, the broad generalisation of the research results. However, this study, in the way it was designed, provides four levels of contribution.

At the descriptive level, for instance, it was possible to investigate not only the nature of the links established between firms and academe within the Science Park milieu. The approach also considered other important variables of these links such as their frequency, outputs and significance for the development of the partners' activities.

At the methodological level, this study complements previous research in this area that have been mainly focused on the firms' side of the U-I interaction and considered such a relationship from the point of view of on and off-Park firms and the host (or nearby) university. The research design of the thesis allowed two new types of comparisons: first, between the links of on-Park firms with (i) the host university and (ii) with other universities; and second, between the links of academic researchers from the host university with (i) on-Park firms and (ii) other firms.

As a consequence, this methodological approach allowed, at the analytical level, the investigation of two important aspects of the interaction between University and Industry

and Science Parks. One refers to the extent to which the geographical proximity between the partners influence their interaction. As was already emphasised, the geographical proximity between firms and universities does not influence the establishment of their links, mainly those related to the research links (Formal links). The second aspect relates to the influence particular characteristics of the on-Park firms had on the establishment of their links with universities. In relation to this second aspect, it was possible to observe the importance of the R&D activity within the firms' organisational structure in order to promote their linkages with universities. The analysis of the size of firms confirmed previous studies in this area: the larger the firms, the higher their propensity of linkages with academe, mainly if the firms have R&D activity. Concerning the productive sectors of firms, it was interesting to observe that firms engaged in more mature industrial segments have the same (or even higher) possibilities of linkages with universities as those involved in more high-tech industrial sectors. Here again, the existence of R&D activity within the organisational structure of firms increases the possibilities these companies have in forging links with academics.

At the practical level, this set of information about the U-I interaction/links and Science Parks provided a deeper understanding about the reality of such an interaction and mechanism that complement previous research in this area. Moreover, the research broadens the possibilities of rethinking such an interaction and mechanism within the context of developing countries. As was already stressed, this group of countries usually present a very different industrial and scientific and technological structures as well as a different set of social and economic demands. Then, the results of this research should allow a more critical evaluation about, at least, the following topics: (i) the current stage of development of industrial and scientific and technological sectors in developing countries; (ii) the real needs and resources available in those societies for improving the U-I interaction; (iii) the search for other mechanisms of interaction between university and industry that could better exploit the existent resources; (iv) the search for other mechanisms of interaction between university and industry that could generate better

results than those generated through the Science Parks.

Future research in this area would include, for instance, topics such as: (i) the replication of this methodology in other British Science Parks in order to confirm the results achieved through this single case-study; (ii) the replication of this methodology in other countries which present the same model of Science Parks in order to confirm and compare these results; (iii) the replication of this research in a developing country (e.g. Brazil) in which this mechanism has been strongly stimulated; (iv) the comparison between different models of Science Park in order to check differences and similarities among other models.

The research design and methodology carried out through this research was convenient for a single case-study, covering only one Park and a sample of its firms and researchers from the host University. However, their replication in a broader context would, most probably, require an adjustment. In this case, it would be recommended that the questionnaires used for the interviews with the on-Park firms and researchers from the host university were shorter than the original version. Moreover, it would be interesting if those interviews were also recorded and applied for more than one person in each company. This procedure would, probably, enrich the results generated through the field-work.



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APPENDIXES: QUESTIONNAIRES USED IN THE RESEARCH

As was already explained in Chapter 4 (sub-section 4.1.4), the field work was based on interviews conducted through questionnaires addressed to: (1) Management of the Surrey Research Park; (2) Managing Directors of firms located on the Surrey Research Park; (3) Management of the University of Surrey, represented by the responsible officer for the business area of the University of Surrey; (4) Heads of the Departments and Deans of the Faculties of the University's units selected to take part of this research; (5) Researchers from the University of Surrey.

Relatively unstructured interviews were held with two of the above:

(1) Management of the University of Surrey - the aim of this interview was to investigate the strategies, mechanisms and links that have driven the interaction between the University of Surrey and industry, particularly in relation to the firms established on the Surrey Research Park.

(2) Heads/Deans of Departments/Faculties of the University - these interviews had a similar objective than the previous one, but concerned with the specific policies and strategies the selected Departments/Faculties have had in relation to the establishment of links between their researchers and on and off-Park companies

More structured interviews were held with the other three groups of participants in this field work. The questionnaires used for these interviews are attached.

The interview with the Manager of the Research Park was based on a simple questionnaire, whose aim was to collect a broad set of information about the Surrey

Research Park, covering topics related to the Park management, support for tenants and University, information about the tenants, and university and on-Park links.

However, the interviews with the managing directors of the on-Park firms and researchers from the University of Surrey made use of huge open- and closed-ended questionnaires, covering issues mainly related to the links that they had established with universities/firms. Due to the huge amount of questions in each questionnaire, covering many links and variables related to each link, a "card-file" was created in order to facilitate the interviews. These cards were related to each group of link and the standard categories for answering each specific block of questions. They proved to be very useful for two main reasons: to facilitate the application of the questionnaire and to allow a more interactive interview, from the part of the interviewee. Also, it is worth mentioning that the in tenants' interviews, questions were asked about some topics that have not been covered in the thesis (links between the on-Park firms and between on-Park firms and other firms located elsewhere). These sections are not reproduced in their appendix.

Appendix 1 - SCIENCE PARK MANAGEMENT QUESTIONNAIRE

SCIENCE PARK MANAGEMENT QUESTIONNAIRE

A - IDENTIFICATION

- 1 - Name of the Park
- 2 - Name of the respondent of the questionnaire
- 3 - Position of the respondent of the questionnaire

B - PARK MANAGEMENT

- 4 - How many people in your Park are involved with Park Management:
Full time _____ Part time _____
- 5 - [Please, see Card 01] Park Management - What proportion of your management work (or the work of the management team) is devoted to:
 - Providing business services/facilities for tenants _____ %
 - Property management/routine administration of Park _____ %
 - Promoting/Marketing the Park and attracting new tenants _____ %
 - Raising finance/grants from Government and/or other agencies _____ %
 - Monitoring/Evaluating the effectiveness of the Park's development _____ %
 - Other (please, specify) _____ %
- 6 - [Please, see Card 02] Support to Tenants and University - What proportion of your management work (or the work of the management team) is devoted to:
 - Providing financial/accounts advice to tenants _____ %
 - Promoting access to venture capital sources _____ %
 - Legal advice to tenants and universities(e.g.: patents and licencing) _____ %
 - Providing management expertise to tenants _____ %
 - Fostering links between the University and Park tenants _____ %
 - Fostering links between tenants _____ %
 - Fostering links between on-Park tenants and off-Park firms _____ %
 - Other (please, specify) _____ %

C - INFORMATION ABOUT THE TENANTS

- 7 - Current number of tenants: _____
- 8 - **[Please, see Card 03]** Origin of the tenants - how many tenants are:
- spin-off firms from University _____
 - other new start-up firms _____
 - existing firms/organisations relocated from elsewhere _____
 - part of a University Department _____
 - independent research institutions _____
 - other (*please, specify*) _____
- 9 - **[Please, see Card 04]** What proportion of tenants on your Park is substantially or wholly committed to:
- research and development _____ %
 - product design and engineering _____ %
 - production and manufacturing _____ %
 - consultancy, analysis and testing _____ %
 - sales and distribution _____ %
 - other (*please, specify*) _____ %
- 10 - **[Please, see Card 05]** What proportion of tenants on your Park has the bulk of their activities devoted to the following productive sectors:
- Communication _____ %
 - Computer related-hardware _____ %
 - Computer related-software _____ %
 - Other electronics related _____ %
 - Medical/Health-related products and services _____ %
 - Other Molecular Biology/Genetic Engineering _____ %
 - Energy _____ %
 - Consumer-related products _____ %
 - Industrial products _____ %
 - Other (*please, specify*) _____ %

- 11 - [Please, see Card 06] In your opinion, what are the main reasons for tenants to be located in your Park?

Please, rank each possible reason as follows:

- 0 = not important;
 1 = little influence;
 2 = moderate influence;
 3 = important;

- Access to University research and consultancy _____
- Access to University equipment _____
- Access to University facilities _____
- Recruitment of specialised R&D staff _____
- Interaction with other firms/organisations already located on the Park _____
- Infrastructure and support offered by the Park management _____
- Environment of the region (e.g.: housing opportunities, social and cultural amenities) _____
- Amenities of the Park as a place to work _____
- Access to business services outside the Park but nearby _____
- Special incentives offered by state or local Government _____
- Others (*please, specify*) _____
- (a) _____
- (b) _____
- (c) _____

D - UNIVERSITY/TENANT LINKS

- 12 - [Please, see Card 07] Please, tick the forms of participation that the neighbouring University has in the Park:

- ownership _____
- administration _____
- capital investment _____
- investment of land _____
- expertise _____
- informal involvement _____
- other (*please, specify*) _____

- 13 - [Please, see Card 08] What are the main forms of interaction between the University and Park tenants:

Please, rank each as follows:

- 0 = not important;
- 1 = little influence;
- 2 = moderate influence;
- 3 = important;

- Employment of university faculty as consultants _____
- Employment of university graduates _____
- Employment of university technicians _____
- Access to university facilities (library, computer centre, laboratories) _____
- Training courses for employees _____
- Contracted university research for Park tenants _____
- Joint research between the university academic staff and Park tenants _____
- Other access to university research _____
- Other (please, specify) _____

- 14 - Is there any Liaison Office working on University-tenant links in your Park?

YES NO

[if yes] Staff (number) _____

- 15 - Is there any specific mechanism to strengthen links between University and tenants in your Park?

YES NO

[if yes] What sort of mechanism? _____

- 16 - Does your Park have a mechanism for monitoring University-tenant links?

YES NO

[if yes] What sort of mechanism? _____

- 17 - Does your Park promote links for tenants to other research establishments?

YES NO

[if yes] Please, give details:

(a) in the U.K. _____

(b) overseas _____

Appendix 2 - TENANTS QUESTIONNAIRE



TENANTS QUESTIONNAIRE

A - IDENTIFICATION

- 1 - Name of the unit
- 2 - Park
- 3 - Name of the Respondent of the Questionnaire
- 4 - Position of the Respondent of the Questionnaire
- 5 - How long have you been in this position?

B - BACKGROUND INFORMATION ABOUT THIS UNIT

- 6 - Focusing on this unit on this Park, when did it start its operation here?
- 7 - Could you tell me some historical information about this unit?
- 8 - **[PLEASE, SEE CARD 01]** What is the origin of this unit:
 - (a) spin-off firm from university
 - (b) other new start-up firm
 - (c) existing firm/organisation relocated from elsewhere
 - (d) part of a university department
 - (e) independent research institution
 - (f) other (Please, specify)
- 9 - Is this unit:
 - (a) an independent company
 - (b) a Sector/Dept/part of another company
 - (c) a subsidiary of British company
 - (d) a subsidiary of multinational
 - (e) other (eg university department)

[If the answer to question 9 is "b", "c" or "d", please answer questions 10-11; otherwise, go to question 12]

10 - Could you tell me some background information about the principal company?

- (a) Location
- (b) Year of Foundation
- (c) Main productive activity
- (d) Total employment (1992)
- (e) R&D Department
- (f) Total R&D employment (1992)
- (g) Total turnover
- (h) Total expenditure on R&D activity

11 - Then, in outline, what is the role of this unit on this Park in that set of wider company activities?

12 - What are the main reasons for this unit locating on this Science Park?

I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE ADVANTAGES FOR THIS UNIT FROM BEING LOCATED ON THIS PARK [QUEST.13-14]

13 - [PLEASE, SEE CARD 02] I have listed several possible advantages for this unit from being located here. Could you tell me how important these are to this unit **NOW** in terms of the categories shown underneath the list?

ADVANTAGES

- . Access to university research and consultancy
- . Access to university equipment
- . Access to university facilities
- . Recruitment of specialised R&D staff
- . Interaction with other companies already located on the Park
- . Infrastructure and support offered by the Park management
- . Environment of the region (eg economic, social and cultural amenities, housing opportunities)
- . Access to business services outside the Park but nearby
- . Special incentives offered by state or local Government
- . Others (Please, specify)

CATEGORIES

0 = No advantage at all

1 = little advantage - indirect advantage for the unit's activities

2 = moderate advantage - significant advantage for the development of the unit's activities

3 = a major advantage - crucial advantage for the development of the unit's activities

14 - We focus now on the first five items on the list. Have these always been as important for you as they are now? Which have become more or less important? Could you indicate for those what were the more important changes?

NOW, I WOULD LIKE TO FOCUS ON THE ACTIVITIES OF THIS UNIT [QUEST.15-16-17-18] [PLEASE, SEE CARD 03]

15 - Which of the following is the primary activity of this unit?

16 - Which other activities are also carried out here?

17 - What is the total number of employees in this unit?

18 - What percentage of the total employees are employed in each of these activities noted before?

NOW, CONSIDERING THE TYPES OF PRODUCT THIS UNIT IS CONCERNED WITH, I WOULD LIKE TO KNOW [QUEST.19-20] [PLEASE, SEE CARD 04]

19 - What types of product this unit is mainly concerned with? (Please, rank the three main types of product).

20 - What proportion of the unit's output is accounted for by each of those categories?

21 - [PLEASE, SEE CARD 05] What are the main markets for your products/services?

(a) local marketplace

(b) national marketplace

(c) international marketplace

- (d) Government Defence Institutions
- (e) Universities/Research Institutions
- (f) Other (Please, specify)

22 - [PLEASE, SEE CARD 06] What is the turnover of this unit?

- (a) 0 - £ 100,000
- (b) £ 100,001 - £ 500,000
- (c) £ 500,001 - £ 1 million
- (d) £ 1,000,001 - £ 5 million
- (e) £ 5,000,001 - £ 20 million
- (f) £ 20,000,001 - £ 50 million
- (g) more than £ 50 million

C - R&D ACTIVITIES OF THIS UNIT

NOW, I WOULD LIKE TO TALK ABOUT THE UNIT'S R&D ACTIVITIES [QUEST.23-32]

23 - Remind me, did you indicate earlier whether this unit does or does not do any R&D activity?

24 - [If NO R&D is present] - How does this unit develop new products/solve technical problems?

25 - [If R&D is present] - Broadly, what kind of R&D activity is undertaken, for what general purposes or objectives?

26 - How is the unit's R&D activity organised?

- (a) mainly full-time specialised unit
- (b) mainly part-time by staff with other responsibilities

[IF (a), go to questions 27-29; IF (b), go to questions 30-31]

[FULL TIME SPECIALISED UNIT]

27 - Please, could you tell me the total current R&D staff number, and their qualifications?

28 - **[PLEASE, SEE CARD 07]** Is it possible to classify your R&D activity into these categories? What has been the proportion of each category?

- (a) Basic Research
- (b) Strategic Research
- (c) Development of a new product
- (d) Development of a new process
- (e) Improvement of an existing product
- (f) Improvement of an existing process
- (g) New managerial techniques
- (h) Other (Please, specify)

29 - What is the percentage of the unit's turnover allocated to R&D activity?
[PLEASE, SEE CARD 08 IF IT IS NECESSARY]

[GO TO QUESTION 32]

[PART-TIME STAFF WITH OTHER RESPONSIBILITIES]

30 - **[PLEASE, SEE CARD 07]** Is it possible to classify your R&D activity into these categories? What has been the proportion of each category?

- (a) Basic Research
- (b) Strategic Research
- (c) Development of a new product
- (d) Development of a new process
- (e) Improvement of an existing product
- (f) Improvement of an existing process
- (g) New managerial techniques
- (h) Other (Please, specify)

31 - Approximately, what is the percentage of the unit's turnover allocated to this part-time R&D activity? **[PLEASE, SEE CARD 08 IF IT IS NECESSARY]**

[GO TO QUESTION 32]

32 - [PLEASE, SEE CARD 09] What have been the main sources of financial support for the R&D activities of this unit over the last two years? What have been the percentage of these?

- (a) Own capital of the unit
- (b) Bank loans
- (c) Government grants
- (d) Government defence budget
- (e) Non-profitable institutions
- (f) Venture capital
- (g) International institutions
- (h) Other (Please, specify)

D - UNIT'S EXTERNAL LINKS

PART I - UNIT AND HOST UNIVERSITY

I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE LINKS THAT MAY EXIST BETWEEN THIS UNIT AND THE HOST UNIVERSITY [QUEST.33-108]

[PLEASE, SEE CARD 10] - I have listed a number of different kinds of possible links on this card

LINKS

GROUP I - INFORMAL LINKS

1. Personal contact with university academic staff
2. Access to specialised literature
3. Access to university department research
4. Attendance at seminars and conferences
5. Access to university equipment
6. Attendance to specific education/training programmes
7. Other Informal links (Please, specify)

GROUP II - HUMAN RESOURCES LINKS

1. Students involvement in projects
2. Recruitment of recent graduates
3. Recruitment of more experienced scientists and engineers
4. Formally organised training for firm's personnel in university
5. Other Human Resources links (Please, specify)

GROUP III - FORMAL LINK

1. Engagement of university academic staff for consultancy
2. Analysis and testing in university departments
3. Establishment of research contract
4. Establishment of joint research
5. Other Formal links (Please, specify)

33 - Has this unit been involved in any of these links during the last 2 years?

[If NO, answer questions 34-35-36 and go to Part II, pg.21]

34 - Has this unit been involved in any of these links before (the last 2 years)?

35 - Why has this interaction been interrupted?

36 - Would you have wanted to maintain these links? Why?

[If YES, go to question 37 onwards]

37 - Have these links been of the type in:

GROUP I [Informal]

YES NO [If YES, go to Q.38 - pg.10]

GROUP II [Human Resources]

YES NO [If YES, go to Q.46 - pg.11]

GROUP III [Formal]

YES NO [If YES, go to Q.53 - pg.14]

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE LINKS LISTED IN GROUP I
[PLEASE, SEE CARD 11]

GROUP I - INFORMAL LINKS

1. Personal contact with university academic staff
2. Access to specialised literature
3. Access to university department research
4. Attendance at seminars and conferences
5. Access to university equipment
6. Attendance to specific education/training programmes
7. Other Informal links (Please, specify)

CATEGORIES

(a) Frequency

0 = twice a year or less frequently

1 = around 3-6 times per year

2 = about once per month

3 = about once per week or more frequently



(b) Activity/Department in the unit

- a = Research
- b = Development
- c = Design
- d = Production Engineering and Implementation
- e = Production and Manufacturing
- f = Distribution and Marketing

(c) Type of Output

- a = Verbal advice
- b = Provision of information
- c = Advisory report
- d = Implementation of a particular program
- e = Design specification
- f = Prototypes
- g = Other (Please, specify)

(d) Importance/Benefits

- 0 = no important
- 1 = little important: peripheral benefit for the development of this unit's activities
- 2 = important: direct benefit to complement the development of this unit's activities
- 3 = very important: crucial benefit for the development of this unit's activities

38 - Which of these links has this unit been involved in during the last 2 years?

NOW, USING THE CATEGORIES SHOWN UNDERNEATH THE LIST, COULD YOU TELL ME

39 - How frequent have these links been?

40 - Which of these unit's activities/departments have been most involved in these links?

41 - Which of the **host** university's departments have been involved in these links?

42 - Which has usually been the type of output?

43 - How important have these links been to this unit?

44 - Did any of these links exist **before** this unit was located here?

45 - Is it important to be located **ON** this Science Park in order to establish these links/gain these benefits? [YES/NO -> comments].

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE LINKS LISTED IN GROUP II [PLEASE, SEE CARD 12]

GROUP II - HUMAN RESOURCES LINKS

1. Students involvement in projects
2. Recruitment of recent graduates
3. Recruitment of more experienced scientists and engineers
4. Formally organised training of firm's personnel in university
4. Other relating to personnel/manpower (Please, specify)

CATEGORIES

(a) Activity/Department in the unit

- a = Research
- b = Development
- c = Design
- d = Production Engineering and Implementation
- e = Production and Manufacturing
- f = Distribution and Marketing

(b) Significance/Benefits

- 0 = no important
- 1 = little important: peripheral benefit for the development of this unit's activities
- 2 = important: direct benefit to complement the development of this unit's activities
- 3 = very important: crucial benefit for the development of this unit's activities

46 - Which of these links has this unit been involved in during the last 2 years?

47 - How many student-projects has this unit committed during the last 2 years?

48 - How many recent graduates or more experienced scientists and engineers have been employed by this unit during the last 2 years?

NOW, USING THE CATEGORIES SHOWN UNDERNEATH THE LIST, COULD YOU TELL ME

49 - In which of this unit's activities/departments have these people worked?

50 - How important have these links been to this unit?

51 - Did any of these links exist before this unit was located here?

52 - Is it important to be located ON this Science Park in order to establish these links/gain

these benefits? [YES/NO -> comments].

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE LINKS LISTED IN GROUP III [PLEASE, SEE CARD 13]

GROUP III - FORMAL LINKS

1. Engagement of university academic staff for consultancy
2. Analysis and testing in university departments
3. Establishment of research contract
4. Establishment of joint research
5. Other related to consult./testing/research (Please, specify)

CATEGORIES

(a) Activity/Department in the unit

- a = Research
- b = Development
- c = Design
- d = Production Engineering and Implementation
- e = Production and Manufacturing
- f = Distribution and Marketing

(b) Type of Output

- a = Verbal advice
- b = Provision of information
- c = Advisory report
- d = Implementation of a particular program
- e = Design specification
- f = Prototypes
- g = Other (Please, specify)

(c) Importance/Benefits

- 0 = not important
- 1 = little important: marginal contribution for the development of this unit's activities
- 2 = important: direct contribution for the development of this unit's activities
- 3 = very important: decisive contribution for the development of this unit's activities

COULD WE DEAL SEPARATELY WITH EACH CATEGORY IN CARD 13?

- I. Consultancy - Q.53 - 66 - pg. 14-15
- II. Analysis and Testing - Q.67 - 76 - pg. 16
- III. Research Contract - Q.77 - 91 - pg. 17-18
- IV. Joint Research - Q.92 - 108 - pg. 19-20

I. ENGAGEMENT OF UNIVERSITY ACADEMIC STAFF FOR CONSULTANCY

53 - Has this unit been involved with the **host** university academic staff for **consultancy**?

54 - How many projects have been active during the last 2 years?

55 - On average, how long have the consultancy projects lasted?

NOW, USING THE CATEGORIES SHOWN UNDERNEATH THE LIST, COULD YOU TELL ME

56 - Which of these unit's activities/departments have been mainly involved in these projects?

57 - Which of the **host** university's departments have been involved with?

58 - Which has usually been the type of output?

59 - How important has the **consultancy** been to this unit's activities?

60 - Is it important to be located **ON** this Science Park in order to establish consultancy/gain these benefits? [YES/NO -> comments]

61 - Did consultancy with the **host** university exist before this unit was located here?

62 - Could you indicate the approximate total annual costs of consultancy activities during the last 2 years?

63 - How has the consultancy been established?

64 - Would you have hoped for stronger Consultancy links?

65 - Broadly, what have been the main obstacles faced by this unit in establishing consultancy links with the **host** university?

66 - In your opinion, what should be done to overcome these obstacles?

II. ANALYSIS AND TESTING IN UNIVERSITY DEPARTMENTS

67 - Has this unit been involved in analysis and testing activities in the **host** university's departments?

68 - How many "applications" have been active during the last 2 years?

69 - On average, how long have the "applications" lasted?

NOW, USING THE CATEGORIES SHOWN UNDERNEATH THE LIST, COULD YOU TELL ME

70 - Which of these unit's activities/departments have been mainly involved in these "applications"?

71 - Which of the **host** university's departments have been involved in these test/analysis projects?

72 - Which has usually been the type of output?

73 - How important have the analysis and testing applications been to this unit's activities?

74 - Is it important to be located ON this Science Park in order to establish analysis and testing activities/gain these benefits? [YES/NO -> comments]

75 - Did analysis and testing activities with the **host** university exist before this unit was located here?

76 - Could you indicate the approximate annual costs of analysis and testing applications done for this unit in the **host** university departments during the last 2 years?

III. ESTABLISHMENT OF CONTRACTED RESEARCH

77 - Has this unit established any contracted research with the **host** university?

78 - Did this link exist before this unit was located here?

79 - How many contracted researches with the **host** university have been established during

the last 2 years?

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT A TYPICAL EXAMPLE OF CONTRACTED RESEARCH ESTABLISHED BETWEEN THIS UNIT AND THE HOST UNIVERSITY

80 - When did this research contract start? [Is it finished? When will it be finished?]

NOW, USING THE CATEGORIES SHOWN UNDERNEATH THE LIST, COULD YOU TELL ME

81 - Which of this unit's activities/departments have been mainly involved in this research contract?

82 - Which of the host university's departments have been involved in?

83 - How many scientists/engineers have been worked in this research?

84 - Which has usually been the type of output?

85 - How important has the establishment of research contract been to this unit's activities?

86 - Is it important to be located ON this Science Park in order to establish research contract with the host university? [YES/NO -> comments]

87 - Could you indicate the approximate total annual costs of this research research for this unit?

88 - How has the research contract been established?

89 - Would you have wanted more intensive research contract links?

90 - Broadly, what have been the main obstacles faced by this unit in establishing research contract links with the host university?

91 - In your opinion, what should be done to overcome these obstacles?

IV. ESTABLISHMENT OF JOINT RESEARCH



92 - Has this unit established any joint research with the **host** university?

93 - Did this link exist before this unit was located here?

94 - How many joint research projects with the **host** university have been established during the last 2 years?

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT A TYPICAL EXAMPLE OF JOINT RESEARCH ESTABLISHED BETWEEN YOUR UNIT AND THE HOST UNIVERSITY

95 - When did this joint research start? [Is it finished? When will it be finished?]

NOW, USING THE CATEGORIES SHOWN UNDERNEATH THE LIST, COULD YOU TELL ME

96 - Which of this unit's activities/departments have been mainly involved in this joint research?

97 - Which of the **host** university's departments have been involved in?

98 - Are there other universities involved in this project?

99 - Are there other firms involved in this project?

100- How many scientists/engineers have been worked in this project?

101- Which has usually been the type of output?

102- How important has the establishment of joint research been to this unit's activities?

103- Is it important to be located ON this Science Park in order to establish joint research with the **host** university? [YES/NO -> comments]

104- Could you indicate the approximate total annual costs of this joint research?

105- How has the joint research been established?

106- Did you want more intensive joint research projects links?

107- Broadly, what have been the main obstacles faced by this unit in establishing joint research projects with the host university?

108- In your opinion, what should be done to overcome these obstacles?

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE LINKS THAT MAY EXIST BETWEEN THIS UNIT AND OTHER UNIVERSITIES LOCATED ELSEWHERE [QUEST.108-126]

I have listed a number of different kinds of possible links on this card [PLEASE, SEE CARD 14]

LINKS

GROUP I - INFORMAL LINKS

1. Personal contact with university academic staff
2. Access to specialised literature
3. Access to university department research
4. Attendance at seminars and conferences
5. Access to university equipment
6. Attendance to specific education/training programmes
7. Other Informal links (Please, specify)

GROUP II - HUMAN RESOURCES LINKS

1. Students involvement in projects
2. Recruitment of recent graduates
3. Recruitment of more experienced scientists and engineers
4. Formally organised training of firm's personnel in university
5. Other relating to personnel/manpower (Please, specify)

GROUP III - FORMAL LINKS

1. Engagement of university academic staff for consultancy
2. Analysis and testing in university departments
3. Establishment of research contract
4. Establishment of joint research
5. Other related to consul./testing/research (Please, specify)

CATEGORIES

(a) Frequency

- 0 = twice a year or less frequently
- 1 = around 3-6 times per year
- 2 = about once per month
- 3 = about once per week or more frequently

(b) Activity/Department in the unit

- a = Research
- b = Development
- c = Design
- d = Production Engineering and Implementation
- e = Production and Manufacturing
- f = Distribution and Marketing

(c) Type of Output

- a = Verbal advice
- b = Provision of information
- c = Advisory report
- d = Implementation of a particular program
- e = Design specification
- f = Prototypes
- g = Other (Please, specify)

(d) Importance/Benefits

- 0 = not important
- 1 = little important: peripheral benefit for the development of this unit's activities
- 2 = important: direct benefit to complement the development of this unit's activities
- 3 = very important: crucial benefit for the development of this unit's activities

109- Has this unit been involved in any of these links during the last 2 years?

[If NO, answer questions 110-111-112 and go to Part III, pg. 25]

110- Has this unit been involved in any of these links before (the last 2 years)?

111- Why has this interaction been interrupted?

112- Would you have wanted to maintain these links? Why?

[If YES, go to question 113 onwards]

113- Which of these links has this unit been involved in during the last 2 years?

NOW, I AM GOING TO ASK SOME QUESTIONS CONCERNED WITH EACH GROUP OF LINKS SEPARATELY. PLEASE, USE THE CATEGORIES SHOWN UNDERNEATH THE LIST.

QUESTIONS - GROUP I AND/OR II

- 114- [ONLY GROUP I] - How frequent have these links been?
- 115- [ONLY GROUP II] - How many student-projects, recent graduates or more experienced scientists and engineers, or formally organised training programmes with/from other universities have been committed or employed by this unit during the last 2 years?
- 116- Which of these unit's activities/departments have been most involved in these links?
- 117- What have been the universities involved in these links?
- 118- Which has usually been the type of output?
- 119- How important have these links been to this unit?
- 120- What have been the main reasons for this unit establishes these links with these other Institutions?

QUESTIONS - GROUP III

- 121- How many consultancy/analysis and testing/research contract/joint research have been active with other universities during the last 2 years?

IF MORE THAN ONE PROJECT OF EACH ITEM IS PRESENT, PLEASE CHOOSE A TYPICAL EXAMPLE OF EACH ONE FOR ANSWERING THE FOLLOWING QUESTIONS

- 122- Which of these unit's activities/departments have been involved in these projects?
- 123- What have been the universities involved in these projects?
- 124- Is there other firm engaged in these activities?
- 125- How many scientists/engineers have been worked in these projects?

126- Which have usually been the types of output?

127- How important have the implementation of these projects been to this unit?

128- What have been the main reasons for this unit establishes these links of Group III with these other Institutions?

E - SCIENCE PARK EVALUATION

129- In your opinion, what have been the best contributions of this Science Park for the development of the activities of your unit?

130- What have been the attitudes of the Park management to facilitate the links between this unit and the host university?

131- Considering the Park management, what have been the main obstacles face by this unit in developing its activities?

132- In your opinion, what should be done to overcome this/these obstacles?

133- How important is being located on this Science Park in relation to the unit's overall business activities?

Appendix 3 - RESEARCHERS QUESTIONNAIRE

RESEARCHERS QUESTIONNAIRE

A - IDENTIFICATION

1. Faculty
2. Department
3. Group
4. Interviewee

B - BACKGROUND INFORMATION ABOUT THE INTERVIEWEE

5. What is your background (first degree)?
6. In which University did you get it?
7. Year of Graduation?
8. What is your title?
9. In which University did you get it?
10. When did you start your activities in this Group/Department?
11. What is your position in this Department/University?
12. How long have you been in this position?
13. **[Please, see Card 01]** - Is it possible to classify your activities within this Group/Department into these categories? What have been the proportion of your time dedicated to each one of these activities?
 - (a) Teaching (undergraduate)
 - (b) Teaching (post-graduate)
 - (c) Supervision
 - (d) Basic/Fundamental Research
 - (e) Applied Research
 - (f) Strategic Research
 - (g) Consultancy
 - (h) Other (Please, specify)

C - LINKS

THIS PART OF THE QUESTIONNAIRE CONCERNS THE ACTIVITIES (LINKS) YOU MAY HAVE WITH FIRMS (INDUSTRY) LOCATED ON THE SURREY RESEARCH PARK AS WELL AS FIRMS LOCATED ELSEWHERE

PART I - RESEARCHER AND SURREY RESEARCH PARK FIRMS

[Please, see Card 02] - I have listed a number of different kinds of possible links on this card.

LINKS

GROUP I - "INFORMAL" LINKS

[These are links that occur without formal contracts, although small fees may be charged on an ad-hoc basis]

1. Informal contacts with industrial staff
2. Access to specialised technical reports
3. Access to industrial R&D
4. Access to industrial equipment
5. Small industrial donation of gifts or capital to your research [books, material, equipment]
6. Other "informal" links (Please, specify)

GROUP II - HUMAN RESOURCES AND SKILLS

[These are links related to the improvement and training of qualified manpower]

1. Students involvement in industrial projects
2. Industrial fellowships
3. Short period internship in industry
4. Formally organised training programmes for industrial personnel
5. Other related to human resources/skills (Please, specify)

GROUP III - "FORMAL" LINKS

[These are links that occur with formal contract - both commitment and payment of fees are previously established]

1. Consultancy
2. Use of industrial equipment
3. Analysis and testing in industry
4. Participation in/Establishment of Contract Research
5. Participation in/Establishment of Joint Collaborative Research
6. Other related to consultancy/research (Please, specify)



14. Have you been involved in any of these Groups of links during the last 2 years?

[if NO, answer questions 15-16-17 and go to Part II, pg. 18]

15. Have you been involved in any of these links before (the last 2 years)?

16. Why has this interaction been interrupted?

17. Would you have wanted to maintain these links? Why?

[if YES, go to question 18 onwards]

18. Have these links been of the type in:

Group I [Informal]

YES NO [if YES, go to Q. 19 - pg.06]

Group II [Human Resources and Skills]

YES NO [if YES, go to Q. 33 - pg.08]

Group III [Formal]

YES NO [if YES, go to Q. 45 - pg.11]

NOW, I WOULD LIKE TO ASK SOME QUESTIONS CONCERNING LINKS LISTED IN GROUP 1 [Please, see Card 03]

GROUP 1 - "INFORMAL" LINKS

1. Informal contacts with industrial staff
2. Access to specialised technical reports
3. Access to industrial R&D
4. Access to industrial equipment
5. Industrial donation of gifts or capital to your research [books, material, equipment]
6. Other "informal" links (Please, specify)

CATEGORIES

(A) Frequency	(B) Size of Firm	(C) Status of Firm	(D) Types of Products
0=twice a year or less frequently	1=less than 25 empl.	1=Independent firm	1=Communication
1=around 3-6 times per year	2=26 - 50 empl.	2=Dept/Div. of another firm	2=Computer related-hardware
2=about once per month	3=51 - 200 empl.	3=Subsidiary of a British firm	3=Computer related-software
3=about once per week or more frequently	4=201 - 600 empl.	4=Subsidiary of multinational	4=Other Electronics related
	5=601 - 1500 empl.	5=Other (Please, specify)	5=Medical/health related prod.and serv.
	6=1501 - 5000 empl.		6=Other Mol.Biol/Gen.Engineer.
	7=more than 5000 empl.		7=Energy
			8=Consumer related
			9=Industrial products
			10=Other (Please, specify)
(E) Dept/Div. of Firm	(F) Types of Output	(G) Significance/Benefits	
1=Research	1=Verbal advice	0=No significant benefit	
2=Development	2=Provision of Information	1=Little significant benefit: peripheral benefit for the development of my activities/research	
3=Design	3=Advisory report	2=Significant benefit: direct benefit to complement the development of activities/research	
4=Prod.Eng./Implementation	4=Publications	3=Very significant benefit: crucial benefit for the development of my activities/research	
5=Prod. and Manufacturing	5=Impl.particular program		
	6=Design specification		
	7=Prototypes		
	8=Other		

[PLEASE, USE THE CATEGORIES SHOWN UNDERNEATH THE LIST WHEN APPROPRIATE]

19. Which of these links have you been involved in during the last 2 years?

20. How many firms have been involved in these links?

IF YOU HAVE HAD THESE LINKS WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

21. How frequent have these links been? [cat. A]

22. Do you know what the size of this firm is? [cat. B]

23. Do you know what the status of this firm is? [cat. C]

24. What types of products is this firm mainly concerned with? [cat. D]

25. Which departments or divisions within the firm are involved in these links? [cat. E]

26. Which has been the type of output (for you or your Group/Dept)? [cat. F]

27. How significant have these links been for you (your research)? [cat. G]

28. Did any of these links with this firm exist before the establishment of the Surrey Research Park?

29. Was the establishment of the Surrey Research Park important in order to have these links? [YES/NO -> Comments]

30. What have been the main reasons for you in establishing these links?

31. What have been the main obstacles you have faced in establishing such links?

32. In your opinion, what should be done to overcome these obstacles?

NOW, I WOULD LIKE TO ASK SOME QUESTIONS CONCERNING THE LINKS IN GROUP II [Please, see Card 04]

GROUP II - HUMAN RESOURCES AND SKILLS

1. Students involvement in industrial projects
2. Industrial fellowships
3. Short period internship in industry
4. Formally organised training programmes for industrial personnel
5. Other related to human resources/skills (Please, specify)

CATEGORIES

(A) Frequency	(B) Types of Products	(C) Dept/Div. of Firm	(D) Types of Output
0=twice a year or less frequently	1=Communication	1=Research	1=Verbal advice
1=around 3-6 times per year	2=Computer related-hardware	2=Development	2=Provision of inform.
2=about once per month	3=Computer related-software	3=Design	3=Advisory report
3=about once per week or more frequently	4=Other Electronics related	4=Prod. Eng./Implementation	4=Publications
	5=Medical/health related prod/services	5=Prod. and Manufacturing	5=Impl. part. program
	6=Other Mol. Biol./Gen. Engineering		6=Design specification
	7=Energy		7=Prototypes
	8=Consumer related		8=Other (Please, specify)
	9=Industrial Product		
	10=Other (Please, specify)		

(E) Significance/Benefits

- 0=No significant benefit
- 1=Little significant benefit: peripheral benefit for the development of my activities/research
- 2=Significant benefit: direct benefit to complement the development of my activities/research
- 3=Very Significant benefit: crucial benefit for the development of my activities/research

[PLEASE, USE THE CATEGORIES SHOWN UNDERNEATH THE LIST WHEN APPROPRIATE]

33. Which of these links have you been involved in during the last 2 years?

34. How many firms have been involved in these links?

IF YOU HAVE HAD THESE LINKS WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

35. How many student-projects have been committed by this firm during the last 2 years?

36. How many industrial fellowships have been received during the last 2 years?

37. How many short period internship on this firm have you had during the last 2 years?

38. How frequent have these links been? [cat. A]

39. What types of products is this firm mainly concerned with? [cat. B]

40. Which departments or divisions within the firm are involved in these links? [cat. C]

41. Which has been the type of output (for you or your Group/Dept)? [cat. D]

42. How significant have these links been to you (your research)? [cat. E]

43. Did any of these links with this firm exist before the establishment of the Surrey Research Park?

44. Was the establishment of the Surrey Research Park important in order to have these links?

[YES/NO -> Comments]

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE LINKS LISTED IN GROUP III [Please, see Card 05]

GROUP III - FORMAL LINKS

1. Consultancy
2. Use of industrial equipment
3. Analysis and testing in industry
4. Participation in/Establishment of Contract Research
5. Participation in/Establishment of Joint Collaborative Research
6. Other related to consultancy/research (Please, specify)

CATEGORIES

(A) Frequency	(B) Size of Firm	(C) Status of Firm	(D) Types of Products
0=twice a year or less frequently	1=less than 25 empl.	1=Independent firm	1=Communication
1=around 3-6 times per year	2=26 - 50 empl.	2=Dept/Div. of another firm	2=Computer related-hardware
2=about once per month	3=51 - 200 empl.	3=Subsidiary of a British firm	3=Computer related-software
3=about once per week or more frequently	4=201 - 600 empl.	4=Subsidiary of multinational	4=Other Electronics related
	5=601 - 1500 empl.	5=Other (Please, specify)	5=Medical/health related prod.and serv.
	6=1501 - 5000 empl.		6=Other Mol.Biol/Gen. Engineer.
	7=more than 5000 empl.		7=Energy
			8=Consumer related
			9=Industrial products
			10=Other (Please, specify)
(E) Dept/Div. of Firm	(F) Types of Output	(G) Significance/Benefits	
1=Research	1=Verbal advice	0=No significant benefit	
2=Development	2=Provision of Information	1=Little significant benefit: peripheral benefit for the development of my activities/research	
3=Design	3=Advisory report	2=Significant benefit: direct benefit to complement the development of activities/research	
4=Prod.Eng./Implementation	4=Publications	3=Very significant benefit: crucial benefit for the development of my activities/research	
5=Prod. and Manufacturing	5=Impl.particular program		
	6=Design specification		
	7=Prototypes		
	8=Other (Please, specify)		

COULD WE DEAL SEPARATELY WITH EACH CATEGORY IN CARD 05?

[PLEASE, USE THE CATEGORIES SHOWN UNDERNEATH THE LIST WHEN APPROPRIATE]

I. CONSULTANCY

45. Have you been involved in Consultancy with firms located on the Surrey Research Park during the last 2 years?

46. How many firms have been involved in this link?

IF YOU HAVE HAD THIS LINK WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

47. How many projects have been active during the last 2 years?

48. On average, how long have these consultancy projects lasted?

49. How frequent have these consultancy projects been? [cat. A]

50. Do you know what the size of this firm is? [cat. B]

51. Do you know what the status of this firm is? [cat. C]

52. What types of products is this firm mainly concerned with? [cat. D]

53. Which departments or divisions within the firm are involved in this link? [cat. E]

54. Which has been the type of output (for you or your Group/Dept)? [cat. F]

55. How significant have these Consultancy activities been to you (your research)? [cat. G]

56. Did your consultancy activities with this firm exist before the establishment of the Surrey Research Park?

57. Was the establishment of the Surrey Research Park important in order to establish Consultancy links? [YES/NO -> Comments]

58. Could you indicate the approximate total annual financial benefits you have had from your Consultancy activities with this firm during the last 2 years? [Pls, see Card 06]

59. Have these benefits been shared with other members of your Group/Department and the University? In which proportion?

60. How have your Consultancy links been established?

61. Would you hope for stronger Consultancy links with firms located on the Surrey Research Park?

62. What have been the main reasons for you in establishing such Consultancy links?

63. Have your Consultancy links altered your research agenda? In which sense?

64. What have been the main obstacles you have faced in establishing such links?

65. In your opinion, what should be done to overcome these obstacles?

II. INDUSTRIAL EQUIPMENT

66. Have you been involved in the use of industrial equipment with the Surrey Research Park firms during the last 2 years?

67. How many links of this type have been active during the last 2 years?

68. How many firms have been involved in links of this type?

69. How significant has been the use of industrial equipment for you/your research? [cat. G]

70. Did this link with these firms exist before the establishment of the Surrey Research Park?

71. Was the establishment of the Surrey Research Park important in order to establish this link? [YES/NO -> Comments]

72. What have been the main reasons for you in establishing the use of industrial equipment link with firms located on the Surrey Research Park?

73. What have been the main obstacles you have faced in establishing such link?

74. In your opinion, what should be done to overcome these obstacles?

III. ANALYSIS AND TESTING

75. Have you been involved in analysis and testing with the Surrey Research Park firms during the last 2 years?

76. How many links of this type have been active during the last 2 years?

77. How many firms have been involved in links of this type?

78. How significant has been analysis and testing within these firms for you/your research? [cat. G]

79. Did this link with these firms exist before the establishment of the Surrey Research Park?

80. Was the establishment of the Surrey Research Park important in order to establish this link? [YES/NO -> Comments]

81. What have been the main reasons for you in establishing analysis and testing links with firms located on the Surrey Research Park?

82. What have been the main obstacles you have faced in establishing such links?

83. In your opinion, what should be done to overcome these obstacles?

IV. CONTRACT RESEARCH

84. Have you been involved in Contract Research agreements with the Surrey Research Park firms during the last 2 years?

85. How many firms have been involved in these links?

IF YOU HAVE HAD CONTRACT RESEARCH AGREEMENTS WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

86. How many Contract Research agreements have been active during the last 2 years?

87. On average, how long have these Contract Research agreements lasted?

88. How frequent have these Contract Research agreements been? [cat. A]

89. Do you know what the size of this firm is? [cat. B]

90. Do you know what the status of this firm is? [cat. C]

91. What types of products is this firm mainly concerned with? [cat. D]

92. Which departments or divisions within the firm are involved in these links? [cat. E]

93. Are there other Groups/Departments involved in these links? Which Departments?

94. Which has been the type of output (for you or your Group/Dept)? [cat. F]

95. How significant have these Contract Research agreements been to you (your research)? [cat. G]

96. Did these Contract Research agreements with this firm exist before the establishment of the Surrey Research Park?

97. Was the establishment of the Surrey Research Park important in order to establish Contract Research agreements? [YES/NO -> Comments]

98. Could you indicate the approximate annual costs and financial benefits you have had with these Contract Research agreements during the last 2 years? [Please, see Card 06]

99. Have these costs and financial benefits been shared with other members of your Group/Department and the University? In which proportion?

100. How have these Contract Research agreements been established?

101. Would you hope for stronger Contract Research agreements with firms located on the Surrey Research Park?

102. What have been the main reasons for you in establishing such Contract Research agreements with firms located on the Surrey Research Park?

103. Have your Contract Research agreements altered your research agenda? In which sense?

104. What have been the main obstacles you have faced in establishing Contract Research agreements links?

105. In your opinion, what should be done to overcome these obstacles?

V. JOINT COLLABORATIVE RESEARCH

106. Have you been involved in Joint Collaborative Research agreements with the Surrey Research Park firms during the last 2 years?

107. How many firms have been involved in this link?

IF YOU HAVE HAD THIS LINK WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

108. How many Joint Collaborative Research agreements have been active during the last 2 years?

109. On average, how long have the Joint Collaborative Research agreements lasted?

110. How frequent have these Joint Collaborative Research agreements been? [cat. A]

111. Do you know what the size of this firm is? [cat. B]

112. Do you know what the status of this firm is? [cat. C]

113. What types of product is this firm mainly concerned with? [cat. D]

114. Which departments or divisions within the firm are involved in these links? [cat. E]

115. Are there other Groups/Departments involved in these agreements? Which Departments?

116. Which has been the type of output (for you or your Group/Dept)? [cat. F]

117. How significant have Joint Collaborative Research agreements been to you (your research)? [cat. G]

118. Did these Joint Collaborative Research agreements with this firm exist before the establishment of the Surrey Research Park?

119. Was the establishment of the Surrey Research Park important in order to establish Joint research agreements? [YES/NO -> Comments]

120. Could you indicate the approximate annual costs and financial benefits you have had with Joint Collaborative Research agreements during the last 2 years? [Please, see Card 06]

121. Have these costs and financial benefits been shared with other members of your Group/Department and the University? In which proportion?

122. How have the Joint Collaborative Research agreements been established?

123. Would you hope for stronger Joint Collaborative Research agreements with firms located on the Surrey Research Park?

124. What have been the main reasons for you in establishing these Joint Research agreements?

125. Have these Joint Research agreements altered your research agenda? In which sense?

126. What have been the main obstacles you have faced in establishing Joint Research agreements with firms located on the Surrey Research Park?

127. In your opinion, what should be done to overcome these obstacles?

PART II - RESEARCHER AND FIRMS LOCATED ELSEWHERE

[Please, see Card 02] - I have listed a number of different kinds of possible links on this card.

LINKS

GROUP I - "INFORMAL" LINKS

[These are links that occur without formal contracts, although small fees may be charged on an ad-hoc basis]

1. Informal contacts with industrial staff
2. Access to specialised technical reports
3. Access to industrial R&D
4. Access to industrial equipment
5. Small industrial donation of gifts or capital to your research [books, material, equipment]
6. Other "informal" links (Please, specify)

GROUP II - HUMAN RESOURCES AND SKILLS

[These are links related to the improvement and training of qualified manpower]

1. Students involvement in industrial projects
2. Industrial fellowships
3. Short period internship in industry
4. Formally organised training programmes for industrial personnel
5. Other related to human resources/skills (Please, specify)

GROUP III - "FORMAL" LINKS

[These are links that occur with formal contract - both commitment and payment of fees are previously established]

1. Consultancy
2. Use of industrial equipment
3. Analysis and testing in industry
4. Participation in/Establishment of research contract
5. Participation in/Establishment of joint research
6. Other related to consultancy/research (Please, specify)

128. Have you been involved in any of these Groups of links during the last 2 years?

[if NO, answer questions 129-130-131 and go to Section D, pg.33]

129. Have you been involved in any of these links before (the last 2 years)?

130. Why has this interaction been interrupted?

131. Would you have wanted to maintain these links? Why?

[if YES, go to question 132 onwards]

132. Have these links been of the type in:

Group I [Informal]

YES NO [if YES, go to Q. 133 - pg.22]

Group II [Human Resources and Skills]

YES NO [if YES, go to Q. 145 - pg.24]

Group III [Formal]

YES NO [if YES, go to Q. 155 - pg.27]

NOW, I WOULD LIKE TO ASK SOME QUESTIONS CONCERNING LINKS LISTED IN GROUP I [Please, see Card 03]

GROUP I - "INFORMAL" LINKS

1. Informal contacts with industrial staff
2. Access to specialised technical reports
3. Access to industrial R&D
4. Access to industrial equipment
5. Industrial donation of gifts or capital to your research [books, material, equipment]
6. Other "informal" links (Please, specify)



CATEGORIES

(A) Frequency	(B) Size of Firm	(C) Status of Firm	(D) Types of Products
0=twice a year or less frequently	1=less than 25 empl.	1=Independent firm	1=Communication
1=around 3-6 times per year	2=26 - 50 empl.	2=Dept/Div. of another firm	2=Computer related-hardware
2=about once per month	3=51 - 200 empl.	3=Subsidiary of a British firm	3=Computer related-software
3=about once per week or more	4=201 - 600 empl.	4=Subsidiary of multinational	4=Other Electronics related
	5=601 - 1500 empl.	5=Other (Please, specify)	5=Medical/health related prod.and serv.
	6=1501 - 5000 empl.		6=Other Mol.Biol/Gen.Engineer.
	7=more than 5000 empl.		7=Energy
			8=Consumer related
			9=Industrial products
			10=Other (Please, specify)
(E) Dept/Div. of Firm	(F) Types of Output	(G) Significance/Benefits	
1=Research	1=Verbal advice	0=No significant benefit	
2=Development	2=Provision of Information	1=Little significant benefit: peripheral benefit for the development of my activities/research	
3=Design	3=Advisory report	2=Significant benefit: direct benefit to complement the development of activities/research	
4=Prod.Eng./Implementation	4=Publications	3=Very significant benefit: crucial benefit for the development of my activities/research	
5=Prod. and Manufacturing	5=Impl.particular program		
	6=Design specification		
	7=Prototypes		
	8=Other (Please, specify)		

[PLEASE, USE THE CATEGORIES SHOWN UNDERNEATH THE LIST WHEN APPROPRIATE]

133. Which of these links have you been involved in during the last 2 years?

134. How many firms have been involved in these links?

IF YOU HAVE HAD THESE LINKS WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

135. How frequent have these links been? [cat. A]

136. Do you know what the size of this firm is? [cat. B]

137. Do you know what the status of this firm is? [cat. C]

138. What types of products is this firm mainly concerned with? [cat. D]

139. Which departments or divisions within the firm are involved in these links? [cat. E]

140. Which has been the type of output (for you or your Group/Dept)? [cat. F]

141. How significant have these links been for you (your research)? [cat. G]

142. What have been the main reasons for you in establishing these links?

143. What have been the main obstacles you have faced in establishing such links?

144. In your opinion, what should be done to overcome these obstacles?

NOW, I WOULD LIKE TO ASK SOME QUESTIONS CONCERNING THE LINKS IN GROUP II [Please, see Card 04]

GROUP II - HUMAN RESOURCES AND SKILLS

1. Students involvement in industrial projects
2. Industrial fellowships
3. Short period internship in industry
4. Formally organised training programmes for industrial personnel
5. Other related to human resources/skills (Please, specify)

CATEGORIES

(A) Frequency	(B) Types of Products	(C) Dept/Div. of Firm	(D) Types of Output
0=twice a year or less frequently	1=Communication	1=Research	1=Verbal advice
1=around 3-6 times per year	2=Computer related-hardware	2=Development	2=Provision of inform.
2=about once per month	3=Computer related-software	3=Design	3=Advisory report
3=about once per week or more frequently	4=Other Electronics related	4=Prod. Eng./Implementation	4=Publications
	5=Medical/health related prod/services	5=Prod. and Manufacturing	5=Impl. part. program
	6=Other Mol. Biol./Gen. Engineering		6=Design specification
	7=Energy		7=Prototypes
	8=Consumer related		8=Other (Please, specify)
	9=Industrial Product		
	10=Other (Please, specify)		

(E) Significance/Benefits

- 0=No significant benefit
- 1=Little significant benefit: peripheral benefit for the development of my activities/research
- 2=Significant benefit: direct benefit to complement the development of my activities/research
- 3=Very Significant benefit: crucial benefit for the development of my activities/research

[PLEASE, USE THE CATEGORIES SHOWN UNDERNEATH THE LIST WHEN APPROPRIATE]

145. Which of these links have you been involved in during the last 2 years?

146. How many firms have been involved in these links?

IF YOU HAVE HAD THESE LINKS WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

147. How many student-projects have been committed by this firm during the last 2 years?

148. How many industrial fellowships have been received during the last 2 years?

149. How many short period internship on this firm have you had during the last 2 years?

150. How frequent have these links been? [cat. A]

151. What types of products is this firm mainly concerned with? [cat. B]

152. Which departments or divisions within the firm are involved in these links? [cat. C]

153. Which has been the type of output (for you or your Group/Dept)? [cat. D]

154. How significant have these links been to you (your research)? [cat. E]

NOW, I WOULD LIKE TO ASK SOME QUESTIONS ABOUT THE LINKS LISTED IN GROUP III [Please, see Card 05]

GROUP III - FORMAL LINKS

1. Consultancy
2. Use of industrial equipment
3. Analysis and testing in industry
4. Participation in/Establishment of Contract Research
5. Participation in/Establishment of Joint Collaborative Research
6. Other related to consultancy/research (Please, specify)

CATEGORIES

(A) Frequency	(B) Size of Firm	(C) Status of Firm	(D) Types of Products
0=twice a year or less frequently	1=less than 25 empl.	1=Independent firm	1=Communication
1=around 3-6 times per year	2=26 - 50 empl.	2=Dept/Div. of another firm	2=Computer related-hardware
2=about once per month	3=51 - 200 empl.	3=Subsidiary of a British firm	3=Computer related-software
3=about once per week or more frequently	4=201 - 600 empl.	4=Subsidiary of multinational	4=Other Electronics related
	5=601 - 1500 empl.	5=Other (Please, specify)	5=Medical/health related prod.and serv.
	6=1501 - 5000 empl.		6=Other Mol.Biol/Gen.Engineer.
	7=more than 5000 empl.		7=Energy
			8=Consumer related
			9=Industrial products
			10=Other (Please, specify)
(E) Dept/Div. of Firm	(F) Types of Output	(G) Significance/Benefits	
1=Research	1=Verbal advice	0=No significant benefit	
2=Development	2=Provision of Information	1=Little significant benefit: peripheral benefit for the development of my activities/research	
3=Design	3=Advisory report	2=Significant benefit: direct benefit to complement the development of activities/research	
4=Prod.Eng./Implementation	4=Publications	3=Very significant benefit: crucial benefit for the development of my activities/research	
5=Prod. and Manufacturing	5=Impl.particular program		
	6=Design specification		
	7=Prototypes		
	8=Other (Please, specify)		



COULD WE DEAL SEPARATELY WITH EACH CATEGORY IN CARD 05?

[PLEASE, USE THE CATEGORIES SHOWN UNDERNEATH THE LIST WHEN APPROPRIATE]

I. CONSULTANCY

155. Have you been involved in Consultancy with firms located elsewhere during the last 2 years?

156. How many firms have been involved in this link?

IF YOU HAVE HAD THIS LINK WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

157. How many projects have been active during the last 2 years?

158. On average, how long have these consultancy projects lasted?

159. How frequent have these consultancy projects been? [cat. A]

160. Do you know what the size of this firm is? [cat. B]

161. Do you know what the status of this firm is? [cat. C]

162. What types of products is this firm mainly concerned with? [cat. D]

163. Which departments or divisions within the firm are involved in this link? [cat. E]

164. Which has been the type of output (for you or your Group/Dept)? [cat. F]

165. How significant have these Consultancy activities been to you (your research)? [cat. G]

166. Could you indicate the approximate total annual financial benefits you have had from your Consultancy activities with this firm during the last 2 years? [Please, see Card 06]

167. Have these benefits been shared with other members of your Group/Department and the University? In which proportion?

168. How have your Consultancy links been established?

169. What have been the main reasons for you in establishing such Consultancy links?

170. Have your Consultancy links altered your research agenda? In which sense?

171. What have been the main obstacles you have faced in establishing such links?

172. In your opinion, what should be done to overcome these obstacles?

II. INDUSTRIAL EQUIPMENT

173. Have you been involved in the use of industrial equipment with firms located elsewhere during the last 2 years?

174. How many links of this type have been active during the last 2 years?

175. How many firms have been involved in links of this type?

176. How significant has been the use of industrial equipment for you/your research? [cat. G]

177. What have been the main reasons for you in establishing the use of industrial equipment link with firms located elsewhere?

178. What have been the main obstacles you have faced in establishing such link?

179. In your opinion, what should be done to overcome these obstacles?

III. ANALYSIS AND TESTING

180. Have you been involved in analysis and testing with the firms located elsewhere during the last 2 years?

181. How many links of this type have been active during the last 2 years?

182. How many firms have been involved in links of this type?

183. How significant has been analysis and testing within these firms for you/your research?
[cat. G]

184. What have been the main reasons for you in establishing analysis and testing links with firms located elsewhere?

185. What have been the main obstacles you have faced in establishing such links?

186. In your opinion, what should be done to overcome these obstacles?

IV. CONTRACT RESEARCH

187. Have you been involved in Contract Research agreements with firms located elsewhere during the last 2 years?

188. How many firms have been involved in these links?

IF YOU HAVE HAD CONTRACT RESEARCH AGREEMENTS WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

189. How many Contract Research agreements have been active during the last 2 years?

190. On average, how long have these Contract Research agreements lasted?

191. How frequent have these Contract Research agreements been? [cat. A]

192. Do you know what the size of this firm is? [cat. B]

193. Do you know what the status of this firm is? [cat. C]

194. What types of products is this firm mainly concerned with? [cat. D]

195. Which departments or divisions within the firm are involved in these links? [cat. E]

196. Are there other Groups/Departments involved in these links? Which Departments?

197. Which has been the type of output (for you or your Group/Dept)? [cat. F]

198. How significant have these Contract Research agreements been to you (your research)? [cat. G]

199. Could you indicate the approximate annual costs and financial benefits you have had with these Contract Research agreements during the last 2 years? [Please, see Card 06]

200. Have these costs and financial benefits been shared with other members of your Group/Department and the University? In which proportion?

201. How have these Contract Research agreements been established?

202. What have been the main reasons for you in establishing such Contract Research agreements with firms located elsewhere?

203. Have your Contract Research agreements altered your research agenda? In which sense?

204. What have been the main obstacles you have faced in establishing Contract Research agreements links?

205. In your opinion, what should be done to overcome these obstacles?

V. JOINT COLLABORATIVE RESEARCH

206. Have you been involved in Joint Collaborative Research agreements with firms located elsewhere during the last 2 years?

207. How many firms have been involved in this link?

IF YOU HAVE HAD THIS LINK WITH MORE THAN ONE FIRM, PLEASE CHOOSE A TYPICAL EXAMPLE TO ANSWER THE FOLLOWING QUESTIONS. IF YOUR LINKS

OCCUR WITH VERY DIFFERENT TYPES OF FIRMS, THEN CHOOSE TWO TYPICAL EXAMPLES (e.g. high X low-technology or small X big firms)

208. How many Joint Collaborative Research agreements have been active during the last 2 years?

209. On average, how long have the Joint Collaborative Research agreements lasted?

210. How frequent have these Joint Collaborative Research agreements been? [cat. A]

211. Do you know what the size of this firm is? [cat. B]

212. Do you know what the status of this firm is? [cat. C]

213. What types of product is this firm mainly concerned with? [cat. D]

214. Which departments or divisions within the firm are involved in these links? [cat. E]

215. Are there other Groups/Departments involved in these agreements? Which Departments?

216. Which has been the type of output (for you or your Group/Dept)? [cat. F]

217. How significant have Joint Collaborative Research agreements been to you (your research)? [cat. G]

218. Could you indicate the approximate annual costs and financial benefits you have had with Joint Collaborative Research agreements during the last 2 years? [Please, see Card 06]

219. Have these costs and financial benefits been shared with other members of your Group/Department and the University? In which proportion?

220. How have the Joint Collaborative Research agreements been established?

221. What have been the main reasons for you in establishing these Joint research agreements?

222. Have these joint research agreements altered your research agenda? In which sense?



223.What have been the main obstacles you have faced in establishing joint research agreements with firms located elsewhere?

224.In your opinion, what should be done to overcome these obstacles?

D - EVALUATION - UNIVERSITY/INDUSTRY LINKS AND RESEARCH PARK

225.Broadly, what have been the main stimuli and obstacles you have faced in your activities with industry?

226.What have been the attitudes of your Group/Department and University concerning the links between University/Industry?

227.In your opinion, what have been the contribution of the establishment of the Surrey Research Park by this University for the development or strengthening of the links between University/Industry?

228.How do you evaluate the attitudes of the Park management in stimulating or not the interaction between you (your Group/Dept) and the firms located on the Park?

229.How important are your links with industry for the development of your activities/research?



R&D activity has not still fulfilled such expectation. 33% of the firms that took part of this field work do not develop any R&D activity. Moreover, such activity is a primary activity for only 19% of the tenants and only 10% have been engaged in basic research activity, limiting, in this way, the possibilities of interaction with universities.

After this description concerning the on-Surrey Park firms characteristics and R&D activities, the next Chapter turns to the main topic of this research: the links that exist between this sample of firms and the host University and other university located elsewhere.