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# *ECONOMIC INTELLIGENCE*

# *IN*

# *UNIVERSITY-INDUSTRY INTERACTIONS*

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Aos meus Pais,
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## Abstract.

The relevance of researching the role of University-Industry interactions (and, in particular, the exploitation of R&D results) in the context of regional development is due to the following facts:

1. Technical change is the driving force behind economic development;
2. Community efforts to improve the innovative potential of European economy have to be met with regional innovation strategies in a context of regional development policies;
3. Europe has a limited capacity to convert scientific and technological (S&T) potential into industrial and commercial success (i.e. viable innovations).

This dissertation will show that:

- The exploitation of R&D results is a key factor in strengthening the regional dimension of innovation; however,
- University-industry interactions, according to the new paradigm of technical change, should follow a demand-pull route instead of a technology-push one.

The (apparent) contradiction of the above facts leads to the necessity of applying economic intelligence to university-industry interactions in order to contribute to sustainable regional economic development.

Therefore, this dissertation proposes and defines a regional economic intelligence system to regulate and improve the effectiveness of university-industry interactions (in particular, the exploitation of R&D results), with the objective of allowing the region to adapt S&T policies to changing technological demands on a continuous basis.

This dissertation, by applying the concept of economic intelligence in university-industry interactions, for a more in-depth analysis of the role of a regional innovation system in the context of regional economic development:

1. It systematises and details concepts present in existing literature regarding regional innovation systems and strategies, namely that requires the set-up of special infra-structures, such as a regional innovation observatory, environmental scanning mechanisms, and innovation support organisations (ISOs).
2. In particular, it shows that (regional) governments and ISOs have to have a more interventionist role in the regional innovation system than previously proposed.

In addition, this dissertation highlights two other aspects regarding the REIS, namely:

3. The dissemination of information to promote the exploitation of R&D results should be based on two different technology transfer mechanisms (electronic diffusion and point-to-point transfer); and
4. There is no suitable methodology to measure the innovation profile of SMEs which hinders the evaluation of the effectiveness of the regional economic intelligence system in developing the innovative capacity of the SMEs, and, ultimately, the coherence of the REIS and the regional policies.

## Resumo.

A importância de analisar o papel de interacções Universidade-Empresa (e, em particular, a valorização de resultados de I&D) no âmbito do desenvolvimento regional deve-se aos seguintes factos:

1. A mudança tecnológica é o factor central do desenvolvimento económico;
2. Os esforços comunitários para incrementar a capacidade de inovação da economia Europeia têm de ser suportados por estratégias regionais de inovação no âmbito de políticas de desenvolvimento regional;
3. A Europa tem uma capacidade limitada em transformar potencial científico e tecnológico em sucessos industriais e comerciais (isto é, inovações rentáveis).

Esta dissertação mostrará que:

- A valorização de resultados de I&D é um factor chave no reforço da dimensão regional da inovação; no entanto,
- As interacções Universidade-Empresa, de acordo com o novo paradigma da mudança tecnológica, devem orientar-se segundo as necessidades do mercado (modelo *demand-pull*) e não ter origem na Ciência e Tecnologia – C&T (modelo *technology-push)*.

Esta contradição (aparente), cria a necessidade de aplicar 'inteligência económica' às interacções universidade-empresa, de forma, a contribuir para um desenvolvimento económico sustentado a nível regional.

Assim, esta dissertação propõe e define um sistema de inteligência económica regional (SIER) para regular e melhorar a eficácia das interacções universidade-empresa (em particular, a exploração de resultados de I&D), com o objectivo de permitir à região adaptar políticas de C&T às mudanças das necessidades tecnológicas do mercado.

Esta dissertação, ao aplicar o conceito de inteligência económica a interacções universidade-empresa, analisa com maior profundidade o papel dos sistemas de inovação regionais no desenvolvimento económico regional:

1. Sistematiza e detalha conceitos presentes na literatura existente sobre sistemas e estratégias de inovação regionais, nomeadamente a necessidade de implementar infra-estruturas especiais, tais como, observatório regional de inovação, mecanismos de prospecção, e organizações de apoio à inovação (OAI);
2. Em particular, demonstra a necessidade de uma maior intervenção dos governos (regionais) e das OAI nos sistemas de inovação regionais.

Este trabalho salienta, ainda, dois outros aspectos importantes quanto ao SIER:

3. A disseminação de informação para promover a exploração de resultados de I&D deve basear-se em dois mecanismos de transferência de tecnologia (difusão electrónica e 'ponto-a-ponto');
4. Não existe uma metodologia apropriada para medir o perfil de inovação das PMEs, o que põe em causa a avaliação da eficácia do SIER em melhorar a capacidade de inovação das mesmas, e, em última instância, a coerência do SIER e das políticas de C&T.

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# CHAPTER I - INTRODUCTION

## 1. The purpose of this dissertation

This dissertation will address the application of economic intelligence to University-Industry interactions - focusing, in particular, on the exploitation of R&D results - within the context of regional development policies.

The importance of analysing economic intelligence in university-industry interactions emerges from the recognition that:

- Innovation is the driving force behind sustainable economic development, and
- The exploitation of R&D results is a key factor in strengthening the regional dimension of innovation.

Moreover, there is a pressing need to research economic intelligence in university-industry interactions due, basically, to the following facts:

- regions all over the European Union are conducting the definition, implementation and monitoring of Regional Innovation Strategies (such as the North Portugal region), and
- economic intelligence stands as the corollary to the overall approach on European innovation formulated by the Green Paper of Innovation [EC-DGXIII, 1995].

The author's personal interest in this domain results from the fact that, professionally, she plays the role as:

- technology transfer director of TecMinho (an university-industry interface of Universidade do Minho) for the past five years, and, more recently also as,
- co-ordinator of the Gallaecia Innovation Relay Centre (institution promoted by the European Commission, and hosted by TecMinho, to promote the transfer of R&D results and technologies in accordance with the needs expressed by the local industry).

Hence, the author has to address the demanding question of how to manage technology transfer to promote the competitiveness of local industry through innovation on a day-to-day basis.

This work will thus present a regional economic intelligence system designed to regulate and improve the effectiveness of university-industry interactions (in particular, the exploitation of R&D results) aiming at the development of the innovative capacity of local industry, especially SMEs (Small and Medium sized Enterprises), by, in a concerted way, defining, implementing, updating and evaluating:

- Science and Technology (S&T) policies, targeted at research institutions, namely universities, to better direct research efforts to market demands, and
- Technology management policies to improve SMEs' approach to innovation.

## 2. Background

### 2.1 The Green Paper of Innovation

The Green Paper of Innovation [EC-DGXIII, 1995] proposes an overall approach to innovation in Europe based on 13 routes of action:

1. Develop technology monitoring and foresight,
2. Better direct research efforts towards innovation,
3. Develop initial and further training,
4. Further the mobility of students and researchers,
5. Promote recognition of the benefits of innovation,
6. Improve the financing of innovation,
7. Set-up fiscal regime beneficial to innovation,
8. Promote intellectual and industrial property,
9. Simplify administrative procedures,
10. Set-up a favourable legal and regulatory framework,
11. Develop 'economic intelligence' actions,
12. Encourage innovation in enterprises, especially SMEs (Small and Medium-sized Enterprises), and strengthen the regional dimension of innovation,
13. Update public action for innovation.

This dissertation will focus, as stated, on route actions n° 11 and 12, namely on how to:

- Develop economic intelligence actions – targeted at university-industry interactions,
- Promote innovation in SMEs, and
- Strengthen the regional dimension of innovation.

'Economic Intelligence', seen as the corollary of the global approach formulated in the Green Paper, is defined there as 'the co-ordinated research, processing and distribution for exploitation purposes of information useful to economic operators'[1].

The Green Paper of Innovation also states that 'the situation in Europe as regards innovation is very mixed. Performance in terms of innovation varies greatly amongst the countries, regions, firms and sectors'.

This is why regional or national policies in support of innovation should be introduced in order to meet Community efforts at local and regional level [EC-DGXIII, 1995].

Regional Innovation Strategies are thus being 'designed to create partnerships among the region's key actors so that an innovation strategy can be defined in the context of regional development policy' [Innovation & Technology Transfer, Sept. 1997]. According to the European Commission the final aim of Regional Innovation Strategies is to 'help regions co-operate and innovate locally to compete globally' [Cobbenhagen, 1996].

There are several activities which can contribute to the development of technologies and innovation and thus to the increase of regional competitiveness:

1. Immaterial or intellectual investment: training, registration of patents, purchase of external R&D services, mobility of technicians or researchers, large firm-small firm co-operation, inter-regional co-operation;

2. Technological forecast mechanisms aiming to analyse the technological and competitive environment and contribute to an effective approach by companies to technology management and better target basic and applied research to market demand, i.e. to the technological needs of the local / regional industry.

3. The dissemination and transfer of R&D results which serves to alert companies to knowledge and new opportunities to technological development.

[1] The mechanisms to implement and improve the efficiency of economic intelligence should, therefore, be supported by Information Systems and Technologies.

## 2.2 Economic development and technical change

Technical change can be analysed at two levels: within specific firms and at the aggregate economic level of a region, nation or even the world [Soete and Arundel, 1993].

The dynamic analysis of economic development and technical change is a field pioneered by Schumpeter in the early 40's. The main difference between the evolutionary thought and the mainstream economic theories is that the former considers technical change a factor endogenous to economic development (the key variable) whereas the latter regards technical change as exogenous [Diederen, 1995].

According to Schumpeter innovation is the process by which new or improved goods and services are introduced in the economy [Segal Quince, 1992]. In other words, innovation is the driving force behind economic development and competitiveness.

Competitiveness is an indicator that can be applied to the performance of a whole economy, to a sector, to a region, or to an individual firm. At a regional level the innovation process is a key dimension when analysing the competitiveness of regions however difficult it may be to measure: 'Regional innovation (as a process) should be the key issue for regional development. It is however, much more difficult to define and, as a consequence, to measure' [Nauwelaers and Reid, 1995][2].

Nevertheless, as a starting point, improving innovation at regional level requires know-how at three levels:

1. an understanding of the innovation process in general,
2. thorough understanding of the region's assets, potential and requirements, and
3. experience of improving individual firm's approach to innovation [EC-Innovation, 1997][3].

[2] InfyDe quotation, page 7.

[3] This point has mainly to do with assisting firms to integrate with other management functions an increasingly important strategic activity, <u>technology management</u>, that can be defined as the 'identification, acquisition and exploitation of technology (products, processes and systems) to achieve strategic and operational objectives' [Mullins *et al*, 1995].

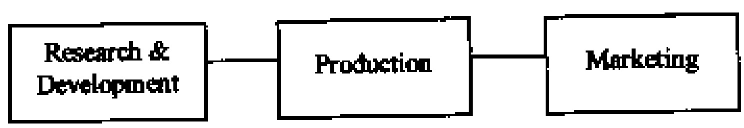
### 2.2.1 The linear model of technical change

The standard approach to modelling innovation is to divide the process of technical change into several independent stages:

- Basic research which produces new scientific discoveries,
- Applied research or development where scientific discoveries are developed into new inventions (e.g. prototypes),
- Production or market experimentation where inventions are further developed into innovations, and finally,
- Marketing or the diffusion of the innovative product or process throughout the economy.

The simplest and most widely-know model of technical change is the basic linear model that became prominent in the 1950s (see figure I.1) [Soete and Arundel, 1993].

**Figure I.1 – Linear model of technical change**




Two opposite theories on the dynamics of the innovation process emerged in the past:

- *Technology-push* – thesis proposed by Schumpeter and dominant until mid 60s,
- *Demand-pull* – thesis proposed by Schmookler on the 2nd half of the 60s,

both compatible with the linear model of technical change presented in Figure I.1.

The linear models of innovation have the following characteristics:

- if on one hand, they present the process of innovation as beginning with basic R&D (Research & Development) in research laboratories and proceeding through design and development work to marketing, without particular attention being paid to external factors such as market demand or the education system (*technology-push*);
- on the other, they assume that market demands feed linearly back into R&D (*demand-pull*).

### 2.2.2 The new paradigm of technological innovation

In the past years, a fundamental break has occurred with the previously dominant paradigm of technological innovation, the linear models of innovation, which have been found to be incomplete and unhelpful as the innovation process is characterised by a series of feedback loops which link market knowledge and needs to R&D.

Therefore, the deficiencies of the linear models have led to a new paradigm of technological innovation - the interactive models of innovation. Figure I.2 presents a model developed by Rosenberg and Kline [Segal Quince, 1992] which captures these feedback, interactive processes - the chain-link model of innovation.

The model starts with the identification of market opportunities and the process of innovation runs through various stages of development and production of products to eventual sales. It is known as the chain-link model because innovation requires R&D activities and contributions from the existing knowledge base in all stages of the process.

Companies normally draw on the existing knowledge base if, and when, problems are encountered at any stage. If, and only if, existing knowledge proves inadequate are R&D projects initiated, either within the company or elsewhere [Segal Quince, 1992].

Though this model is a simplified view of reality, it highlights a number of important aspects of the innovation process and the role that R&D plays in this process:

1. The innovation chain comprises both market-pull and technology-push routes but privileges the former ⇒ This emphasises the need for industry involvement in R&D planning process (namely, the need for the promotion of university-industry interactions, and, in particular, for collaborative research projects);

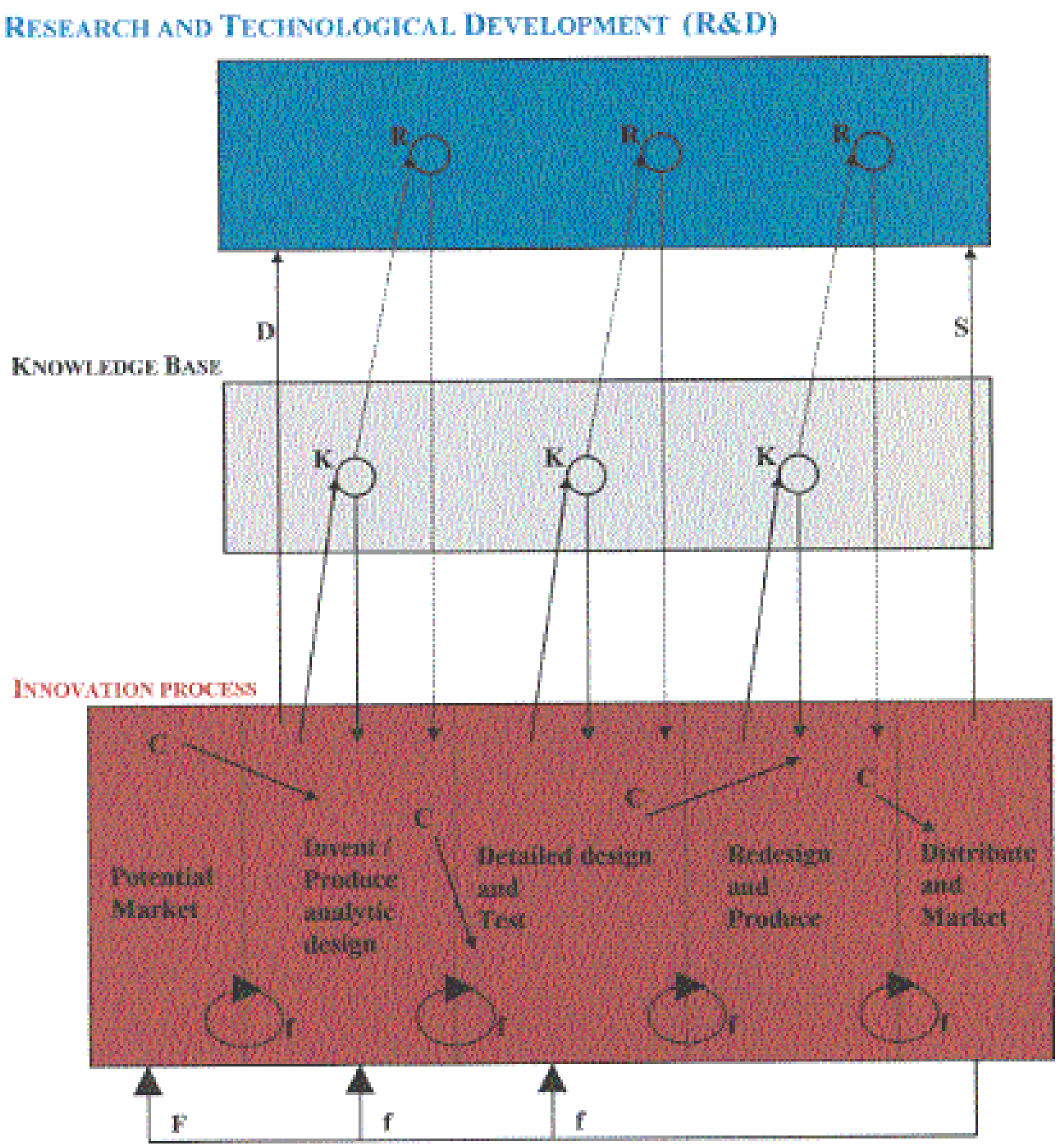
2. R&D is only one part of the innovation process and, except for firms in high-technology sectors, probably a non-existing activity in most companies;

3. Using the existing knowledge base, as opposed to R&D, is likely to be the best option in most cases since it is less costly and more fast and certain in obtaining results ⇒ Improving access to the existing knowledge base can, therefore, be as effective in improving competitiveness as encouraging more R&D [Segal Quince, 1992];

4. Exploitation of R&D results requires an efficient transfer of information to a widely accessible knowledge base and/or to individual users.

The above points (in particular, 3 and 4) highlight the importance of developing economic intelligence actions in University-Industry interactions to promote the exploitation of R&D results.

**Figure I.2 - The Chain-Link model of Innovation**
*adapted from [Segal Quince, 1992]*




| | |
|---|---|
| C | central-chain-of-innovation |
| f | feedback loops |
| F | particularly important feedback |
| K→R | links through knowledge base to R&D and return paths. Only if the existing knowledge base is not sufficient are R&D projects initiated ⇒ the dashed lines |
| D | direct line to and from R&D from problems in innovation and design |
| S | R&D support by instruments, machines, tools, etc. and by monitoring outside work (the information acquired may be applied anywhere along the chain |

According to the new paradigm of technological innovation, it is legitimate to say that 'government and business leaders can no longer afford to regard passively the transfer of technology and its commercialisation' [Charles and Howells, 1992]. This is especially true for the Europe Union since it is often less effective than their competitors in converting and incorporating the fruits of research into innovation processes leading to the successful introduction on the market of new processes, products and services [EC-DGXIII, 1992].

Therefore, the impact of R&D in society, both in economic and social terms, depends on 'how effectively scientific and technological knowledge is disseminated and on the extent to which it is actually used by economic operators' [EC-DGXIII, 1992]. There is relatively little economic benefit from new technology, per se, until it is effectively and widely applied throughout the economy [Segal Quince, 1992].

In other words, as science and technology do not evolve easily into commercialisation, the transfer and exploitation of R&D results are of strategic importance to economic development.

In conclusion, regional innovation requires an economic intelligence system that co-ordinates the research, process and distribution for exploitation purposes of information on R&D results useful to economic operators.

## 3. Outline of the dissertation

**Chapter I** has already introduced the key background points of this dissertation, namely:

- the changes occurring in the process of technology development which have led to the new paradigm of technological innovation;
- the importance of exploiting R&D results in promoting technological growth and economic prosperity; and
- the need to manage Science and Technology at regional level (Regional Innovation Strategies) which implies the convergence of two policy areas: on one side, research and technological development (R&D), and, on the other, regional development.

**Chapter II** will present, basically, a conceptual framework of innovation dynamics and a theoretical background to allow the application of 'economic intelligence' in university-industry interactions at regional level, namely:

- list some useful concepts regarding the process of technological innovation;
- model technology characteristics and the process of transfer itself;
- present the new concept of Regional Innovation Systems.

**Chapter III** will propose a regional economic intelligence system (REIS) comprising six main activities (processes):

1. Technology prospecting,
2. Foster university-industry links (detailed issues regarding university-industry links are presented on annexes I, II and III),
3. Dissemination of technological information / knowledge,
4. Innovation audits,
5. Technology management,
6. Evaluate the effectiveness of the whole system (annex IV reviews a research area fundamental to the implementation of this process).

This chapter will pay particular attention to the following factors:

- The need to set-up special infra-structures to support the application of economic intelligence to university-industry interactions, namely, regional innovation observatories, environmental scanning mechanisms and innovation support organisations (ISOs);
- The role of Information Systems and Technologies in improving the efficiency of economic intelligence in university-industry interactions;
- The lack of a suitable methodology to measure the innovation profile of firms[4].

**Chapter IV** presents the main conclusions derived from this dissertation and recommendation for future and personal research.

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4 The process of evaluating the effectiveness of the REIS is ultimately concerned with measuring the impact of the policies defined in the innovative capacity of SMEs. Therefore, the lack of such a methodology hinders the coherence of the regional economic intelligence system.

**Annexes I to III** detail issues regarding university-industry links, presenting namely:

I. An overview of the current patterns of activity and interaction between University and Industry, its main flows and a set of indicators to measure and evaluate university-industry linkages;

II. A detailed methodology for the exploitation of R&D results extracted from a Bossards Consultants study (1990); and

III. The strategy and results achieved by the Gallaecia Innovation Relay Centre regarding the exploitation of the R&D results of Universidade do Minho.

**Annex IV** presents and analysis methodologies to classify SMEs according to their growth and innovation potential.

# CHAPTER II - CONCEPTUAL FRAMEWORK

It should be underlined that the scope of this dissertation concerns technology innovation as opposed to research and development (R&D) activities. In spite of a general agreement between these two notions some confusion persists. 'Both concepts complement each other, but there is a great deal of innovation without R&D, and research is far from systematically leading to innovations' [EC-DGIII/D, 1995].

The next sections will thus present an overview of current thinking on innovation and technology transfer in order to clarify this subject.

## 2.1 Concepts (glossary)

***R&D*** (research and development) encompasses fundamental research, applied research, and experimental development - it is, thus, only one part of the innovation process. R&D is not only a source of innovative ideas but also a means of resolving problems which may arise during any of the stages of the innovation process. Hence, it may intervene at a number of occasions in the innovation process [Nauwelaers and Reid, 1995].

***Innovation*** is the process that leads from the idea of new products or processes to its successful commercialisation. Innovation is often the result of combining existing technologies in a new product or process [EC-DGXIII/D, 1995]. An innovation has been realised when it has been introduced into the market (product innovation) or used in industry or the service sector in a production process (process innovation). Accordingly, innovation is considered as a process requiring the input of a series of scientific, technological, organisational, financial and commercial activities [Nauwelaers and Reid, 1995].

***Technical change*** is commonly regarded as a process involving three overlapping and often interacting elements:

1. The first is '**invention**' which refers to ideas for new or improved technology, with research being an important source of such ideas,
2. The second is '**innovation**' which occurs when inventions are first transformed into commercial application and become available for practical use,

3. The third, '**diffusion**' is the spread and adoption of innovations (Science & Technology Outlook, p49, 1988, OECD) [Segal Quince, 1992].

*Technical change* is a complex, dynamic process that is dependent upon the ability of firms, institutions and public agencies to develop and apply new knowledge through a cumulative process of learning. This process of learning at the level of the individual agent or organisation is linked to the aggregate economy by the diffusion of information and knowledge [Soete and Arundel, 1993].

***Technology development*** refers to the first two elements: invention and innovation. It can be thought of as representing the supply of new technology and defined as "the technical, design, manufacturing and commercial activities involved in the marketing of a new (or improved) product or the first commercial use of a new (or improved) process or equipment [Segal Quince, 1992].

***Technology diffusion*** is the subsequent application of an innovation after its initial commercialisation. It includes adoption by other users as well as more extensive use by the original innovator. It encompasses all those actions at the level of the firm or organisation taken to exploit the economic benefits of the innovation: this includes incremental modifications and improvements (incremental innovation); truly significant improvements, however, produce a new product or process and a new innovation (radical innovation). There is no sharp boundary between innovation and diffusion, any more than is between invention and innovation. All three form overlapping elements of the continuum of technological change [Segal Quince, 1992].

At this point, it is useful to distinguish between *adoption and diffusion of innovation* as both concepts refer to the introduction of new technology:

- the former corresponds to a choice in time from the perspective of an agent or firm, and
- the latter to a process over time from an aggregate perspective. In this case, the analysis is focused on the new technology, not on the agent[1].

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[1] For a more in-depth analysis of this concepts refer to Rogers (1983) and Metcalfe (1988).

***Technology transfer*** can be described as the diffusion of the complex bundle of knowledge that surrounds a level and type of technology [Charles and Howells, 1992].

These authors detail the above broad definition according to the following typology:

- ***Hardware transfer*** may be broadly interpreted as the transfer of devices, equipment, parts, materials and entire information systems;
- ***Information transfer*** comprises data, documentation, software, standards, specifications, licences, service contracts, manuals, maintenance handbooks and guidelines of uses;
- ***Knowledge transfer*** requires (1) an understanding of the origins and potential impact of the technology or process, the competence to plan, manage and evaluate applications, skills and know-how and relevant policy issues; (2) the ability to adapt and diffuse innovation.

An innovation can comprise both *formal and tacit knowledge*:

- the former can be easily formalised and transferred through algorithms, procedures, formulas, patents, etc and, more indirectly, through publications and training courses. In this case, one is basically dealing with information transfer;
- the latter is more difficult, in some cases impossible, to codify: it is based on experience and know-how and its transfer implies the availability of training systems 'on the job' and the direct involvement of the innovators.

Charles & Howells (1992) identify also two main flows in the technology transfer process: the pre-innovation and the post-innovation stages. These flows can be related to two definitions presented above, technology development and technology diffusion, respectively:

***Pre-innovation stage of technology transfer*** means the actual basic research and invention of the new product, process or service through the development, testing, prototype, pilot plan and pre-launch marketing phases up to the full-scale production and actual launch of the product onto the market.

***Post-innovation phase of technology transfer*** comprises the subsequent full-scale manufacture and marketing of innovations and their diffusion. It consists of the diffusion of existing innovations on an inter-firm or inter-organisational basis (Patents and other forms of licensed proprietary knowledge form an intermediary level between pre- and post-innovations transfer phases).

## 2.2 Technology transfer

As already stated, technology transfer mechanisms are dependant on the characteristics of the technology in question. It is important to recognise, from the beginning of a technology exploitation project, what kind of transfer one is involved in order to:

- establish user expectations,
- allocate resources appropriately, and
- choose transfer managers with the right skills [Leonard-Barton, 1990].

This section will present two proposals to model the characteristics of the technology being transferred and the process of transfer itself:

1. The first model [Leonard-Barton, 1990] relates two technological characteristics: technology scope and technology span, with two technology transfer mechanisms: diffusion Vs point-to-point. The result is a matrix (Boston matrix - see figure II.1) depicting four modes of technology transfer.
2. The second model [Avery and Smilor, 1990] presents an orthogonal model relating three technology variables: transfer continuity, technological level and equivocality (see figure II.2). This model is based on the hypothesis that transfer continuity is a function of technological level and equivocality. (The equivocality dimension of the second model refers to the technology scope characteristic of the first model).

### *1. Technology transfer matrix*

*Technology span*

The key dimension distinguishing the two ends of the technology transfer process is the number of individuals targeted as users for a particular application of the technological innovation. The fewer the users/receivers per technology application, the closer the situation is to a pure point-to-point transfer, the theoretical extreme of which a custom-made tool for one user is an example. At the other extreme would be diffusion of a generic tool to thousands of users.

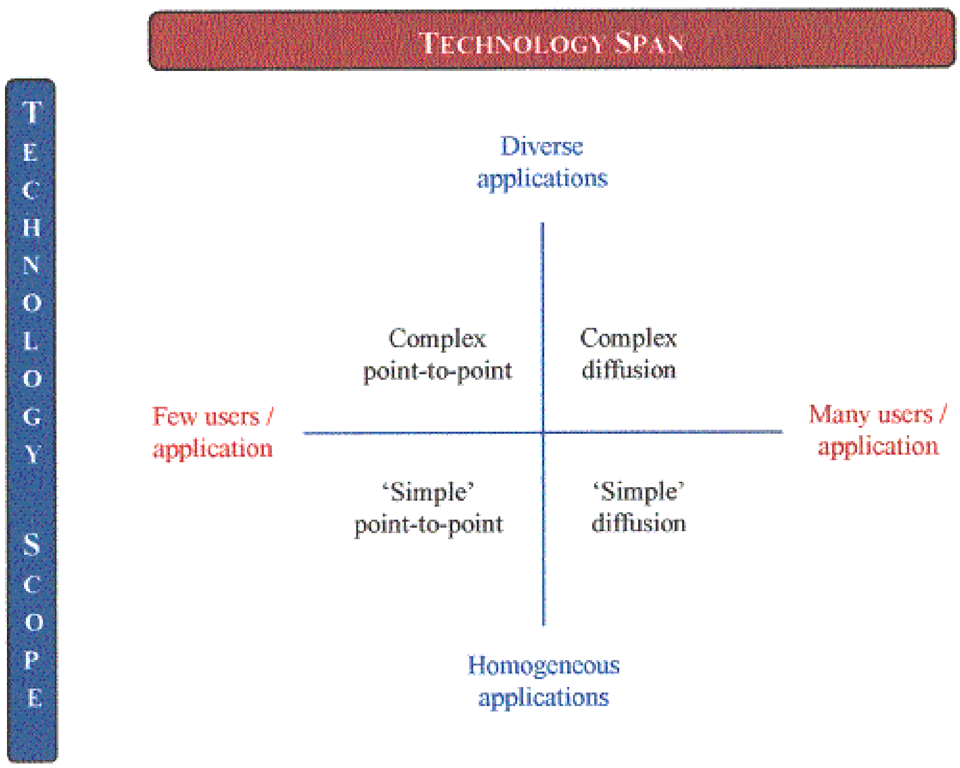
*Technology scope*

Each technology transfer mode is complicated by the degree of diversity in the applications of the tool, that is, the number of different tasks the tool performs. At the low end of this process, all users apply the tool to the same task; at the high end, users with diverse jobs use the same tool but apply it to very different tasks.

These two dimensions, technology span (number of people - end users) and technology scope (number of different applications), combine to create four technology transfer situations:

**Figure II.1 - Four modes of technology transfer**

*Source:* Leonard-Barton in Gibson and Williams, 1990




## 2. *Technology transfer orthogonal model*

Characteristics of the technology influence how transfer mechanisms are designed, selected, and employed, and to what extent they are successful. Three technology variables were found to affect communication between the technology source (providers) and destination (users) of the technology transfer process:

1. *Level*, the degree to which the work on a technology is basic as compared to applied;
2. *Equivocality*, the degree to which interpretations of a technology vary across technologies (technological domains) and across cultures; and
3. *Continuity*, the degree to which communication in technology transfer is relatively discrete (one-way and of short duration) as opposed to relatively continuous (interactive or transactive and sustained).

1. The technology level dimension accounts for large number of findings concerning organisational communication and technology transfer, and accounts for much of the variance attributed to success or failure of technology transfer. Transfer mechanisms symbolically convey the level of technology and its importance. For instance, technology will be perceived as close to or far from commercialisation depending upon whether it is communicated through research reports (far from commercialisation) or demonstrations (close to commercialisation).

2. Technologies that are highly equivocal - those that have many possible interpretations or applications - are perceived as more difficult to transfer and are associated with a search for technology transfer mechanisms capable of dealing with the variety of possible interpretations.

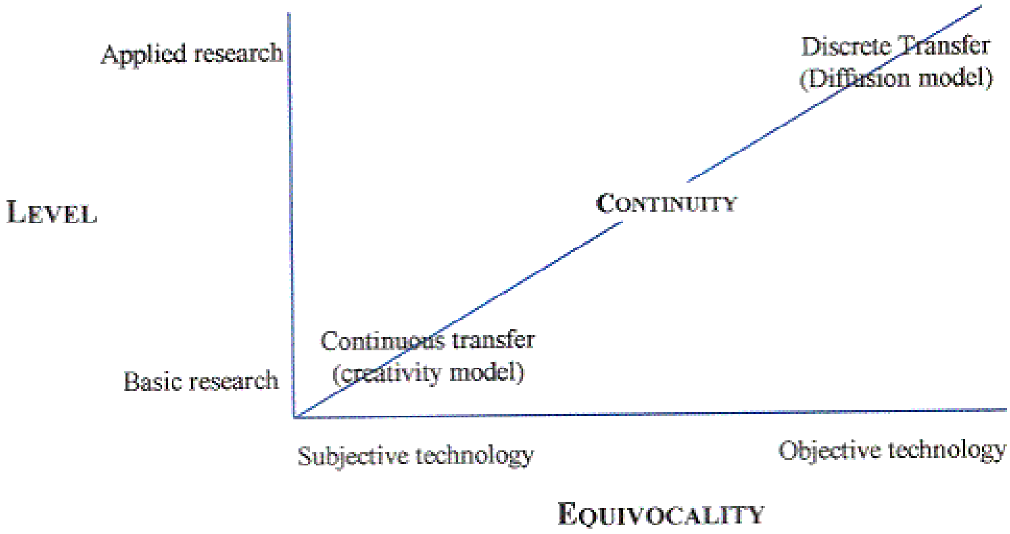
3. The continuity dimension shows that transfer mechanisms can be located along a continuum where at one end are relatively discrete processes and at the other end are relatively continuous processes. The continuity dimension can explain both one-way and two-way communication processes.

As shown in figure II.2, this model predicts that an objective and applied technology can be transferred successfully through discrete transfer processes, such as in the diffusion-of-innovations process popularised by Rogers (1983) [Avery and Smilor, 1990]. These processes tend to transfer a finished technology from an expert environment to a non-expert environment using target marketing and persuasion techniques.

On the other hand, the model predicts that a subjective and basic technology is suited best for a continuous transfer process inviting creativity and collaboration. These processes tend to transfer conceptual information between entities interested in advancing the concept toward some utility (i.e. the technology needs further R&D activities before it can be transferred to industry).

**Figure II.2 - TT as a function of technology characteristics**

*Source:* Avery and Smilor in Gibson and Williams, 1990




## 2.3 Regional Innovation Systems

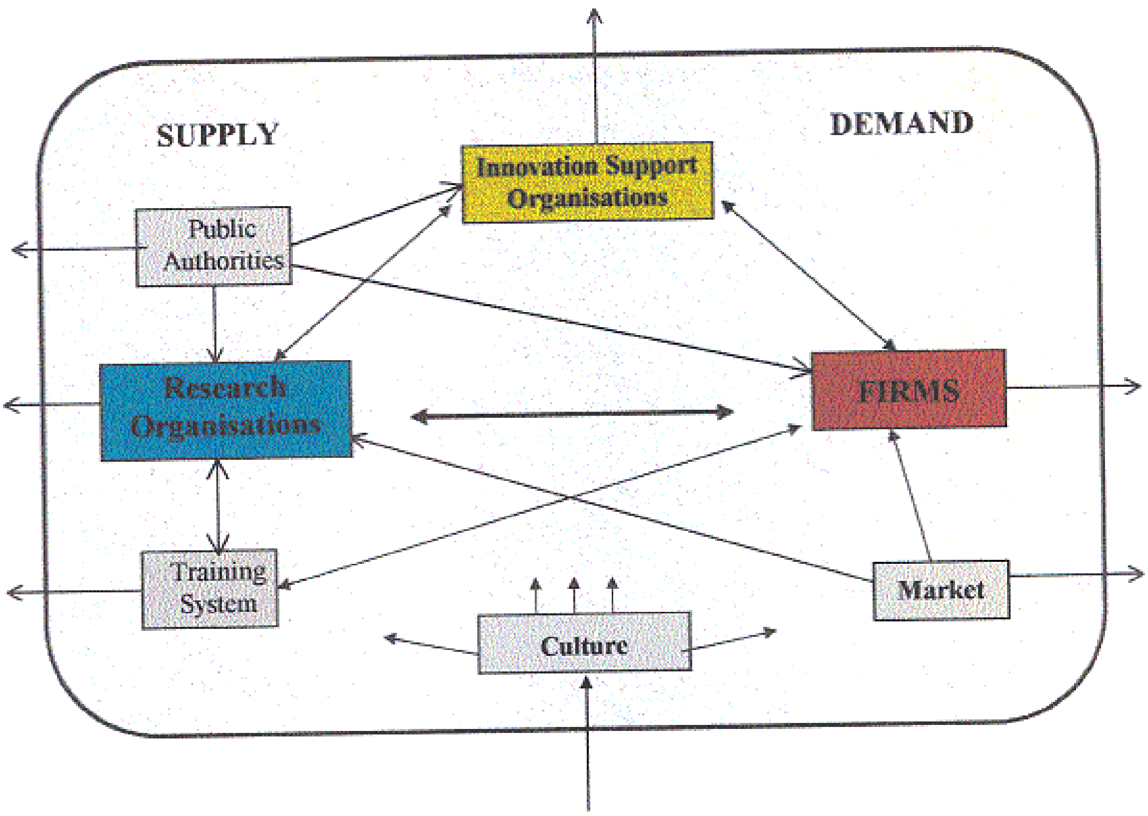
A regional innovation system (RIS) is the set of economic, political and institutional relationships in a given geographical area which generates a collective learning process leading to the rapid diffusion of knowledge and best practice (see figure II.3). A main distinction is made between the agents of a RIS: the agents directly (the key actors) or indirectly (the 'secondary' actors) involved in the creation and promotion of innovation within a region:

- The key actors of the RIS are the research institutions (supply side), the firms (demand side) and the innovation support organisations (ISOs) which play a fundamental role in bridging the gap between both, and in particular between universities and SMEs. The interactions between these actors represent the heart of the RIS.
- The 'secondary' actors are the market, the training system, the public authorities and the culture.

The relationships between these and the key actors characterise the environment of the RIS.

**Figure II.3 - Regional Innovation System**

*Source:* Nauwelaers and Rider, 1995, DGXIII-D & RIDER




According to the model depicted in figure II.3, the characterisation of a *RIS* follows under five main headings, namely:

1. key types of actors of the *RIS*,
2. the 'secondary' actors of the *RIS*,
3. demand / supply axis,
4. the degree of openness of the *RIS*,
5. the network of relationships within the *RIS*.

*1. Key actors.*

Three key types of actors can be identified in a RIS:

- research organisations (public and private), that carry out fundamental and / or applied research, with the frontier between the two becoming more and more indistinct. These organisations may be research centres or laboratories, universities, technological centres;
- firms, which are recipients of scientific and technological advances, through various modes of technology acquisition, of which hiring skilled personnel is one form. In addition, a number are also producers of new knowledge via in-house R&D activities;
- innovation support organisations (ISOs): a set of diverse organisations whose aim is to favour the transfer process between, broadly speaking, "science-producers" (source) and "technology users" (destination). For instance:
    - technical centres,
    - technology brokers organisations,
    - service companies in the technology field,
    - chambers of commerce,
    - business innovation centres,
    - interface units of universities and research organisations, and also
    - the financial system - ISOs may also be considered to include the private and/or semi-public organisations which finance innovation (banks, venture capital firms, etc.).

*2. 'Secondary' actors.*

The other elements of the model refer to the secondary actors of the RIS:

- the market: the final recipient of the technological innovations and a stimulus to undertake investments geared towards product and process innovations ;
- the training system: the producer of the skilled manpower necessary to undertake research in the supply-side and to implement the innovation process on the other side. Human resources are a key to the functioning of the RIS;
- public authorities: depending on the level and the direction of their intervention in the system, they can act as a more or less important stimulus to the process: through

their support to the three main actors of the system and their actions in favour of increased synergy between them;

- culture: the prevailing entrepreneurial culture, the level of regional identity, the level of collective confidence of regional agents, etc., permeates the whole system. These cultural aspects may lead either to smooth interactions or hinder synergy between the elements of the RSI.

*3. Demand-supply axis.*

The supply side corresponds to the actors involved in the creation of the knowledge base necessary for innovation, namely the research organisation. Training establishments are closely linked with certain supply side actors (typically with universities) through the provision of human resources to the system.

The demand side corresponds to the productive sector: firms which are using the scientific and technological output of the supply-side of the system, and the market which is the main stimulus, but also the final beneficiary, of innovation.

Innovation support organisations (ISOs) bridge the gap between the supply side (research organisations) and the demand side (firms) of the system. Within the demand-supply axis coexist both technology-push and demand-pull strategies that foster the process of technological innovation.

Public authorities have been placed somewhat arbitrarily on the supply-side of the system since traditionally their role has been to support the organisations on this side of the supply-demand axis. Nevertheless, more recently, their place in the innovation system has been shifting towards the middle of the picture, given a growing emphasis on assisting technology transfer.

*4. Degree of openness.*

The fourth characteristic of the RIS - the degree of openness of the RIS (arrows running out of the main frame of figure II.3) - is of vital importance. Each of the elements presented above may have relationships with counterparts outside the RIS or may co-operate with other actors in different RIS.

Examples of the first type of external relations are well known, namely:

- international co-operation between university research centres,
- transnational inter- or intra-firms relationships,

- exchange of information between technology transfer organisations in different countries or regions,
- international exchange programmes between training institutions, etc.

The second type of external relations concern linkages between actors of different nature, such as:

- research contracts between firms in one region and research centres in another region;
- transnational mobility of researchers between firms and education institutions (e.g. COMETT projects),
- activities of technology transfer organisations extending beyond the RIS, etc.

*5. Network of relationships.*

The network of relationships between the elements described up to now is the fifth and most important characteristic of the RIS:

- Research-Industry relationships: The supply-side of the RIS becomes more and more influenced by the demand-side, as feedback loops between each of the innovation phases, within firms and industries, lead to an increasingly integrated process and causes circular dependency between market forces and technological development efforts.
- Research – ISOs - Industry relationships: The intermediate organisations, created from the recognition that the relationship between research and industry should be supplemented by interface mechanisms, become central pieces in an interactive RIS. As a consequence, another type of relation emerges within a RIS: the networking between firms, ISOs, and research organisations (the heart of the RIS).

The concept of a RIS is therefore consistent with the new paradigm of technological innovation and the interactive models of innovation discussed earlier.

The innovative capacity of a region is viewed as being dependent not only on the R&D infrastructure available but also on the various internal and external networks of relationships between private and/or public actors.

The growing globalisation of the economy and technology induces the need for the three main actors of the RIS (ISOs, Firms and Research Organisations) to organise themselves in regional partnerships.

Technological innovation is thus the driver for new alliances between academia, business and government. In particular, as basic research is carried out mainly in universities, collaborative R&D projects between academia and industry can accelerate the development of technological innovations.

However, recent studies have found that the failure of firms or regional economies to innovate is not due primarily to scientific or technological problems but to shortcomings in the social and economic organisational framework within which S&T has to operate.

Moreover, technology cannot be expected to assist in resolving the problems of competitiveness unless it functions as a part of a system which is institutionally and organisationally capable of adapting to changing demands on a continuous basis [Nauwelaers and Reid, 1995]. These authors highlight this point by stating Cooke and Morgan (1994): 'innovation is first and foremost a collective social endeavour, a collaborative process in which the firm, especially the small firm, depends on the expertise of a wider social constituency than is often imagined (workforce, suppliers, customers, technical institutes, training bodies, etc.').

The organisational capacities of these networks of relationships become, therefore, a crucial determinant of the performance of the region.

# CHAPTER III – ECONOMIC INTELLIGENCE IN UNIVERSITY-INDUSTRY INTERACTIONS

## 3.1 Introduction

This dissertation and, in particular, this chapter will evolve around the ultimate goal of economic intelligence in university-industry interactions namely the development of the innovative capacity of local SMEs through the exploitation of R&D results, within a regional innovation strategy.

The innovative capacity of a company has to do with the way it succeeds to:

- Secure or raise its profit and turnover by introducing new products and/or
- Reduce the cost or increase the quality of its processes by introducing new processes, and/or
- Raise the quality of its service by introducing new or improved organisational systems [Cobbenhagen, 1996].

In order to facilitate the application of Information Systems and Technologies to improve the efficiency of the problem at hand - *regional innovation via the exploitation of R&D results* – a region will be considered as a regional innovation system i.e., the set of all agents directly or indirectly involved in the creation and promotion of innovation within a region (e.g. educational sector, R&D organisations, enterprises, financial sector, regulations, etc.).

## 3.2 Characterisation of the problem – *regional innovation via exploitation of R&D results.*

### 3.2.1 Introduction: the European paradox

Europe has to tackle with a series of weaknesses which have been largely identified in the 1994 White Paper of Growth, Competitiveness and Employment and in the 1995 Green Paper on Innovation [EC-Stride, 1996]. These include:

- low levels of R&D investment,
- the lack of co-ordination at the different levels of R&D activities, and

- the limited capacity to convert scientific and technological potential into industrial and commercial success[1].

Therefore, it is necessary that Europe mobilises every effort to successfully transform R&D results into viable innovations and competitive advantage. In fact, and according to the Green Paper on Innovation [EC-DGXIII, 1995], the European Commission has set the task of improving the innovative potential of the European economy at the top of the agenda.

Furthermore, Europe faces major disparities among its Member States especially in terms of R&D and organisational potential in the regions. Thus, the Commission was given the mission to reduce the differences of development between the regions of the Union and to promote economic and social cohesion. In this context, the European Commission is committed to develop the less favoured regions (LFRs) of Europe by, among other things:

- strengthening their capacities regarding Science and Technology (S&T), and
- raising the awareness of regional and national authorities to the importance of excelling on the major trends of technical change at the local / regional level.

It is important, however, that community efforts are met at local and regional level with a regional innovation strategy. Regional authorities and local innovation support organisations (ISOs) must not disregard the fact that managing Science and Technology at regional level implies the convergence of two policy areas: on one side, research and development (R&D), and, on the other, regional development.

From the perspective of regional policy, as a whole, 'innovation is one of the key determinants of economic development' [ EC-Stride, 1996].

Therefore, in order to overcome the technology gaps among the European regions, increasing importance is being given to the role of innovation and technology as a way to foster regional economic development. In particular, the diffusion of new technologies across regions is a critical success factor in securing and increasing regional competitiveness.

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[1] In other words, Europe suffers from a major paradox. Though its scientific performance is excellent when compared with its main competitors, the USA and Japan, Europe's technological and commercial performance has declined over the last fifteen years. This is especially true in high technology sectors.

With this background in mind (the European paradox and the need to mobilise R&D for regional development), it is possible to conclude that the exploitation of R&D results is a key factor in the promotion of regional economic development:

- if, on one hand, regional development requires the strengthening of industrial activities,
- on the other, a strong regional industry requires an improved relation with technology.

### 3.2.2 The process: technology exploitation

Firms can have access to new technologies mainly through two technology transfer mechanisms, technology dissemination and technology acquisition:

- Technology dissemination (or diffusion) mechanisms are generally supply driven *(technology-push)* and play a key role in helping firms to keep up with new technological developments.

- Technology acquisition mechanisms on the other hand, are generally demand-led *(demand-pull):* a firm identifies a need to acquire new technology or know-how and then looks for a technology provider.

In practice, dissemination and acquisition are often connected [Charles and Howells, 1992]: dissemination mechanisms may first alert a company to a technology ('awakening' a latent need) which subsequently sets out to acquire. This process is often launched in co-operation with a (local) ISO that has previously helped the company identify its technological requirements through a technological audit.

According to the source of the technology, the dissemination mechanism can be divided in two basic mechanisms: technology exchange and technology exploitation:

- Technology exchange, where technology is passed on from one firm to another; and
- Technology exploitation, where technological knowledge developed in the research world is transferred to industry to drive innovation [EC-DGXIII/D, 1995].

The exploitation process of R&D results is long and complex. Exploitation projects can last 6-10 years (compared with 3-5 years for a research project) and can only be launched when the initial results of the research project are available. According to the Bossard Consultants study (1992), on behalf of DGXIII, the wide range of specialised services required in the course of the various phases of an exploitation project include:

- industrial property counselling,
- market studies, technology-watch, technology assessment
- search for industrial partners,
- financial studies, elaboration of a technology business plan,
- procurement of venture capital (finance for pre-competitive research: production of prototypes, samples, feasibility studies, seed capital, etc.)

Experience plays such a vital role in all the activities of the exploitation process that special structures need to be set up to ensure that all these tasks are successfully accomplished [Bossard Consultants, 1992][2].

Technology exploitation is thus an activity to promote and develop within a regional innovation strategy. However, an 'economic intelligence' system to promote regional innovation based solely on technology exploitation mechanisms falls basically in the linear '*technology-push*' model of innovation. And as we have seen in chapter I, linear models of innovation, found to be incomplete and unhelpful, have evolved to interactive models of innovation, such as the chain-link model developed by Rosenberg and Kline [Segal and Quince, 1992].

Therefore, it is necessary that the economic intelligence system proposed later in this chapter stresses the *demand-pull* innovation route, though still focusing on technology exploitation mechanisms.

## 3.3 Regional economic intelligence system

'The capacity of an economy to derive competitive advantages from technical change is dependant on the dynamic efficiency with which firms and institutions can diffuse, adapt and apply information and knowledge' [Soete and Arundel, 1993].

[2] Such is the case of the Innovation Relay Centres (IRC) promoted by DGXIII and supported under the INNOVATION Programme within the 3rd action of the 4th Framework Programme.

Enhancing the capacity of individual firms to participate in innovative activities is, however, no longer seen as sufficient for the promotion of regional innovation. Policy is now turning to encourage the development of indigenous regional innovation capacity.

The European Commission is therefore funding Regional Innovation Strategies, 'designed to create partnerships among the region's key actors so that an innovation strategy can be defined in the context of regional development policy' [EC-Innovation, 1997].

However, to ensure that the regional innovation strategy reaches its goal (the promotion of regional innovation within the context of a regional development policy), it is crucial to implement a regional economic intelligence system that co-ordinates the research, process and distribution, for exploitation purposes, of information on R&D results useful to economic operators.

Several attempts have been made to define information, distinguishing it from signals, data, knowledge, and wisdom, arguing whether it is a process or a product [Confland, 1993].

The economic intelligence system proposed in this dissertation will deal with information as knowledge - S&T knowledge - and thus be defined ('constrained') within the boundaries presented in table III.1.

Table III.2 and Figure III.1, followed by an analysis of the system and the actions proposed, identify the four major actors, the policies and specific tasks necessary to develop a regional economic intelligence system (REIS).

Regarding the development of economic intelligence actions at regional level to promote technological innovation and the development of the innovative capacity of firms, the key issues are to:

- Maintain the coherence of the regional innovation strategy,
- Set up instruments to evaluate and monitor its implementation, and
- Privilege a demand-pull approach to technological innovation.

The above issues define the regulatory function of the regional economic intelligence system (REIS) that should be co-ordinated by the government or a regional authority (section 3.4 will detail this point further).

**Table III.1 – Premises of the regional economic intelligence system (REIS)**

| | |
|---|---|
| ***Information*** | Knowledge. |
| ***Technology*** | Scientific and technical (S&T) knowledge engineered, i.e. applied for a practical purpose [EC-DGXIII/D4, 1995]. |
| ***Technology Transfer*** | The process through which the results from basic and applied research are communicated to potential users [Wigand, 1990]. |
| ***Regional Innovation System*** | The set of all the agents directly or indirectly involved in the creation and promotion of innovation within a region (e.g. educational sector, R&D organisations, enterprises, financial sector, regulations, etc.) [DGXIII and DGXVI, 1996]. |
| ***Innovative Regional Innovation System*** | The set of economic, political and institutional relationships occurring in a given geographical area which generates a collective learning process leading to the rapid diffusion of knowledge and best practice [Nauwelaers and Reid, 1995]. |
| ***Aim of the REIS*** | Regulate and optimise university-industry interactions (in particular, the exploitation of R&D results) in order to promote regional innovation within the context of regional development policies. |

The REIS was defined taking into account the new paradigm of technological innovation and based on the interactive model of innovation developed by Rosenberg and Kline – the chain-link model. Therefore, this system allows both technology-push[3] and market-pull routes, though it privileges the latter.

[3] This route originates especially from the ILOs (Industrial Liaison Offices) - interfaces of Universities - with an explicit policy to exploit RTD results.

The regional economic intelligence system (REIS) proposed comprises six processes:

1. Technology prospecting,
2. Foster university-industry links,
3. Dissemination of R&D results,
4. Innovation audits,
5. Technology management,
6. Evaluate the system's effectiveness.

**Table III.2 - Regional 'economic intelligence' system**

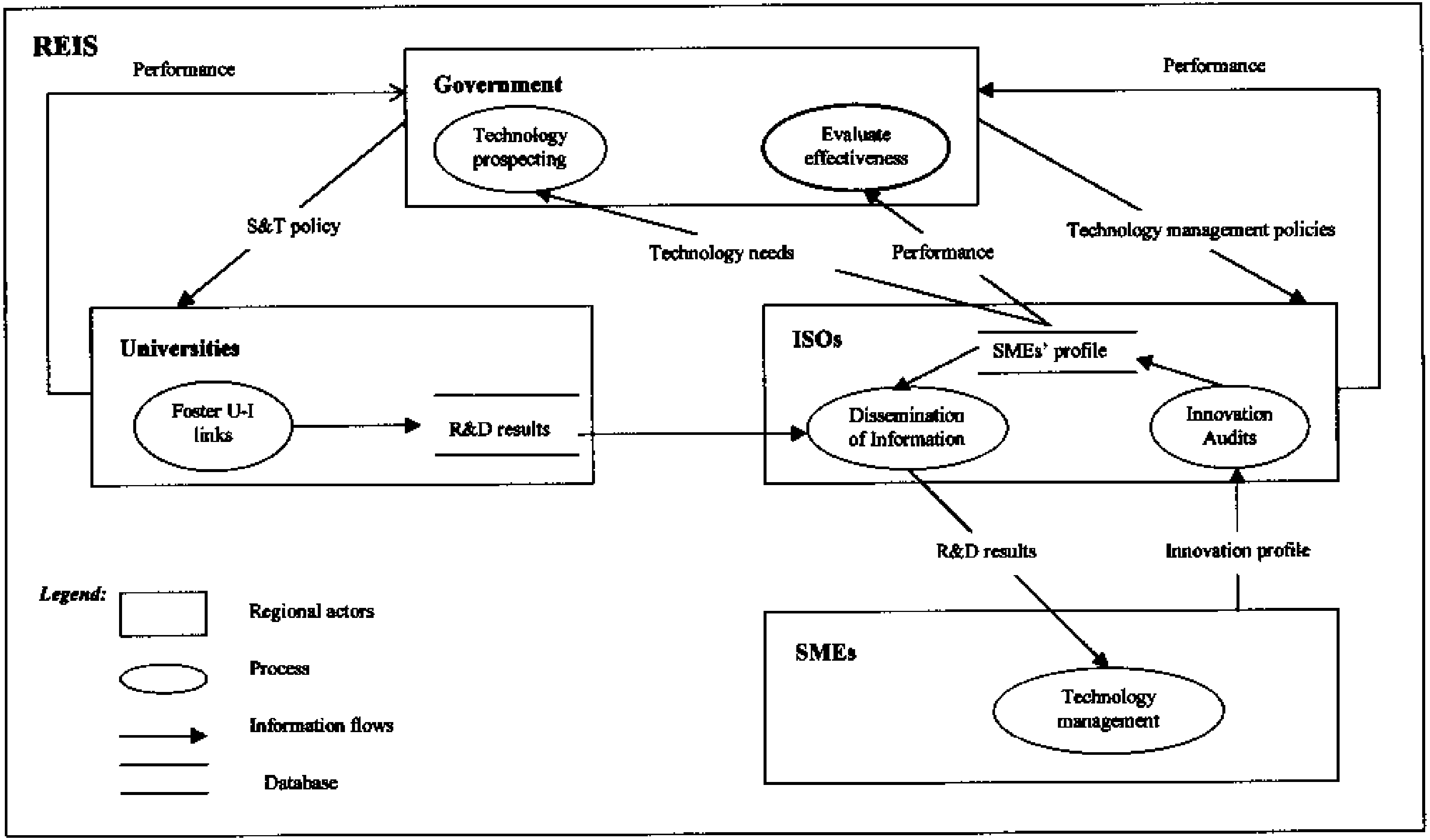
| Actors | General policies (specific tasks) |
|---|---|
| Government | develop regional innovation and technology diffusion strategies (technology prospecting[4] and evaluate the system's effectiveness[5]) |
| Universities | foster university-industry links (set-up a technology transfer office, develop a R&D results electronic database) |
| ISOs | facilitate the process of technology transfer (innovation audits[6], process and distribute technological information) |
| SMEs | technology management (strengthen their capacity to absorb technology) |

[4] The aim is to optimise Science and Technology (S&T) supply to the emerging / predicted needs of society and the economy [Gavigan, 1997].

[5] The purpose is to assess whether the resources spent have met their objectives, i.e. developed the innovative capacity of companies [CM International, 1996].

[6] Innovation audits is a tool proposed by the European Commission within the Regional Innovation Strategies initiative to assess a company's technological status, needs and capabilities.

**Figure III.1 - Regional 'economic intelligence' system (REIS)**



*1. Technology prospecting*

The technology prospecting process aims at targeting S&T supply to the emerging and predicted needs of the society and the economy, promoting thus the 'demand-pull' innovation route advocated by the interactive models of innovation. This process should embrace both technology forecast and technology foresight activities:

Technology forecast is a short-term analysis regarding 'probabilistic predictions of future technological developments' [Gavigan, 1997];

Technology foresight exercises focus on the medium to long run (from 5 to 30 years) and may be used to identify and alert firms to emerging technologies, to identify research areas to which government funding should be targeted, and also to encourage interaction between the research, industry and government communities [Thyme Ltd, 1996]. In other words, 'identify present S&T (Science & Technology) priorities in the light of hypothetical projections of future economic and societal developments' [Gavigan, 1997].

This process needs therefore the set-up of environmental scanning mechanisms to support technology forecast and technology foresight activities (section 3.4 will detail this issue further).

Technology prospecting, complemented by the evaluation of the REIS' effectiveness, will support the definition and update of the regional innovation strategy (the REIS' 'backbone), and, in particular, regarding this dissertation domain (economic intelligence in university-industry interactions), S&T policies and technology management policies.

There are two publications that could be the basis for an in-depth study regarding the definition of regional innovation and technology diffusion strategies, namely:

1. 'An integrated approach to European Innovation and Technology Diffusion Policy – a Maastricht Memorandum', May 1993, CEC, by Soete and Arundel (MERIT);
2. 'Innovative regions? A comparative review of methods of evaluating regional innovation potential', 1995, EC-DGXIII, by Nauwelaers and Reid (RIDER).

***2. Foster university-industry links.***

The need to exploit the potential of universities' R&D results is widely accepted throughout Community members as a key requirement for technological growth and economic prosperity which has led to various initiatives to set-up or expand university-industry links, namely the establishment of technology transfer offices (ISOs).

However, to obtain the desired technological growth, the required linkages between Universities and Industry must be developed and strengthened in every possible way. These structures can not be established in a haphazard manner. Their staff must possess the expertise required to achieve co-operation and technology transfer on a planned and systematic basis. Furthermore, the management of the whole exploitation and technology transfer process requires the mobilisation of a wide variety of professional expertise in the legal, marketing and financial fields [Bossard Consultants, 1990].

If university-industry interactions are considered to be the 'heart' of a Regional Innovation System [RIDER, 1995], ISOs are the necessary technology transfer channels between University and Industry. ISOs (including Universities' interfaces: in UK literature also called ILOs – Industrial Liaison Offices) are therefore technology transfer facilitators to overcome barriers of communication and culture that 'block' links between SMEs and Universities.

For the benefit of universities regarding a wider analysis of university-industry links, annex I presents an overview of the current patterns of activity and interaction between University and Industry. It identifies the main flows between the two sub-sets of the Regional Innovation System and proposes a set of indicators to measure and evaluate U-I linkages.

For those that have already established ILOs, annex II describes a detailed methodology for the exploitation of R&D results extracted from a Bossards Consultants study (1990).

Also, annex III presents the strategy and results achieved by the Gallaecia Innovation Relay Centre (an ISO promoted by the European Commission and hosted by TecMinho) regarding the exploitation of the R&D results of Universidade do Minho.

***3. Dissemination of R&D results.***

'Technological innovation and development within an economic system depends on the transfer of information as well as its invention or generation; innovations both in their actual development and their subsequent use must involve some kind of transfer or flow' [Charles and Howells, 1992].

The dissemination of technological information (knowledge) is of particular relevance in the chain-link model of innovation. As seen earlier in chapter I, the successful exploitation of R&D results requires an efficient transfer of information to a widely accessible knowledge base.

The efficiency of the economic intelligence system depends therefore on each university's policy regarding the set-up of university-industry links and, in particular, fostering technology transfer namely by building, and continuously updating, a R&D results database, with exterior access (e.g internet) - the 'supply side' of the regional innovation system.

This activity is becoming current practice in some European Universities, such as in the North region, promoted by AURN – Associação das Universidades da Região Norte, and in the Galiza region, promoted by the regional government – Xunta de Galicia.

However, a very important aspect to stress in relation to the process of exploiting R&D results is 'the role of people in initiating and facilitating transfers of knowledge and technology between organisations and places' [Charles and Howells, 1992]...

Section 3.5 (Information Systems in regional economic intelligence) will analyse the application of Information Systems and Technologies to the regional economic intelligence system proposed in figure III.1 and, in particular, to this process: the dissemination of technological information to support the exploitation of R&D results.

***4. Innovation audits.***

Innovation audits are a tool proposed by the European Commission to assess a company's technological status, needs and capabilities. This process generates information on the innovation profile of local SMEs (the 'demand side' of the regional innovation system) which, if processed by Information Systems and Technologies, would improve the efficiency of the REIS by:

- allowing the ISOs to better target its efforts regarding selective information dissemination on R&D results;
- feeding the technology forecast activity with information on the technological needs of the local firms; and
- monitoring the evolution of the SMEs' innovative capacity thus contributing to the assessment of the REIS's effectiveness.

The following publications present a detailed analysis regarding innovation audits:

- 'Analysis of SME Needs', Fraunhofer ISI, 1996, EIMS publication n° 18, European Comission (DGXIII and DGXVI);
- 'Auditorias de Inovação', João Gunther Amaral, MSc Dissertation, 1997, FEUP.

### *5. Technology Management*

Technology management is a key activity to secure the coherence of the whole system. If the above economic intelligence actions are to achieve their main goal (increase SMEs' capacity to innovate), the managers have to be given the core skills on innovation and technology management, namely how to identify, acquire and exploit technology to achieve strategic and operational objectives.

Policies to improve firms' approach to innovation will not be dealt within this dissertation since technology management alone can produce a large number of research reports due to the important changes that are taking place in science, technology and industry. As a result, governments and enterprises alike are forced to develop new ways of thinking and acting to make the best of opportunities offered by technological change [Cannel and Dankbaar, 1996].

Two studies could be the basis for further research activities in this area:

1. a joint publication of the European Commission and the Oxford University Press – 'Technology Management and Public Policy in the European Union', edited by Cannel and Dankbbar, 1996.

   This book analyses in particular the technology management challenges faced by large firms and SMEs and the role of the ISOs in supporting technology management on the part of the firms.

2. a major research initiative on technology management, with an agenda of 11 research questions[7], supported by the United Kingdom Engineering and Physical Sciences Research Council.

One can foresee, however, the ISOs playing an important role in, for instance, promoting continuing training on technology management and innovation management techniques (quality management, value analysis, design, intellectual property, etc).

***6. Evaluate the effectiveness of the regional economic intelligence system.***

The effectiveness of the REIS (measured ultimately by the development of the innovative capacity of SMEs) depends, on one hand, on the correct definition of regional innovation policies, and, on the other, on the efficient implementation of these policies by the local agents. Monitoring the performance of the SMEs, ISOs and universities, both at the aggregate and individual level, will allow the regional government to react quickly regarding eventual adjustments and updates to the regional innovation policies and infrastructure.

Since there is currently no single existing methodology to evaluate regional innovation potential, Nauwelaers and Reid (1995) propose an eclectic methodology to this question based on multidimensional evaluation approach to the regional innovation system.

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[7] According to Mullins *et al* (1995), the agenda is grouped under three subtopics:

*Linkages between Business Strategy and Technology Strategy*:

1. Technology audits, assessment processes and technology forecasting
2. The process of formulating business led technology strategies
3. Choosing process and systems technology to operationalise manufacturing strategy

*The Acquisition of Technology*

4. Capturing customer requirements to enable companies to match these to current and future technologies
5. Identification of current and future technology requirements
6. Selection of methods for acquiring technology
7. New process and system technology in SMEs in mature industries
8. Corporate knowledge and experience in technology management

*Management of Technology within the Business Process*

9. Management of the integration of technology, especially with regard to product definition and product creation
10. Managing the life cycle of technology
11. Management of technology to enable best use of human capabilities and learning potential in the execution of manufacturing systems and processes

Table III.3 presents, for each regional dimension, a brief description of the corresponding methodological approach's aim.

This research was performed by a group of experts from RIDER (Interdisciplinary Research on Regional Development), of the Catholic University of Louvain, on behalf of DGXIII of the European Commission (Telecommunications, Information Market and Exploitation of Research).

The RIDER study also presents a set of indicators of regional innovative performance under the following headings: supply-side, demand-side, supply/demand, and environment indicators. Within the first three categories, the study makes a distinction between data which is: quantitative, qualitative, focused on network relations and refers to the openness of the regional innovation system. Each indicator receives an evaluation quotient according to the criteria of robustness, reproducibility, and innovativeness.

The multidimensional approach to evaluate the regional innovation potential and the set of indicators of regional innovative performance proposed by the RIDER study could be applied to assess, at the aggregate level, the performance of the regional actors and the coherence of the policies defined.

Charles and Howells (1992) refer that until recently research on the evaluation of university-industry interactions has devised only a set of static indicators - input / output indicators - more devoted to measuring resources and evaluating research programmes or institutions than the evaluation of the performance and effectiveness of the linkages themselves.

The RIDER study proposes the use of process indicators, in a more dynamic context. Tables III.4 and III.5 present, namely:

1. a comparison between the classical and innovative methodologies for evaluating regional innovation systems (RIS),
2. the theoretical relations between indicators and the different views of the regional innovation system (linear Vs interactive models).

**Table III.3 – Methodological approach for assessing regional innovation potential**
*Adapted from Nauwelaers and Reid (1995)*

| Regional Dimension | Methodological approach | Aim |
|---|---|---|
| *Regional environment* | Strength / Weakness approach | Identification of regional weaknesses and opportunities or advantages. |
| *Technology supply* | Forecasting inventory approach | To assess the technology supply potential of the region, to identify the deficits in the supply / demand relation of this potential and to define the position of the region in the context of inter-regional / international competition. |
| *Innovation services* | Supply / Demand approach | To identify deficits in innovation services supply according to the regional demand. |
| *Inter-firm relations* | Network approach | Evaluation of firms' propensity to network as a variable of their innovation ability. Determination of the regional dimension of these networks and characterisation in terms of strengths/weaknesses for the region. |
| *Firms' innovation profile* | Inventory approach | Identification of the R&D efforts and innovation profile of the regional firms. |
| *Policies* | Instruments evaluation | Assessment of the regional impact of policy measures and programmes, including an identification of unfulfilled needs. Analysis of the coherence between policies formulated and applied by different levels of the government (regional, national and European). Identification of possible means of improving policy measures and programmes. |

**Table III.4 - Two polar methodologies regarding RIS's evaluation**
*Adapted from Nauwelaers and Reid* (1995)

| Classical choice | | Innovative choice |
|---|---|---|
| **Inventory and characterisation of local innovation actors** | *refers to* | **evaluation of the capacity of the RIS to favour learning processes and synergies** |
| | *focuses on* | |
| • description | | • evaluation |
| • components of the RIS | | • interfaces in the RIS |
| • technology creation | | • technology diffusion |
| • homogeneity between regions | | • regional diversity and specificity |
| • quantitative indicators | | • qualitative indicators |
| • input/output indicators | | • process indicators |

**Table III.5 - Theoretical links between indicators and regional innovation models**
*Adapted from Nauwelaers and Reid (1995)*

| | Regional innovation models | |
|---|---|---|
| | Linear vision | Interactive vision |
| **Indicators** | *input/output* | *process* |
| **Advantages** | ▪ easy to replicate and compare<br>▪ based on statistical sources | ▪ qualitative and dynamic<br>▪ capture networking in the RIS |
| **Disadvantages** | ▪ static | ▪ difficult to duplicate and compare<br>▪ based on questionnaires and interviews |

However, as the effectiveness of the regional economic intelligence system should be measured by the impact of the policies defined by the government sub-system in the SMEs' innovative capacity, it is essential to evaluate and monitor the performance of the SMEs at the individual level.

The RIDER study, however, fails to describe the methodology to assess the innovation profile of firms, which is precisely the focus of this dissertation regarding the evaluation of the effectiveness of the regional economic intelligence system: measure the impact of the policies defined by the government sub-system in the SMEs' innovative capacity.

Moreover, apart from some qualitative attempts to classify companies (described in annex IV), there is no methodology available that allows the quantitative assessment of a firm's innovative capacity, and its growth, at the individual level. There is thus the need for further research in this area.

Still, the evaluation of the effectiveness of the regional economic intelligence system will also require the set-up of environmental scanning mechanisms (see section 3.4) to allow the implementation of the performance evaluation methodologies.

## 3.4 Critical Success Factors

Innovation has already been acknowledged by the evolutionary economic theories as the driving force behind economic development and lasting growth.

Economic intelligence in university-industry interactions is fundamental to foster regional innovation within the context of regional development policies.

In order to accomplish the concerted promotion of 'research, processing and distribution of information for exploitation purposes of information useful to economic operators', economic intelligence in university-industry interactions requires the set-up of special infrastructures, namely:

1. regional innovation observatories,
2. environmental scanning mechanisms and
3. innovation support organisations (ISOs).

In the following sections, each of these infrastructures will be presented in detail.

### 3.4.1 Regional innovation observatories

In order to achieve the desired results (the development of the innovative capacity of SMEs) the regional economic intelligence system should:

1. Build regional consensus, so that the action plan is understood and accepted by the main actors in the region[8];
2. Maintain the coherence of the policies defined (included in the regional innovation strategy), i.e. continuously monitor and update the action plan;
3. Privilege the demand-pull innovation route through technology forecast and foresight exercises (the 'backbone' of the Regional Economic Intelligence System - REIS);
4. Evaluate the effectiveness of the regional economic intelligence system, in particular evaluate the impact of the policies, especially the technology management ones, in the SMEs' innovative potential;

The first and second key issues have mainly to do with integrating the Economic Intelligence System in the overall Regional Development policy and therefore responsibility of the (regional) government. The third and fourth are, on the other hand, per definition of the economic intelligence system, already responsibility of the (regional) government.

As already stated, policies to increase the innovative capacity of SMEs must be based on a careful examination of their specific needs by region and industrial sector [Soete and Arundel, 1993].

Furthermore, by recognising in the Green Paper of Innovation (1995) the increasingly important role of SMEs as a 'reservoir for the creation of jobs and a source of diversity in the industrial fabric'[9], the European Commission has increased its interest in the regional

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[8] To develop economic intelligence actions aiming at promoting regional innovation via the exploitation of RTD results it is crucial to launch awareness campaigns and training activities targeted at the different regional actors involved in the four-level policy identified in table III.2 in order to develop indigenous regional innovation capacity.

[9] Some interesting figures on the importance of SMEs at community level from the Green Paper of Innovation [EC-DGXIII, 1995]:

- 99.8% of Community firms have less than 250 employees (91% fewer than 20);
- SMEs account for 66% of jobs and 65% of turnover in the European Union;
- Between 1988 and 1995 net job creations in SMEs exceeded job losses in large companies;
- Firms with less than 100 employees account for virtually all new jobs, at a net rate of 259.000 per year.

dimension of innovation as this level is more suitable for monitoring SMEs' requirements and for promoting the development of their innovative capacity.

Moreover, as the above key issues define the regulatory function of the regional economic intelligence system, they should be implemented by a regional authority – the regional innovation observatory - under direct supervision of the (regional) government.

The government sub-system (set in motion by the regional innovation observatory) corresponds thus to the 'brain' of the regional economic intelligence system (REIS); its kernel activity being the definition of:

- S&T policies to better target research efforts to market needs, and
- Technology management policies to improve the SMEs' approach to innovation.

### 3.4.2 Environmental scanning mechanisms

A regional innovation strategy should not be limited to 'matching' local supply and demand of technological innovation, instead it should seek a high degree of openness to external relationships[10]. The analysis of other regions' strengths and weaknesses regarding technological innovation is thus of the utmost importance for the (regional) government sub-system when defining regional S&T policy.

The regional innovation observatory should therefore implement environmental scanning mechanisms to support the definition of S&T and technology management policies based upon:

1. technology foresight exercises (outward and into the future), and
2. the assessment of SMEs' innovation profile (inward and now).

Regarding the former, James P. Gavigan (1997) of the Institute for Prospective Technological Studies (IPTS), in Seville, presents a list of methodologies and techniques that could be used in technology foresight exercises, namely:

[10] As defined in chapter II, a regional innovation system is characterised by the following items: key actors, secondary actors, demand/supply axis, network of internal relationships, degree of openness to external relationships.

*Qualitative:*
- Intuitive thinking: brainstorming, utopian writing, science fiction;
- Exploratory: moving from past/present to the future in an heuristic manner – expert opinion (Delphi based studies), scenarios;
- Normative: backtracking from desirable future goals – relevance trees, scenarios, key-technologies;

*Quantitative:*
- Time series: trend extrapolation, pattern identification, probabilistic forecasting;
- Models and simulation: system dynamic simulation, cross-impact analysis, input-output analysis.

Regarding the latter, the mechanisms should scan the performance of the key regional actors of the REIS, both at the aggregate and individual level:

- The regional innovation observatory should monitor the performance of the universities and the ISOs.
- The ISOs should monitor the performance of the SMEs and the evolution of their innovation profile.

As stated earlier in this chapter, Nauwelaers and Reid (1995) in the RIDER study present a set of methodological approaches and indicators that could be applied by the regional innovation observatory to assess the performance of the regional actors at the aggregate level and the coherence of the policies defined.

There is, however, as stated earlier, no methodology available that allows the quantitative assessment of the firm's innovative performance, at the individual level.

The European Commission (1996) proposes a list of possible evaluation indicators for setting-up a system for continuous monitoring and evaluation of the Regional Innovation System regarding the assessment of:

- the regional technology supply and
- the strengths and weaknesses of regional firms[11].

These, however, are more useful to compare different regions (Regional Innovation Systems), for benchmarking purposes for instance, regarding the strengths and weaknesses of regional firms than to categorise an individual firm according to its innovation profile.

### 3.4.3 Innovation support organisations (ISOs)

Although SMEs are almost always managed in an entrepreneurial way, they need, however, considerable help to venture out in co-operative research and technology transfer projects as they often lack:

- the means to address their requirements themselves,
- the in-house resource and experience to explore fully the potential of technology,
- the financial and human resources to explore long-term product development opportunities, and
- the knowledge and insight in the potential of Technology Transfer as a strategic business tool.

Moreover, innovation often needs access to 'complementary assets' beyond the reach of even the largest firm due to the difficulty of acquiring tacit knowledge on the market place, or uncertainty which prevents costly internalisation of R&D activities [20].

As a consequence SMEs are largely reliant on ISOs to:

- help them find potential partners,
- assist and support them throughout the process of developing and completing a technology transfer agreement,

[11] *Evaluation indicators of the strengths and weaknesses of regional firms:*

- Sector characteristics (size, value-added, employment, export rate, ...),
- Evolution in the number of firms created, particularly hi-tech firms,
- Evolution in the number of firms under certification (ISO 9000),
- Evolution of R&D budgets by SMEs,
- Evolution in the number of patents submitted and obtained,
- Share of the turnover by new products,
- Increase in the level of product/process innovation,
- Number of collaborative contracts with the supply infrastructure,
- Evolution in the number of scholarships granted to researchers,
- Evolution in the structure of qualified jobs/intermediaries,
- Evolution in the response rate and approval rate of CRAFT bids,
- Evolution in the activity of Science Parks.

- disseminate (selectively) technological know-how developed in universities to help SMEs add value to their products, processes and services.

ISOs are therefore of crucial importance for innovative firms of all sizes because they provide the channels through which they can identify and acquire new know-how in a world in which the production of knowledge continues to accelerate [DGXIII/D4, 1995].

The ISO sub-system corresponds thus to the 'heart' of the regional economic intelligence system (REIS). Due to its dual role as (1) technology transfer facilitator and (2) environmental scanning mechanism, it contributes to the concerted implementation, monitoring and updating of the regional innovation strategy, the S&T policy targeted at the universities and the innovation support initiatives targeted at the SMEs.

Therefore, the efficiency of the regional economic intelligence system (REIS) defined earlier depends heavily on the efficiency of the ISO sub-system as technology transfer facilitator and as environmental scanning mechanism.

Information systems and technologies can play an important role in improving the efficiency of the REIS by the implementation of two information systems on R&D results and SMEs' innovation profile.

The former (R&D results) is crucial to ensure an efficient transfer of information on R&D results to a widely accessible knowledge base.

The latter (SMEs' innovation profile) should process and storage the information acquired during the innovation audits (the history of the firms' innovation profile) to allow:

1. an aggregate analysis of the technological needs of the local companies to support technology forecast exercises and the identification of S&T priorities and innovation support initiatives, and
2. the evaluation of the effectiveness of the innovation support initiatives by measuring the growth in the innovative capacity of the companies.

   As already stated, however, there is no methodology available that allows the quantitative assessment of the growth of a firm's innovative capacity, which hinders in particular the accomplishment of point 2.

At this point, this dissertation will converge its analysis to the ISO sub-system. In particular, the next section (3.5) will analyse the application of Information Systems and Technologies to support the exploitation of RTD results.

## 3.5 Information systems in regional economic intelligence

The interactive model developed by Rosenberg and Kline (the chain-link model of innovation, in the 90's) highlights two important facts:

- Companies draw on public knowledge to solve problems at any stage of the innovation process if the know-how is not available internally; and
- R&D projects are initiated, either within the company or elsewhere, if and only if the existing knowledge proves inadequate.

This implies that, on one hand,

- improving the access to the existing knowledge base (public S&T knowledge) can prove more effective in improving competitiveness than promoting more R&D;

and, on the other,

- the successful exploitation of R&D results requires an efficient transfer of information to a widely accessible knowledge base and/or to individual users.

Both situations (the former falling on the demand-pull innovation route and the latter privileging the technology-push innovation route) represent the nucleus of University-Industry interactions. Figure III.2 represents the flows of S&T information in U-I interactions according to the interactive models of innovation.

**Figure III.2 – Flows of S&T information in U-I interactions**

External monitoring of universities' R&D results (environmental scanning) is a key to the success of technology innovation. However, while most large companies have mechanisms in place to monitor R&D results (Green Paper's route action n°1 – technology monitoring and foresight), SMEs often find the process difficult. The obstacles are mainly associated with culture, communication[13] and finance within the company [Woolgar *et al*, 1994].

The Green Paper of Innovation has highlighted the role of the regions in disseminating information and supporting innovation, especially regarding SMEs. This Paper states also that access to know-how and information is far more difficult and expensive for SMEs than for large businesses; on the other hand, SMEs are usually reluctant to turn to existing services and schemes for aid, assistance or advice.

'The ability of SMEs to access external information can be increased by supporting institutions that provide an interface between SMEs and the sources of new technologies' [Soete and Arundel, 1993].

To address this situation, the European Commission has set a network of 50 Innovation Relay Centres (IRCs) to serve as 'one-stop shops' for SMEs regarding their innovation process (for instance, identification of technology requirements, innovation audits, assistance in setting R&D projects, searching for technological solutions/partners, negotiating technology transfer contracts).

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[12] This route originates especially from the ILOs (Industrial Liaison Offices) - interfaces of Universities - with an explicit policy to exploit RTD results.

[13] Gibson and Williams (1990) address technology transfer as a communication process. They highlight the fact that successful technology transfer requires overcoming the many barriers to communication encountered when individuals use different vocabularies, have different motives, represent organisations of widely differing cultures, and when the technology being transferred may vary from highly abstract concepts to concrete products. These barriers can be observed in communication transactions between individuals (such as scientist-scientist, scientist-client, manager-customer, manager-scientist, etc.), within and among corporations, in university-industry collaboration and new R&D consortia, between government and industry, and in international transfer.

In communication research literature, this is often referred to as a general *source-destination paradigm*. Therefore, technology transfer does not necessary lend itself to a rational mathematical model.

There is another aspect to the process of exploiting R&D results that needs be stressed, especially when actions are targeted to SMEs, namely the role of people in initiating and facilitating technology transfer between university and industry [Charles and Howells, 1992].

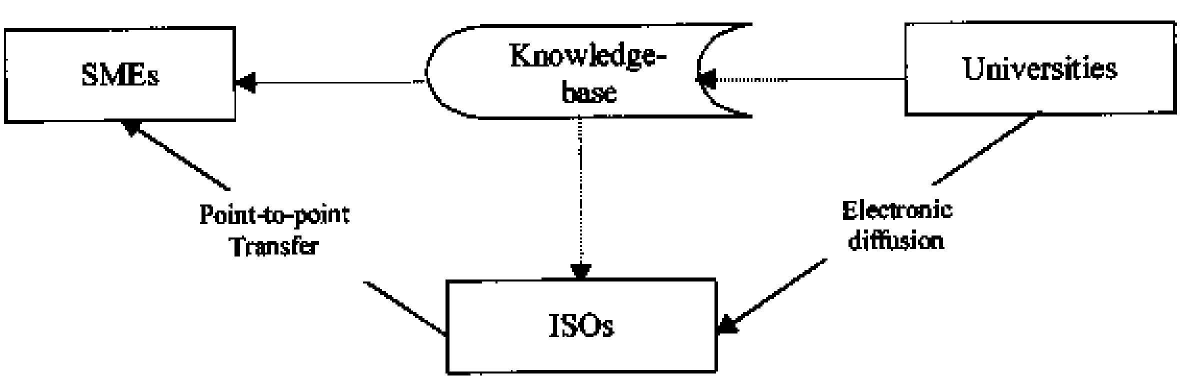
Given that the fundamental reason for University-Industry interactions is the transfer of information, economic intelligence actions targeted at the exploitation of R&D results are absolutely dependent on person-to-person communications.

This fact alone should be sufficient to demonstrate the error in setting up an electronic information service to support the dissemination of R&D results to SMEs. If not, the fact that SMEs do not have the resources to search, collect, process and interpret technological information, or in other words develop technology-monitoring activities, should suffice.

Large companies and new technology based firms (NTBFs)[14] could certainly benefit from such a tool. Still, the impact on innovation in the region, nation, Europe would be minimal. After all, according to the Green Paper of Innovation [EC, 1995], 99.8% of Community firms have less than 250 employees.

However, the impact on regional innovation through the exploitation of R&D results would increase if the electronic communication network were to be used by the local ISOs (the Innovation Relay Centres, for instance). These institutions could therefore search, process, interpret the information and afterwards distribute the R&D results on a person-to-person basis, according to each SME's innovation profile (see figure III.3).

**Figure III.3 – Flows of S&T information in an economic intelligence system**




[14] Firms that exploit new technologies.

The dissemination of S&T information to promote the exploitation of R&D results should be based on two different technology transfer mechanisms according to their destination (the main clients: ISOs, on one hand, and SMEs, on the other) and on a two-stage process:

1. Firstly, universities should place their R&D results on databases accessible through the Internet, i.e. transfer their S&T information to a widely accessible knowledge base;

2. Secondly, ISOs should process and distribute the information to the SMEs on a point-to-point base, customising the information taking into consideration the innovation profile of the final end-users (an industrial sector, a group of SMEs, an individual firm). The diffusion mechanisms to use will depend on the characteristics of the technology, namely scope (number of different applications) and span (number of end users).

An electronic information system on R&D results is therefore crucial to the efficiency of a regional economic intelligence system.

For those interested in pursuing this line of research there are two electronic communication systems set up to promote the exploitation of R&D results that could be used to evaluate the application of Information Technologies as the privileged vehicle to support and facilitate the dissemination of technological information between suppliers and clients of new technology:

1. CORDIS – Community R&D Information Service (http://www.cordis.lu/) and, (more recently, at regional level),
2. AURN – Associação das Universidades da Região Norte (http://www.aurn.pt).

# Chapter IV – CONCLUSIONS

The relevance of researching the role of University-Industry interactions (and, in particular, the exploitation of R&D results) in the context of regional development is due to the following facts:

1. Technical change is the driving force behind economic development [Soete and Arundel, 1993], [Diederen, 1995], [EC-DGXIII, 1995], [EC-Stride, 1996]:

   Companies need to innovate constantly in order to remain competitive. The same is true for countries and regions, which need to convert new ideas into new products and markets shares if they are to maintain growth, competitiveness and jobs.

2. Community efforts to improve the innovative potential of European economy have to be met with regional innovation strategies in a context of regional development policies [EC-Stride, 1996]:

   The capacity of a region to obtain competitive advantages from Science and Technology is dependant on the dynamic efficiency with which institutions and firms can disseminate, adapt and apply information and knowledge. The transfer and exploitation of R&D results are thus of strategic importance to economic development.

3. Europe has a limited capacity to convert scientific and technological potential into industrial and commercial success (i.e. viable innovations) [EC-DGXIII, 1995], [EC-Stride, 1996]:

   Establishing university-industry links accelerates the development and dissemination of technological innovations throughout the economy. However, this is not enough: to introduce effectively new technologies in the marketplace, it is necessary to co-ordinate the actions that need to be taken simultaneously in various institutions at different levels - government, universities, and industry.

This dissertation has also shown that:

- The exploitation of R&D results is a key factor in strengthening the regional dimension of innovation,

but

- University-industry interactions according to the new paradigm of technical change, should follow a demand-pull route instead of a technology-push one.

The (apparent) contradiction of the above facts leads to the necessity of applying economic intelligence to university-industry interactions in order to foster long-lasting regional economic development.

The concept of Regional Innovation System was first analysed by Nauwelaers and Reid (1995). This research report, led by RIDER on behalf of DGXIII, considers university-interactions to be the 'heart' of the Regional Innovation System.

Therefore, this dissertation contributes for a more in-depth analysis of the role of a regional innovation system in the context of regional economic development. In particular, it systematises and details concepts present in existing literature regarding regional innovation systems and strategies, as synthesised below by the main findings of this dissertation marked with the symbol '∴'.

The regional economic intelligence system proposed by this dissertation has three main objectives:

1. target research efforts to market needs,
2. process and distribute information on R&D results useful to local economic operators, and
3. increase the capacity of SMEs to absorb new technology.

Through the concerted implementation of these activities the regional economic intelligence system aims to:

4. Develop the innovative capacity of SMEs, and
5. Strengthen the regional dimension of innovation.

∴ This dissertation has shown that the successful accomplishment of the above five points, i.e. to be successful in fostering regional innovation, economic intelligence in university-industry interactions requires the set-up of special infra-structures, namely:

- <u>A regional innovation observatory</u>, to maintain the coherence of the regional economic intelligence system as a whole (the brain),
- <u>Environmental scanning mechanisms</u>, to (1) anticipate market demands and technical evolution and (2) evaluate the performance of the key actors and the effectiveness of the system in developing the innovative capacity of SMEs (the eyes), and

- Innovation support organisations (ISOs)[1], to initiate and foster the transfer of knowledge between the universities and local SMEs and overcome barriers of communication and culture that usually block university-industry interactions (the heart).

The universities and SMEs corresponds thus to the 'limbs' of the regional economic intelligence system, i.e. the productive agents behind regional economic development.

In short, a regional economic intelligence system has to be capable of adapting its S&T policies and technology management policies to changing technological demands on a continuous basis. Therefore, it is necessary to develop indigenous regional innovation capacity by launching awareness and training campaigns targeted at the key players on issues, such as, S&T policy in the context of regional development, exploitation of R&D results (the set up of universities' technology transfer offices, intellectual property), innovation audits, innovation management techniques and technology management[2].

Regarding the existing literature on regional innovation systems and strategies (mainly edited by or on behalf of the European Commission), the critical success factors presented above highlight the main differences between the regional economic intelligence system presented in this dissertation and the regional innovation system described in the RIDER book, namely:

∴ The (regional) government has to increase its intervention in the regional innovation system becoming a key player instead of a 'secondary' actor. In particular, it should promote technology prospecting and monitoring activities to allow the better definition of S&T policies and technology management policies at regional level and thus privileging the demand-pull innovation route;

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[1] Already identified as a key actor of a regional innovation system by Nauwelaers and Reid (1995).

[2] Regarding technology management, special consideration should be given to improving the SME's approach to innovation and, in particular, to strengthen the innovative capacity of SMEs by developing their:

- Technological competence: the ability to master the particular technologies which are relevant to the needs of the company;
- Entrepreneurial competence: the ability to generate and implement strategies for research and technology coherently linked to business strategy;
- Learning ability: the ability to adapt organisationally and culturally in order to accommodate technological change.

∴ ISOs have a dual role on the regional innovation system: on top of being technology transfer facilitators, they have also to become environmental scanning mechanisms regarding the monitoring of the SMEs' innovation profile.

This dissertation highlights also two other aspects, more of a methodological and operational procedures nature, namely:

∴ The dissemination of S&T information to promote the exploitation of R&D results should be based on two different technology transfer mechanisms (electronic diffusion and point-to-point transfer) according to its main targets (ISOs and SMEs) and on a two stage process (from universities to ISOs and only then to SMEs) as depicted in figure III.3;

∴ There is no suitable methodology to measure the innovation profile of SMEs (their technological status, needs and capabilities) which hinders seriously the evaluation of the performance and effectiveness of the regional economic intelligence system and ultimately the coherence of the S&T and technology management policies.

***Research recommendations and future work.***

I am particularly interested in proceeding this line of research, namely design a regional economic intelligence system for the North Portugal region, and especially, its 'brain': the regional innovation observatory[3].

This is a wide research domain because designing a regional economic intelligence system (REIS) implies, in particular:

1. study in depth each of the six processes that comprise the regional economic intelligence system (technology prospecting, foster university-industry links, dissemination of S&T information, innovation audits, technology management and evaluate the effectiveness of system). Each of these processes could stand for a master or doctorate thesis;
2. analyse the interactions between and within each of the sub-systems: government, universities, ISOs and SMEs.

[3] I have recently obtained a contract between TecMinho and the European Commission (DGXIII) to perform a feasibility study for setting-up a regional innovation observatory in the North region, within the context of the regional innovation strategy exercise that is being implemented by Agência de Inovação.

There are two areas of particular and immediate interest to me, namely:

1. Design a methodology to assess and quantify SMEs' innovation profile in order to evaluate the effectiveness of the regional economic intelligence system, and in particular, the effectiveness of the Gallaecia IRC, and
2. Analyse the viability of applying the strategic information systems methodology to map the regional innovation strategy in order to select the most appropriate types of information systems that would improve the efficiency of the regional economic intelligence system.

1. *Methodology to assess a SME's innovation profile*.

The absence of methodology to quantify the SMEs' innovation profile can put at stake the role of the ISOs as technology transfer facilitators and environmental scanning mechanisms and therefore the whole economic intelligence system (which aims at the development of the innovative capacity of SMEs through the exploitation of R&D results).

Regarding the evaluation of the regional economic intelligence system, the typology presented by the University of Bath (presented in annex IV) needs to be translated into an allocation tool in order to allow, on one hand, the quantification of the interface segments of the innovation triangle, and, on the other, the measurement of the innovation potential of the SMEs, so as to monitor its evolution within the life-cycle of the system.

A correlation has to be found between the multidimensional analysis of characteristics and needs {market and competitive environment (d1); plans and strategies (d2); innovation activities and policies (d3); management and organisation (d4); main descriptive factors (d5)} and the innovation potential (I) so as to place undoubtedly the SME in the innovation triangle. Each dimension (di) could be valorised as a function of the major 'innovativity' factors that characterise the SME in that particular dimension - I=f(di).

A report by Roland Berger & Partner and Algoe Management of 1993 included in the 'SME categorisation literature analysis' report [OPTEM, 1994], presents a set of six 'innovativity' factors and, for each, identifies different profiles/attitudes:

1. Explicit strategy: Leadership by product differentiation and cost control; Specialisation on world market niches; Control of local market through low costs; Imitation of a leader.

2. Market location: World-wide market strategy; Specialising on developing countries' / distant markets; Focus on European market; Focus on domestic markets.

3. Networking with clients and suppliers: Minimal commercial relations; Purely commercial interdependence; Commercial and EDI link proximity; Technological and industrial relation.

4. Organisational Flexibility: Entrepreneur-decided flexibility; Little organised flexibility; Flexibility by outsourcing; Flexibility by organisational innovativeness.

5. Management of technological resources: R&D department; Internally innovating; Open to external resources; Little developed.

6. Performance: Global performance; Dynamic growth; Moderate growth; Decline.

Each dimension (di) could be quantified as a function of the profiles that characterise the SME in each area - di=f(pj).

Table V.1 stand as an example of an allocation tool regarding the five dimensions analysed in the University of Bath's typology and the six innovation factors proposed by Roland Berger *et al* in the OPTEM report.

The fundamental question remains, however, assuming that the above dimensions and profiles are enough to classify the SMEs into the 9 types defined by the University of Bath's typology (hypnotises that needs to be validated), how to correlate the different profiles and dimensions with the innovation performance of the SMEs[4].

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[4] Regarding this issue, I am planning to submit a research proposal led by TecMinho to the TSER community programme (Targeted Socio-Economic Research) to develop a methodology to assess and measure the innovation profile of SMEs by industrial sector (textile, clothing and shoe industry, wood, cork and furniture industry, metalo-mechanics, agro-food, etc, i.e. the main traditional sectors of North Portugal).

**Table IV.1 – Allocation tool to classify SMEs according to their innovation profile**

| **Dimensions** | **Innovation factors** | | | | | | **Sub-total** |
|---|---|---|---|---|---|---|---|
| | Explicit Strategy | Market Location | Networking | Organis. Flexib. | Tech. Resources | Performance | di=f(pj) |
| Market and competitive environment | | | | | | | |
| Plans and strategies | | | | | | | |
| Innovation activities and policies | | | | | | | |
| Management & Organisation | | | | | | | |
| | | | | | | **Total** I=f(di) | |

The 'main descriptive factors' were not considered a dimension in itself as the quantitative factors analysed in the Bath typology could be used measure the performance of the SME, and thus become instead an innovation factor. The performance profiles are therefore dependant on the:

- Industrial sector,
- Company's age, ownership and size,
- Ratio managers and engineers vs. total staff,
- Employee size and turnover evolution over the past 5 years,
- Turnover per employee, profits, exports.

2. *Strategic Information Systems*

The application of Information Systems and Technologies to improve the efficiency of the interactions between and within each of the REIS' sub-systems is a research issue of extreme importance and of particular interest to me due to my university degree background – Information Systems and Computing Engineering. I would like, in particular, to study the possibility of applying the methodology proposed by Wiseman (1988) – Strategic Information System - to the selection of the type of information systems that would improve the efficiency of the regional economic intelligence system.

This methodology comprises the thought of Porter regarding the model of competition analysis [Barata, 1996]. Being an evolutionary economist, Porter puts technological change at the centre of its analysis, stating that 'competitiveness depends on the capacity to innovate and upgrade' and that 'the basis of competition has shifted more and more to the creation and assimilation of knowledge'[Diederen, 1995].

In conventional MIS methodologies there are two motivations or impulses for the implementation of Information Technologies: (1) automate the basic processes of the firm, and (2) satisfy the staff's information needs according to the different management levels (generic objectives), namely strategic planning, management control and operational control.

The Strategic Information Systems approach considers five 'strategic impulses' - cost, differentiation, innovation, growth, alliances – which are movements initiated by the firm to gain or maintain certain competitive advantage, or to reduce the competitiveness or negotiation strength of the three 'strategic objectives' – suppliers, clients, competitors (see figure V.1). In this case, the model generates 15 'areas of strategic opportunities', instead of the 6 generated in the conventional models.

The desegregation of each 'area of strategic opportunities' will allow the selection of the type of information systems that would optimise the main mechanisms and procedures of the regional economic intelligence system. Information Technologies are perceived by this methodology as the privileged vehicle for the accomplishment of the above strategic impulses and for gaining competitive advantage [Barata, 1996].

**Figure V.1 – Strategic Information Systems**

*adapted from Barata (1996)*

| Strategic Impulses | | Strategic Objectives | | |
|---|---|---|---|---|
| | | Suppliers | Clients | Competitors |
| | Cost | 1 | 2 | 3 |
| | Differentiation | 4 | 5 | 6 |
| | Innovation | 7 | 8 | 9 |
| | Growth | 10 | 11 | 12 |
| | Alliances | 13 | 14 | 15 |

# ANNEX I - UNIVERSITY / INDUSTRY INTERACTIONS

## 1. Introduction: Technology transfer settings

Technology transfer operates on a variety of settings as it can involve research and technical interactions at different levels:

1. within a firm (or a group of firms working closely together),
2. between organisations (for example, between an individual firm and the S&T system in which is located), and, more widely,
3. between industrial sectors and economies.

This broad typology is depicted in table AI.1 and shows the three main levels:

1. intra-organisational,
2. inter-organisational (including intra and inter-industry) and
3. inter-economy.

This dissertation has converged its analysis of technology transfer within a multi-institutional sector, in particular the analysis of University-Industry interactions, as highlighted in table AI.1.

## 2. Technology transfer links and mechanisms

A problem when analysing the typologies of university-industry interactions is the lack of distinction between 'links' and 'mechanisms' found in current literature:

- Links refer generally to both formal and informal flows and often rely on personal contact established between a firm and an individual (or group of) researcher(s) within a department. The degree of formality can be associated with the time period involved in such contact, moving from one-to-one relationships to consortia arrangements;
- Mechanisms are more policy-orientated and cover more formal S&T collaboration between industry and university, with a more specific institutional arrangement associated with a physical (for example, research park) and/or legal (such as a limited company) form.

**Table AI.1 - Settings of technology transfer**
*Source: Charles and Howells, 1992*

| Setting | Contents | Selected references |
|---|---|---|
| **1. Intra-organisational** | | |
| Intrafunctional (within functions) | Especially R&D | Allen and Cohen, 1969<br>Allen et al., 1979<br>Cohen et al., 1979 |
| Interfunctional (between functions) | R&D, Manufacturing and Sales & Marketing | Sagal, 1978<br>Ounijian and Carne, 1987<br>Souder and Padananabhan, 1989 |
| **2. Inter-organisational** | | |
| **2.1 Single institutional sector** | | |
| Inter-firm | | Hagedoorn, 1990 |
| Intra-industry | Horizontal cooperation between potential/existing rivals | Von Hippel, 1987 |
| Inter-industry | Vertical cooperation<br>Complementary technologies<br>Producer-user relationships | Mowery, 1988<br>Von Hippel, 1977 |
| Inter-universities | Joint academic collaboration, in particular, more formal relationships to gain government or private funding | |
| Inter-research centre | Develop complementary technologies or joint resources | |
| **2.2 Multi-institutional sector** | | |
| University-Industry | Research and technology collaboration and alliances | Fusfeld and Haklish, 1984<br>Coursey and Bazeman, Geisler and Rubenstain, 1989<br>Charles and Howells, 1989<br>Malecki, 1990 |
| **3. Inter-economy** | | |
| **3.1 Interregional** | Core periphery flows | Howells and Charles, 1989 |
| **3.2 International** | | |
| Intracontinental | Intra-EU | |
| Transcontinental | North-South economic development issues | Spencer and Woroniaka, 1967<br>Germidis, 1977<br>Stewart, 1979 |
| Global | Personnel<br>Intra-firm<br>Inter-firm<br>Interorganisational<br>General | Hammond and McPherson, 1979<br>Germidis, 1977<br>Erdilek, 1989<br>Contractor and Segafi-Neijod, 1987<br>Sahal 1982 |

Another issue is the overlapping between the different classifications and the increase in the overall number and variety of university-industry types of interactions which fall mainly within four broad categories:

1. Research and technical links (research collaboration and/or shared used of university and industry facilities);
2. Information transfer (cross-licensing deals, advisory services and consulting);
3. Human resources mobility (movement of staff and students in both directions, training);
4. Transfer of economic activities (creation of new firms: spin-offs).

Within each of these generic categories exist a number of different mechanisms, some of which may encompass a wide range of functions crossing these boundaries. However, the range of such mechanisms is so varied in institutional arrangements and in the scope of actions carried out that such overlap is inevitable and inescapable [Charles and Howells, 1992].

As stated before in this dissertation, technology transfer between industry and universities involves the movement and application of knowledge. Hence, university-industry links in research and innovation can be classified according to a two-way interactive flow of initiative, funds and personnel, as shown by table AI.2, rather than their actual physical mechanisms (such as co-operative research centres).

**Table AI.2 - University/Industry links in research and innovation**
*Adapted from Charles and Howells, 1992* (source: *Howells, 1986)*

| |
|---|
| 1. Industry research consultancies undertaken by academic personnel<br>2. Industry workers appointed as part-time professors/lecturers<br>3. Basic and applied research in an university department funded by industry<br>4. Development, testing and trial (e.g. drugs) for industrial products and processes<br>5. Other industry-funded activities: patent advice, product liability/litigation |
| |
| 1. Academics associated with part-time secondment to industry<br>2. Academics as non-executive directors<br>3. Inventions originating in universities - taken up by existing industrial companies<br>4. Inventions originating in universities - leading to new high technology companies (spin-offs) |

## 3. Evaluation of University/Industry interactions

In order to further stimulate university-industry links, universities need to assess the results of their efforts more systematically and effectively.

An effective evaluation of university-industry interactions need to be aware of the different dimensions and scales that are involved in such links (see table AI.3), namely direction, formality and orientation of suck links as well as their eventual outcome.

**Table AI.3 - Key dimensions of university-industry links**
Adapted from Charles and Howells, 1992 (*source:* Howells, 1986)

| | |
|---|---|
| **Direction** | Direction of flows between industry and universities (varied and not uni-directional). |
| **Formality** | The degree of the formality of the contact varies, ranging from informal links based on personnel ties through highly formalised structural contacts via university consultancy groups, where contracts are involved. |
| **Fund size** | The amount of funds involved |
| **Outcome** | The outcome ranges from background information through to development work, the generation of an invention leading to a major new product or process and sometimes, associated with this, the formation of a new company to market or produce such an invention. |
| **Orientation** | The orientation of U-I ties can range from short-run development work associated with specific commercial objectives through to long-term, basic research which has no immediate commercial application. |
| **Geographical scale** | U-I links involve a geographical component or perspective. Links can be local, regional, national or international in nature. |

Another important aspect to be considered is that the evaluation of university-industry interactions can be separated into two distinct elements:

- the monitoring and measurement of the actual flows (inputs), and afterwards
- the evaluation and measurement of the subsequent impact of such flows (outputs).

Until recently most studies have tended to take a simple static approach to the evaluation of university-industry links, focusing on the economic evaluation of S&T covering a small range of indices: R&D expenditure, R&D employment, scientific and technical personnel, and patents. These indices were then related to data on industrial and economic growth at a micro (firm) level, meso (industry) level, or macro (national) level.

In particular, a number of studies have attempted to devise a set of indicators for the evaluation of the research output, namely [Charles and Howells, 1992]:

- Martin and Irvine, 1981; 1983
- Martin et al., 1986
- Frome, 1983;
- Narin et al., 1984
- McQueen and Wallmark, 1984
- OECD, 1987a
- Wallmark et al., 1988
- Hare and Wyatt, 1988
- Meyer-Kramer and Montigny, 1989.

However, most the indicators of research output that have been used - bibliometric data, technology indicators, peer review and other systems, measures of esteem - are more concerned with evaluating research programmes or individual institutions rather than the evaluation of the performance and effectiveness of linkages themselves.

There are some exceptions, however. Such is the case, for example, of Steinnes (1987) and Meyer-Krahmer & Montigny (1989) that present a set of economic or industrial indicators, namely:

- numbers of spin-off companies,
- external research funding,
- sectoral employment growth.

However, it should be stressed that the study of flows and links is above all a dynamic process [Charles and Howells, 1992]. Nowadays, more applied research in this field (including other social science disciplines) tries to relate research inputs (R&D activity) with research outputs, such as product or process innovations.

Table AI.4 lists a more comprehensive set of indicators for evaluating the character of University-Industry interactions.

**Table AI.4 - List of potential indicators[1] in University/Industry interaction**

*Adapted from Charles and Howells, 1992*

| **1. Process of interaction[2]** |
|---|
| 1. Number of contacts between parties at each stage of the interaction<br>2. Organisational level of contacts<br>3. Duration / intensity level of contacts (brief conversation, meetings, etc.)<br>4. *Flavour* of contact (pleasant, stressful)<br>5. Focus of contact (administrative, technical)<br>6. Type of participants in contact (individuals, groups, researchers/administrators)<br>7. Usefulness of information content of contacts (by survey of participants)<br>8. Perceptions of the *seriousness or integrity* of the other party in participating in contact<br>9. Number of decisions made in contact<br>10. Organisational level at which decisions are made<br>11. Resources initially allocated to contacts (people, facilities) |
| **2. Immediate (short/term) outputs/outcomes** |
| 1. Change in probability of interaction in the future<br>2. Number of commitments made: monetary information and personnel exchange, access to facilities<br>3. Number of agreements drawn up (grants, licences, joint ventures)<br>4. Number of contracts signed<br>5. Amounts of money changing hands<br>6. Number of technical problems solved<br>7. Number of reports delivered<br>8. Number of conferences, workshops, symposia, and joint seminars conducted<br>9. Number of fellowships established<br>10. Number of faculty hired as consultants as consultants to industry<br>11. Number of graduate students hired by industry<br>12. Number of joint projects established<br>13. Number of industrial researchers as guest lecturers at university<br>14. Number of patents, inventions, and innovations in joint effort |

[1] Possible measures for the indicators may range from *number of* (as included in some indicators), to *degree of: usefulness, intensity, etc.*, to be provided by surveying key participants and entering responses on a scale.

[2] *Process* includes, but is not limited to, such aspects of the interaction as inputs of resources, professional activities, and decision and other managerial processes.

**Table AI.4 - List of potential indicators[3] in University/Industry interaction** (cont.)

| 3. Longer-term outputs/outcomes |
|---|
| 1. Number of faculty accepting employment with industry<br>2. Number of spin-off enterprises<br>3. Number of consortia developed<br>4. Number of third-party involvement's (government, venture capital firms)<br>5. Level of third-party involvement ($)<br>6. Level of satisfaction with interaction among participants<br>7. Impacts on teaching<br>8. Level of industrial support for research centres and programmes<br>9. Changes in per cent or number of faculty with industrial contacts<br>10. Changes in patent and licensing rules and other procedures to accommodate the needs of other party to interaction<br>11. Changes in general perception of needs, quality, and motives of other party<br>12. Developing of networks: change in average number of regular contacts<br>13. Changes in production rates, sales, productivity, profits, and other indicators of success attributed to interaction |
| **4. Type and pattern of interaction** |
| 1. Time to fruition of interactions (days, weeks, years to research agreements or research results)<br>2. Levels of each organisation involved in a given interaction<br>3. Degree of institutionalisation of contacts (multiyear agreements, permanent committees formed, etc.)<br>4. Formation of Advisory Boards and degree of formalising interaction mechanisms |

[3] Possible measures for the indicators may range from *number of* (as included in some indicators), to *degree of: usefulness, intensity, etc.*, to be provided by surveying key participants and entering responses on a scale.

# ANNEX II - METHODOLOGY FOR EXPLOITING R&D RESULTS

The methodology proposed in the Bossard Consultants study (1990) on behalf of DGXIII for exploiting R&D results consists of six phases whose total duration is generally of the order of ten years: see table AII.1 for a synthesis of the process of exploiting R&D results.

**Table AII.1- Methodology for exploiting R&D results**
*Adapted from Bossard Consultants (1990)*

| Phases | Activities |
|---|---|
| **0. Research programme** | • R&D activities |
| 1. Identification of projects | • Publicity aimed at R&D actors (researchers, industrial sponsors) |
| 2. Compilation of dossier | • Talks with R&D project actors;<br>• Identification of potential applications;<br>• Evaluation of patentability (if necessary) |
| 3. Critical analysis of the dossier:<br>• criteria (technical, commercial, marketing)<br>• means (experts, industrial sponsors) | • Finalisation of dossier (target application, profiles of industrial partners, establishment of the research strategy, supplementary pre-competitive financing)<br>• Closure of dossier (return of dossier to all the actors with reasoned arguments and information) |
| 4. Search for partners | • Search for partners (identification of the most promising potential partners)<br>• Selection of partners (letter of intention, confidentiality agreements, initial negotiation) |
| 5. Finalisation of the project | • Finalisation of the exploitation project (market research, technical feasibility, business plans, industrial property rights)<br>• Final negotiations: signature of transfer agreements (project description, industrial property, licensing conditions, special clauses) |
| 6. Project monitoring and management | • Analysis of progress reports<br>• Management of royalties (reimbursement of expenses, royalties, remuneration of researchers, laboratories, industrial sponsors)<br>• Payment of royalties |
| 0. *Research programme* | |

**Phase 1: Identification**

The identification of exploitable projects requires vigorous publicity aimed at:

- researchers,
- industrialists,
- programme managers.

**Phase 2: Compilation of the dossier**

This phase commences with the appointment of an exploitation specialist to be responsible for the project. This expert will manage and monitor the exploitation process from start to finish. The compilation of the dossier requires the active participation of the researchers and other actors (managers, industrial sponsors). The objective of phase 2 is:

- to formulate an unequivocal definition of the nature and value of the inventive discovery;
- to define the first potential applications.

This phase may also include a summary appraisal of the patentability of the discovery but the patent application does not need to be filled until very much later, at the stage of selection of industrial partners.

**Phase 3: Critical analysis of the dossier**

This is the project selection phase. The analysis is based on different sets of criteria:

| | |
|---|---|
| 1. Technical criteria - | What real technical advances can result from the exploitation of the innovation? Under what conditions? |
| 2. Marketing criteria - | Does the market have any real need for the innovation in question? What are the needs? Why? |
| 3. Commercial criteria - | What is the best marketing strategy for the innovation?<br>Who is the ideal partner?<br>What is the best partnership arrangement? |

The means of executing this critical analysis are:

- documentary research;
- the opinions of experts in the field of technology or area of application, which must always be subjected to criticism (e.g. at round-table meetings)
- contacts with a few potentially interested industrialists, possibly after the signature of confidentiality agreements.

This phase ends with the finalisation of the dossier, which can go both ways:

1. the analysis produces a negative result (75% of cases) and the dossier must be closed. This negative decision must be communicated to the actors in the process, who must be informed of the reasons for the negative response and the comments made with regard to the discovery; or
2. the result of the analysis is positive (25% of cases). The industrial operators have shown a positive or even a partial interest in going ahead with the exploitation project, whereas the experts have taken a positive view of the technical and commercial potential of the discovery. It must then be possible to:
    - define the targeted potential applications;
    - define the profiles of the proposed industrial partners;
    - compile the partner search dossier;
    - decide whether supplementary pre-competitive financing is an essential pre-requisite for the success of the project.

**Phase 4: The search for partners**

This is the trickiest phase, leading to the identification of the most appropriate industrial partners for the project in hand. The success of this phase requires a fine analysis of the industrial fabric. The partner search dossier compiled in the course of phase 3 can now be sent to national and regional structures (for instance, technological centres, chambers of commerce, industrial associations, etc.) for implementation of the search procedure in their respective geographical zones under the supervision of the exploitation specialist responsible for the dossier, who will continue to be the interface with the participants in the R&D project.

This phase ends with the definitive selection of the most promising partners with the most positive interest in the potential application or the discovery.

Letters of intention and confidentiality agreements can now be signed, and the preliminary negotiations commenced. depending on the partners discovered by the search, the industrial property process (general strategy, filling of patent applications) can be started in parallel.

**Phase 5: Finalisation of the exploitation project**

Wherever possible, the responsibility for this phase should be entrusted to the selected industrial partners (this gets them involved in the project). The exploitation expert continues to provide support in the form of:

- personal professional advice;
- advice from external consultants.

Phase 5 comprises:

- market studies,
- preparation of business plans defining the commercial and financial objectives of the project;
- technical feasibility studies;
- discussion of the industrial property protection strategy to be recommended;
- establishment of a precise work schedule comprising:
  - a timescale for the development and fine-tuning of the application,
  - a marketing schedule,
  - a growth schedule for the activity in question;

This phase ends with the signature of transfer agreements covering the elements referred to above, which must be worded to the mutual satisfaction of all parties concerned, mainly:

- the actors involved in the research programme,
- the industrial partners,
- the exploitation specialist.

**Phase 6: Monitoring and management of the project**

This phase is frequently neglected, although it should be an integral part of the exploitation process. The success of the operation depends on it: there is no point in signing a transfer agreement if the agreement is not applied, which is often the case.

This is the phase of verification of the industrial partners' compliance with the undertaking they have signed:

- transmission of progress reports on the project;
- payment of royalties:
  - reimbursement of expenditure incurred in the process (filling of patent applications, financing of prototypes, etc.),
  - royalties.

These payments must be passed on to the final recipients:

- the researcher in person,
- his/her laboratory,
- the industrial sponsors, etc.

This redistribution will ensure the credibility of the exploitation structure and boost the propensity to propose new exploitation dossiers in the future.

**Summary**

The exploitation process is long and complex and its management requires the mobilisation of a wide variety of professional expertise in the legal, marketing and financial fields, namely:

1. industrial property counselling,
2. market studies,
3. searchers for industrial partners,
4. financial studies, elaboration of business plans,
5. management counselling prior to start-up,
6. management head-hunting,
7. finance for pre-competitive research:

- direct financing for production of prototypes, samples, feasibility studies, seed capital, etc.
- 'subsidiological' assistance (assistance with the procurement of financial resources).

1. Counselling on **industrial property rights** comprises the following services:
   - intellectual property protection strategy
   - patenting strategy,
   - geographical expansion strategy,
   - renewal strategy,
   - drafting of preliminary agreements (confidentiality),
   - licence segmentation strategy (country, application, industrial sector)
   - drafting of formal agreements,
   - evaluation of licensing conditions,
   - drafting of special clauses (guarantees, production minima, improvement, renewal, reciprocity).

2. **Market studies** comprise:
   - state-of-the-art studies,
   - studies of rupture marketing prospects,
   - marketing simulation exercises,
   - organisation of round tables,
   - market segmentation and evaluations,
   - identification of potential 'pilot projects',
   - marketing studies.

3. **The search for partners** comprises:
   - preparation of profiles of potential partners,
   - definition of search targets,
   - international prospecting,
   - conduct of preliminary negotiations.

# ANNEX III - Exploitation of R&D results: the Gallaecia IRC

## 1. The Innovation Relay Centres (IRCs)

As already stated, the innovation process has much to gain from the exploitation of new technologies, but only if they are widely disseminated and put to effective use. 'Rather than their gestation, it is their dissemination and utilisation, i.e. the integration and widespread adoption of new products, processes or services in the real economy, that leads to the improvement of industrial competitiveness' [Bossard Consultants, 1990].

The recognition of the fact that the transfer of knowledge from universities into commercial innovations is all but an automatic process, has led authorities at regional level to create a wide range of innovation support organisations (ISOs) with the aim of favouring a better diffusion of S&T advances into the industrial fabric of the region.

The Commission of the European Communities has acknowledge such a fact and has launched in December 1994 a Call for Proposals under the INNOVATION Programme to create a network of Innovation Relay Centres (IRCs).

The NRC is a dedicated network of proactive advisory centres bringing research and technology closer to their clients. Its main objective is to promote the transfer of research results and technologies in accordance with the needs expressed by the local industrial fabric, in order to improve its competitiveness through innovation. The network approach of the scheme and the regional orientation of the individual IRCs will ensure that less advanced regions can take advantage of results achieved and technologies developed in regions with higher R&D potential and will thus contribute to economic cohesion in the Union.

The two main aims of the IRC can be summarised as follows:

1. Promoting innovation in local industry, notably via the exploitation of research results and technology transfer. This will be carried out largely by facilitating the diffusion of scientific and technological information between researchers and industry after analysis of and in response to local technological requirements; and
2. Promoting Community R&D programmes and in particular its results, provision of information on the specific programmes and assistance in drawing up research projects, support during the project realisation and assistance in the promotion of exploitation.

In March 1995, a consortium co-ordinated by FEUGA (Spain) submitted a project to establish an Innovation Relay Centre in the north-west regions of the Iberian Peninsula:

- North of Portugal (co-ordinator: TecMinho) - objective 1 region,
- Galicia (co-ordinator: FEUGA) - objective 1 region,
- Asturias (co-ordinator: FICYT) - objective 1 region,
- Castilla y Leon (co-ordinators: FUEVA and Technological Park of Boecillo) - objective 1 region.

The project, named **Gallaecia**, has been approved and begun its activities in October 1996. The Commission has considered it a pilot-project as it was one out of two to cover a transnational geographical area, that is, to have an inter-regional orientation.

## 2. Gallaecia in North Portugal

### 2.1 Presentation of the IRC

This section will present a brief description of the Gallaecia's Portuguese geographical coverage and a characterisation of the local industrial fabric - the main industrial sectors of the North Portugal region. It will also present the overall strategy of Gallaecia for the North Portugal region presented at the start-up meeting targeted at the Portuguese IRCs, in Lisbon - October 1996 - at *JNICT's*, promoted by DGXIII.

***Geographical coverage.***

The Portuguese GALLAECIA IRC covers the North Portugal region, above the metropolitan area of Oporto. The sub-regions involved are Minho-Lima, Cávado, Ave, Tâmega, Douro and Alto Trás-os-Montes. Two IRCs cover Portugal to the south: Agência de Inovação and Instituto de Soldadura e Qualidade.

***Industrial characterisation.***

North of Portugal's specialisation pattern is based on traditional, low-skill industries. Gallaecia has targeted the main industrial sectors of the above mentioned regions namely: textile and clothing, agro-food, wood and cork, and metalo-mechanics. The tables AIII.1 and AIII.2 show a distribution of these sectors at regional and national level.

These regions suffer from a major weakness namely the lack of innovation support organisations (innovation consultancy, technology brokers, information services, management consultancy). Moreover firms are not fully aware of the importance of these services - suppliers are still the main source of technological information for the Portuguese enterprise.

**Table AIII.1 - GALLAECIA's target group - distribution by sub-regions**
(number and %)

| | Agro-food | Wood and cork | Furniture | Metalo-mechanics | Textile / clothing | Total (region) |
|---|---|---|---|---|---|---|
| Minho-Lima | 41 (4.8%) | 43 (5%) | 14 (1.6%) | 31 (3.6%) | 106 (12.4%) | 853 |
| Cávado | 42 (1.9%) | 65 (3%) | 50 (2.3%) | 148 (6.9%) | 656 (30.8%) | 2.129 |
| Ave | 101 (3.1%) | 60 (1.8%) | 30 (9.4%) | 209 (6.5%) | 1463(45.9%) | 3.186 |
| Tâmega | 70 (3.1%) | 87 (3.9%) | 354(16.1%) | 81 (3.6%) | 624 (28.4%) | 2.196 |
| Douro | 19 (5.4%) | 11 (3.1%) | 0 | 11 (3.2%) | 5 (1.4%) | 347 |
| Alto Trás-os-Montes | 33 (7.3%) | 11 (2.4%) | 3 (0.6%) | 22 (4.8%) | 6 (1.3%) | 450 |

*Source*: INE - December 1993

**Table AIII.2 - GALLAECIA's target group - distribution by sectors**
(number of companies and percentage)

| | Agro-food | Wood and cork | Furniture | Metalo-mechanics | Textile / clothing |
|---|---|---|---|---|---|
| Minho-Lima | 41 (4.3%) | 43 (4.3%) | 14 (1.7%) | 31 (1.3%) | 106 (2.1%) |
| Cávado | 42 (4.4%) | 65 (6.5%) | 50 (6.3%) | 148 (6.5%) | 656 (13.2%) |
| Ave | 101(10.8%) | 60 (6%) | 30 (3.8%) | 209 (9.2%) | 1463(29.5%) |
| Tâmega | 70 (7.4%) | 87 (8.7%) | 354(45%) | 81 (3.5%) | 624 (12.6%) |
| Douro | 19 (2.3%) | 11 (1.1%) | 0 | 11 (4.8%) | 5 (1%) |
| Alto Trás-os-Montes | 33 (3.5%) | 11 (1.1%) | 3 (3.8%) | 22 (0.9%) | 6 (1.2%) |
| **Total (Portugal)** | 934 | 995 | 785 | 2253 | 4951 |

*Source*: INE - December 1993

***Strategy.***

GALLAECIA, in a wider context, aims to promote regional economic development by fostering technological co-operation between university and industry at two different levels of the innovation chain (see figure AIII.1):

1. the adoption of new technologies (by SMEs) and,
2. the up-take of pre-competitive research activities (by universities).

In order to achieve the IRC's mission, promote regional innovation via technology transfer and exploitation of R&D results, GALLAECIA has the following specific objectives:

- increase the participation of local companies in R&D projects,
- develop training programmes on innovation management techniques (IMT),
- diffuse information selectively on new technologies and R&D results,
- foster the creation of spin-off companies[1].

[1] As new kinds of institutional developments among business, government and academia are beginning to promote economic development and technology diversification, universities are becoming more proactive in the spawning on new businesses. The university increasingly is being looked upon to become a generator for cutting-edge technologies and economic development in addition to the traditional roles of teaching and research [Dietricht and Gibson, 1990].

Spin-off activities can foster a dynamic environment for promoting regional innovation by providing:

- the application of research results,
- the creation of cutting-edge technology-intensive companies,
- an exciting environment for attracting and retaining quality graduate students in the region,
- an increased intervention of the university in the community,
- and enhanced national and international prestige, both at university and regional level,

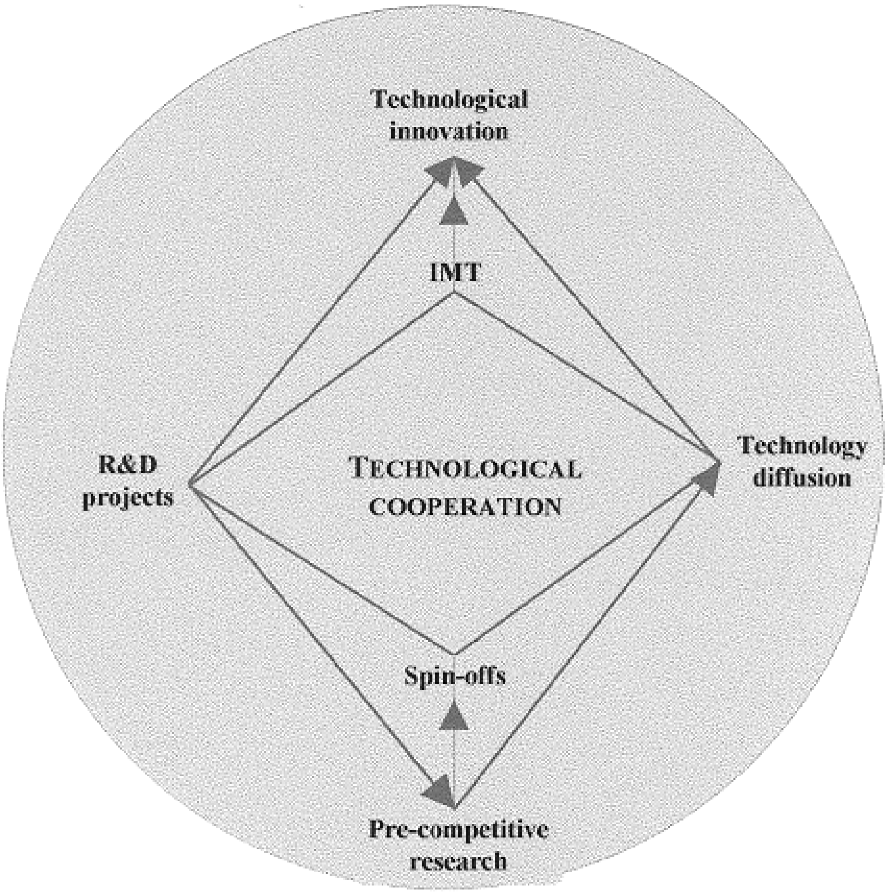
and these are only the non-financial benefits of university spin-off activities.

There are three main ways by which universities could encourage the spin-off process:

1. sell the rights to the innovation;
2. license the rights to the innovation; and
3. arrange for an equity position in the venture [Dietricht and Gibson, 1990].

Universities should therefore establish their own technology transfer interfaces (such as TECMINHO) to promote the commercialisation of academic research and facilitate interaction with industry. These institutions could apply for patents, arrange licensing agreements, and work with the venture-capital industry for the creation of spin-offs based on university research. Incubation units could support the 'selling of ideas', and the set-up and management of the spin-off ventures.

**Figure AIII.1 - GALLAECIA´s mission: regional innovation**




## 2.2 Setbacks

In order to present a coherent strategy to improve the process of technology transfer in a region, and according to the concept of the interactive innovation model of a regional innovation system, one should first study the region's innovation potential, namely:

- measure and evaluate regional technological innovation services and infrastructure,
- map inter and intra-regional innovation networks,
- analyse the interactions between 'Innovation Support Organisations' (ISOs) and firms and other agents on a regional basis,
- evaluate the technology management strategy of the local industry.

Such a study is already in due course in the North Portugal region co-ordinated by Agência de Inovação:

In 1994, the European Commission decided to launch a pilot action, jointly managed by DGXIII and DGXVI, entitled Regional Technology Plans, renamed in 1997 as Regional Innovation Strategies (RIS). The RIS action provides assistance for developing regional research and technological development strategies in the context of Structural Funds for objective 1 (regions whose level of development is lagging behind) and objective 2 (regions affected by industrial decline) zones. These studies are specifically targeted to assist regions in order to help them optimise the use of European Regional Development Funding (ERDF) with regard to investments in R&D activities.

Six main themes form the basis of the methodology of these exercises:

- strengths and weaknesses of regional firms including the assessment of regional R&D and innovation demand;
- an analysis of the main technological an industrial trends in the regions;
- an analysis and assessment of the regional technology supply;
- modes of intervention and main orientations of institutional actors;
- definition of strategic goals;
- definition and implementation of a monitoring and evaluation system.

As the study is just beginning, there was no possibility to 'design' the Gallaecia IRC within the Regional Innovation Strategy.

## 2.3 Technology transfer and exploitation of R&D results

TECMINHO is following two different routes to accomplish technology transfer and the exploitation of Universidade do Minho's R&D results: through demand-pull and technology-push schemes. The results achieved by each of these schemes are the following:

### *1. Demand-pull scheme*

A questionnaire was sent to 4000 companies regarding their technological needs and innovation potential, during April 1996. As this was a very long questionnaire and companies are overwhelmed by mailings of this kind, the questionnaire was divided in two:

- the 1st mailing, targeted at the 4000 companies, dealt with the firm's technological needs and was sent by the Technological Centres partners of Gallaecia; whereas
- the 2nd, dealing with their innovation potential was sent by TECMINHO to the companies that answered the first one.

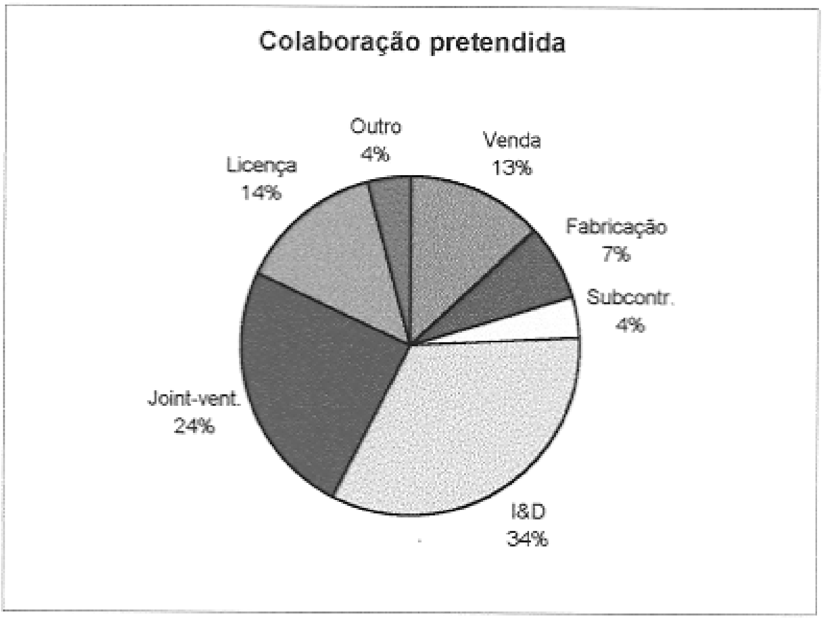
TecMinho had, by the end of July 1996, a response of (only) 4% regarding the 1st questionnaire, though the 2nd mailing achieved a rate of 30%. Each company is now being visited by GALLAECIA's staff to assess the firms' technological status, needs and capabilities.

*2. Technology-push scheme: Exploiting Universidade do Minho's R&D results*

TECMINHO initiated this innovation route by identifying exploitable R&D results resulting from research activities of the Schools of Engineering and Sciences of Universidade do Minho. The tasks performed by the author corresponded to phases 1 and 2 of the methodology presented in annex II.

During the months of July, September and October of 1995, 80 exploitable R&D results were identified at various levels of development and with different valorisation strategies (see figure AIII.2).

**Figure AIII.2 - An analysis of Universidade do Minho's R&D results**




The exploitation strategy for each of the above results will vary according to:

- the different levels of development regarding its industrial application,
- the type of technology involved (process, product, equipment, know-how, etc.), and
- the degree of involvement of industry in the R&D projects that lead to these results.

Both tasks (companies visits and the identification of exploitable R&D results) will allow TecMinho to match Universidade do Minho's S&T offer with local industry's technological demand.

# Annex IV - Classification of SMEs

Within a region, there are a great diversity of firms (especially SMEs) in terms of entrepreneurial attitudes, stages of development, willingness to grow, capacity to innovate, dependence on technology, etc.

The definition, implementation and evaluation of regional innovation strategies, in particular, S&T policies supported by technology management policies targeted at the SMEs, developed by the regional economic intelligence system should take these differences into account, which creates the need to classify SMEs by their innovative potential.

A categorisation one could apply consists in the triangle of SMEs (figures AIV1, 2 and 3). Within these segmentations, the proportion of each type of SME will vary according to the local industrial environment. Invariably, however, the number of SMEs decreases as their innovative capacity increases, thus the denomination of 'triangle of SMEs'.

When defining technology management policies to develop the innovative capacity of SMEs, it is important to acknowledge that '<u>firms at the interface between segments may be of the most interest to policy makers as the maximum impact may be achieved by helping to move these up into the next group</u>' [Fraunhofer ISI, 1996].

**Figure AIV.1 – Classification of firms according to their growth potential**

*adapted from Fraunhofer ISI (1996) and RTACs' internal report – EIMS contract n° 93/96*

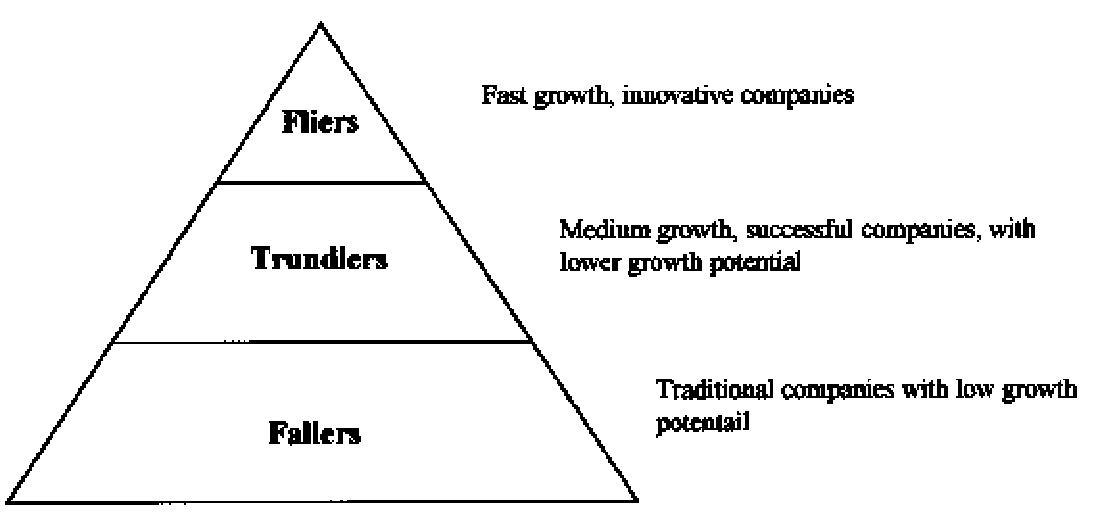
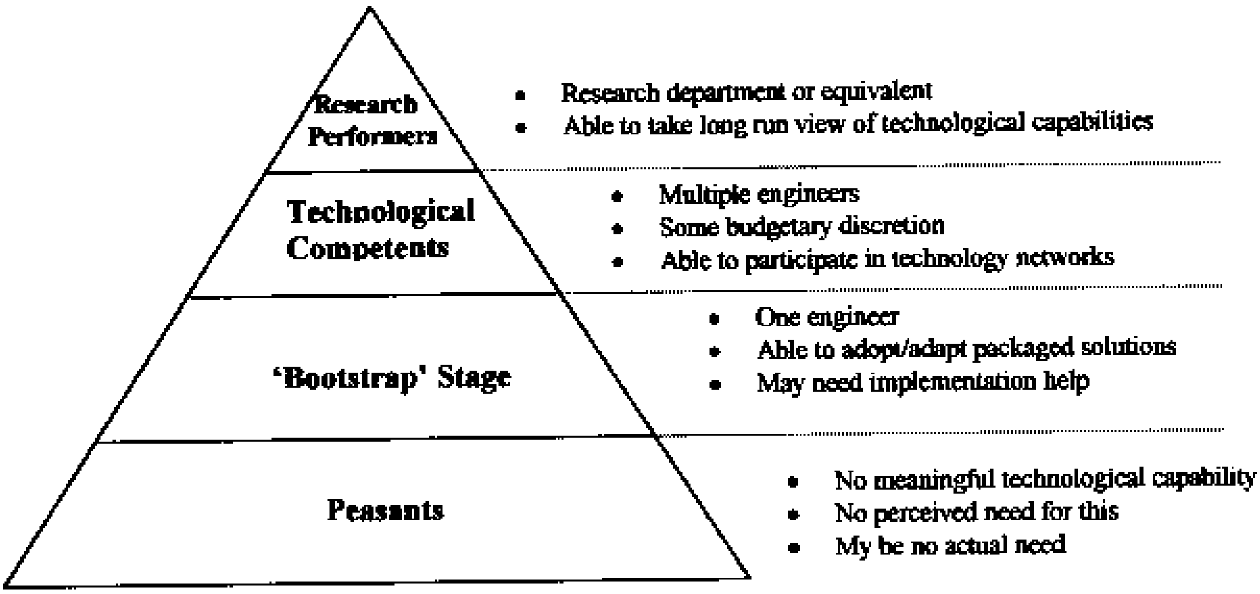


**Figure AIV.2 - Classification of firms according to their technological capabilities**
*adapted from the Green Paper of Innovation [EC, 1995] (source: Guy & Arnold, 1993)*




The effectiveness of an economic intelligence system to promote regional innovation via technology exploitation could be measured by the growth in the innovative potential of SMEs, by how many SMEs were supported and accomplished in 'climbing the steps of innovation', i.e. in moving from one segment to another.

The main goal of a regional economic intelligence system would be thus to shift the weight of the triangle from the basis (dependent regions) to the vortex (advanced regions)[1].

Therefore, the more these generic types can be sub-divided, the more specific could the innovation policies become, as well as better targeted, and the final results better evaluated. This leads us to the third categorisation of SMEs based on an internal EIMS report (project 95/137), whose research was led by the University of Bath (1997) – School of Management - UK (see figure AIV.3).

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[1] According to RIDER (1995) regions can also be categorised according to their level of economic development:

- Advanced regions – the core regions of the 'blue banana' and the metropolitan regions in each member state;
- Adaptive regions – traditional industrial regions with a high potential of fundamental research but limited private sector research and university-industry links;
- Dependent regions – objective 1 and rural regions.

**Figure AIV.3 - Classification of firms according to their innovation profile**

*Adapted from Morgan (1997)*

| | |
|---|---|
| 1. New technology based firms | SMEs successfully pursuing technological advance in specific areas of new, fast developing technologies. |
| 2. Niche market differentiators | SMEs successfully exploiting value added niches[2] in traditional markets, with great creativity and inventiveness as regards new product ideas, yet not necessarily with much technological content. |
| 3. Technological leaders | SMEs which have succeeded in becoming industrial leaders, with their own products and technologies, and in acquiring leading market shares in their own markets, with a strong innovation policy based both on product R&D and process effectiveness. |
| 4. Joint developers | SMEs working as subcontractors but having an important role in designing, or co-designing / developing the products which their clients ask them to produce. |
| 5. Efficient classical subcontractors | SMEs with no or hardly any products of their own, working mainly on customers' specifications, with no substantial input into product design while attaining high levels of efficiency and performance within that framework. |
| 6. Resilient SMEs | SMEs characterised by having, only recently, positively reacted to adverse market conditions by focusing on innovation strategies. They have had their own products, or at least their own specific know-how, but with little technological content. |
| 7. Would-be reactive SMEs | SMEs that, although quite aware of the need to react, mainly through innovation and diversification, find themselves constrained, whether it is for lack of innovation structures and know-how, of investment capacity, or merely management time. |
| 8. Quietly passive SMEs | SMEs which in recent years have followed already established tracks without much growth or change, and without being menaced by any significant adverse events in their market or in their operations. These companies are characterised by great stability. |
| 9. Barely surviving SMEs | SMEs which have been subject to very hard pressures and exposed to difficulties that threaten their existence. Their energy is largely absorbed by their struggle for survival, and they appear helplessly unable to find out ways of moving out of that situation. |

[2] Those niches are generally found in markets where larger firms are also active, but concentrate on larger volume segments.

The qualitative classification proposed by this report segments SMEs into nine types based on a multidimensional analysis of characteristics and needs and derived from in-depth fieldwork with a sample of companies across Europe.

The report describes, for each type:

- A summary type definition, with a list of the most likely industrial sectors / activities to be included in each type;
- The market and competitive environment;
- Plans and strategies;
- Innovation activities and policies;
- Management and organisation;
- Main descriptive factors (quantitative);
- Problem areas and potential support needs.

According to this segmentation, the SMEs classified in the first five types have experienced unequally fast, but generally regular growth over the past five years and, on the whole, maintained existing successful strategies. Specific innovation support initiatives targeted at each one of these types are the most likely to achieve better and faster results regarding overcoming the problem areas identified and thus increase their innovative capacity.

The other four types represent SMEs facing serious adverse market conditions or gradual market erosion. These types of SMEs need especially the help of consultants for diagnostics and strategy definition to overcome the company's major weaknesses (technology, marketing, organisation, etc) before other innovation measures can be successfully implemented.

Type six SMEs, however, which have recently been saved from severe crisis or problems by engaging in successful innovation activities, need also assistance to set up permanent basis for building innovation policies, such as

- innovation strategy and follow-up consultancy, and
- innovation management techniques.

Though much more detailed, this classification is still qualitative and fails to propose an allocation tool to operationalise the typology and allow the companies to be classified to type on the basis of limited information.

Therefore, further research is necessary on this subject if the coherence of the regional economic intelligence system is to be maintained.

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