UNIVERSIDAD POLITÉCNICA DE VALENCIA

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BENCHMARKING REGIONAL INNOVATION SYSTEMS: THE RELEVANCE OF EFFICIENCY TO THEIR PERFORMANCE

PhD DISSERTATION

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Hoy,

quisiéramos ser grandes,

tan grandes como la tristeza,

como la vida que cosechaste a manos llenas.

Tan sólo por hoy,

gigantes como tu alegría,

como nuestros puños cerrados,

como los brazos abiertos.

Solamente hoy,

confundidos con las lágrimas de este cielo que,

tal que los tuyos,

nosotros,

por ser hoy,

también está llorando.

Kutxi Romero (2006)

A la memoria de todos aquellos que estuvieron y siempre estarán.

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BERD (Business sector Expenditure on R&D)

CDTI (Centre for the Industrial Technological Development)

CIBEPAT (Spanish and Iberoamerican Patents Database)

CIS (Community Innovation Surveys)

CRS (Constant Returns to Scale)

CSIC (Spanish National Research Council)

CRUE (Spanish University Statistics)

DEA (Data Envelopment Analysis)

DG (Directorate General)

DMU (Decision Making Unit)

EC (European Commission)

ECI (European Competitiveness Index)

EIS (European Innovation Scoreboard)

EPO (European Patent Office)

EU (European Union)

FDH (Free Disposal Hull)

FEDIT (Spanish Confederation of Innovation and Technology Companies)

GERD (Government Expenditure on R&D)

HEI (Higher Education Institutions)

HERD (Higher Education Expenditure on R&D)

IAIF (Institute of Industrial and Financial Analysis)

ICT (Information and Communication Technology)

INE (Spanish National Statistical Institute)

IPR (Intellectual Property Rights)

IRE Network (Innovating Regions in Europe)

IS (Innovation System)

NIS (National Innovation System)

NISTEP (National Institute of Science and Technology Policy)

NRS (Non-increasing Returns to Scale)

OTRI (Research Results Transfer Office)

PIT (Process, Intervention and Theory)

RIT (Regional Innovation and Technology)

RIS (Regional Innovation Systems)

RIS' (Regional Innovation Strategies)

RITTS (Regional Innovation Technology Transfer Strategies)

RTP (Regional Technology Programmes)

R&D (Research and Development)

SFA (Stochastic Frontier Analysis)

SFTP (Spanish Food Technology Programme)

SME (Small and Medium sized Enterprises)

STI (Science Technology and Innovation)

S&T (Science and Technology)

TE (Technical Efficiency)

VRS (Variable Returns to Scale)

CHAPTER I: INTRODUCTION

The main goal of this thesis is to examine various benchmarking methodologies to compare the development of regional innovation systems, in order to determine the robustness of regional innovative capacity evaluation methodologies. This involves detailed study of the Research and Development (R&D) and innovation indicators to be included in these methodologies. We also investigate efficiency analysis as a complementary methodology for assessing innovative capacity. The rationale for using efficiency to complement existing benchmarks in the scientific literature lies in the fact that these methodologies are mainly based on the rationale of “the more the better”; their main foundation being the amount of resources employed, rather than how they are used. We consider that the introduction of efficiency as a criterion in the evaluation (or regional benchmarking) of innovative capacity is one of the main contributions of this research.

Innovation has become a core issue in European policy. The agreements adopted by the Lisbon and Barcelona Councils (European Lisbon Council, 2000; European Barcelona Council, 2002) reflect this trend. Against this background, the regional dimension has gained in importance (Landabaso, 1995; European Commission, 1996), demonstrated by the number of programmes – RIS’ (Regional Innovation Strategies), RTP (Regional Technology Programmes), RITTS (Regional Innovation Technology Transfer Strategies), etc. - aimed at promoting innovation, that have been implemented in the less favoured European regions since 1994 (European Commission, 1997, 1998, 1999; Henderson, 2000; Morgan and Nauwelaers, 2003). The First Action Plan for Innovation in Europe (European Commission, 1996) provided the structure as well as the analytical method for defining innovation policies. Based on this, the ‘Trend Chart on Innovation in Europe’ has become a practical tool for designers and managers of innovation policies, and has facilitated a continuous updating and analysis of available information on innovation policies. The results of the First Action Plan and the Trend Chart should enable less favoured territories to learn from good practice and to institute processes oriented to defining and implementing more territorially ‘embedded’ innovation policies (Georghiou, 1998). This justifies the increasing attention devoted to benchmarking analyses dealing with R&D and innovation in recent years (Hurmenlinna et al., 2002; Luque-Martínez and Muñoz-Leiva, 2005), as a process that allows regions to learn from their own and others' experience. Within this context we should stress the key role played by the IRE (Innovating Regions in Europe) Network as a support structure for carrying out benchmarking exercises on innovation policies in European regions. In December 2006, the Directorate General for Enterprise and Industry launched the PRO INNO platform, which complements the IRE Network, aimed at contributing to the development of better innovation policies in Europe, and learning from best practice and trans-regional cooperation (Benz and Furst, 2002; Perkmann, 2003). The scientific literature focuses on innovation policy benchmarking studies as a means to exchange experience among regions and learn from them (Hassink, 1993; Balzat and Hanusch, 2003; Dou, 2004).

There are some regions and sectors that are very active in terms of innovation, but there are others where the available qualified personnel are not sufficiently numerous to justify investment in the resources and infrastructure necessary to enable high value added activities (Freel, 2003), which is the case in most Spanish regions. Nelson (2000) noted that the presence of tertiary educated individuals with good knowledge and skills, was a distinguishing feature of those countries that were able to promote and sustain competitive and innovative firms. The literature suggests a number of reasons for differences among countries (Cooke et al., 1997; Carlsson et al., 2002), mainly related to the characteristics of innovation systems, public policies and the governance models that influence these systems (Scott and Trubek, 2002)[1]. Their analysis (Olazarán and Gómez Uranga, 2001) requires the development of robust methodologies to evaluate and benchmark the design and implementation of science, technology and innovation policies in territories.

One of the main focuses of research in this framework is on the indicators employed to assess innovativeness and the innovation system (national, regional, sectoral, local, etc.) (OECD, 1992, 2005; OECD, 1994, 2002; den Hertog et al., 1995; Leydesdorff, 2001; Saisana et al., 2003). There is implicit agreement in the literature that there is a gap in the indicators available to measure R&D and technological innovation,

[1] For Niosi and Bellon (2002: 20) "*human capital by itself does not initiate the development of regional innovation systems, but institutional and organizational conditions are instead the starting points*". However, as regional absorptive capabilities increase and innovative organizations develop, more skilled labour will be required.

required to study innovation systems in depth (Godin, 2002, 2003; Inzelt, 2004; Wagner-Döbler, 2005).

Several studies have proposed methodologies for the measurement of innovative capacity (den Hertog et al., 1995; Nauwelaers and Reid, 1995; NISTEP, 2001; Furman et al., 2002; Archibugi and Coco, 2004; Faber and Hesen, 2004; Grupp and Mogee, 2004; Huggins et al., 2004). The European Commission, for example, introduced its European Innovation Scoreboard (EIS) and implemented the Community Innovation Surveys (CIS), to provide sets of indicators designed to capture innovative capacity in European regions (European Innovation Scoreboard, 2002, 2003). The Scoreboard was designed to monitor the performance of regions in relation to the goals defined in the Lisbon and Barcelona councils. The EIS, which is considered the main measure of competitiveness in the European regions in terms of innovation, tracks the EU's progress in innovation activities based on 17 indicators, across four categories: human resources for innovation, creation of new knowledge, transmission and application of knowledge, and innovation finance, outputs and markets.

There is much work still to be done since the existing studies and the available statistics do not take account of institutional aspects, interactions, cooperation agreements, etc. which are considered to be crucial elements of an innovation system (IS) (Lundvall, 1992; Edquist, 1997; Etzkowitz and Leydesdorff, 2000). Consequently, it is important to examine the consistency among those methodologies used to determine innovative capacity, so that efforts can be directed towards overcoming their weaknesses. Also, and so as to complement the information that can be derived from the application of already existing benchmarking methodologies, we believe that consideration of efficiency criteria complements and hence increases the robustness of the policy recommendations based upon them.

This is the context for the present thesis, which aims at studying some of the regional innovative capacity measurement oriented benchmarking methodologies. The questions that we will try to answer in the course of this thesis include:

- Is the concept of innovative capacity suitable to be used in the context of innovation benchmarking?
- Are innovative capacity benchmarking oriented methodologies robust?

- Is consideration of efficiency measures (criteria) important in the context of regional innovation?
- Is it possible to complement the information provided by innovation benchmarking studies with that derived from an efficiency approach?

1.1. The “what”, “why” and “how” of the thesis

The above outlines the main framework of the thesis, and the aim of studying regional innovative capacity benchmarking methodologies. The *thesis aims to compare benchmarking methodologies oriented towards the measurement of regional innovation capacity in order to detect strengths and weaknesses, and future requirements, and based on these results, to propose efficiency measurement as a complementary methodology that will allow a more in-depth characterisation of regional innovation systems*.

The main hypothesis that this thesis will try to prove is that *the performance of regional innovation systems can be characterised by their efficiency*. We believe that *consideration of efficiency criteria complements, and hence increases the robustness of the policy recommendations based on innovative capacity benchmarking oriented methodologies*, the focus of our second hypothesis.

To achieve these objectives the research was conducted in three complementary stages that build on one another: (i) Benchmarking the Spanish Innovation System; (ii) Benchmarking the Valencian Innovation System; (iii) Illustrating the need to complement innovative capacity evaluation methodologies using efficiency criteria.

It should be emphasized that this thesis is constituted of a compendium of three inter-related publications, based on the three stages identified above. The first contribution compares the approaches to measuring innovative capacity, taking the Spanish regions as the main unit of analysis in the 1996-2000 period. The methodology proposed by Buesa et al. (2002), is based on the Spanish regions, and was hence considered to be the most appropriate comparison with the EIS.

The second contribution is oriented towards providing a dynamic perspective that shows how the Valencian Innovation System has evolved over time, with respect to its Spanish, Mediterranean and European counterparts. In the Spanish benchmarking we use a set of nine indicators based on national statistics, which are similar to those employed by the EIS, and apply to the period 1992-2004.

The third contribution aims at illustrating the possible benefits that consideration of the efficiency measurement could produce in a benchmarking and evaluation of regional innovation systems (RIS). Our data base was compiled from information taken from the EIS covering 161 European regions for 2002, and 187 regions for 2003. Since the EIS indicators are resource-based indices, regions that invest more resources are ranked higher than regions with lower levels of investment. However, this does not mean that the former group is more competitive (i.e. that their innovation systems are more productive with regard to R&D outputs) than other regions. The efficiency measurement approach aims at providing information about the use (misuse) of these resources.

The thesis is structured as follows. Chapter 2 describes the theoretical framework of this research, the main concepts employed in our contributions and the theoretical arguments that these concepts are derived from. We highlight the concepts of: (a) innovation systems, (b) science technology and innovation (STI) policies, (c) innovative capacity, and (d) evaluation and benchmarking. Chapters 3 and 4 define the major objectives and the hypotheses of the research. Chapter 5 outlines the methodology adopted and the results obtained from each of the three contributions on which the thesis is based. Chapter 6 provides a discussion of the results from the three stages of the research and Chapter 7 presents a discussion of these results. Chapter 8 offers the main conclusions of the research and finally Chapter 9, focuses on the aspects that in our view should be pursued in future research. We believe that the results of this research represent only the starting point of a fruitful research field.

CHAPTER II: THE INNOVATION SYSTEMS PERSPECTIVE IN THE ECONOMICS OF SCIENCE AND TECHNOLOGICAL CHANGE

The arguments presented in the Economics of Science and Technological Change favouring public intervention, are mainly responding to two opposite streams within this literature: the neoclassical and the evolutionary. According to the former, public intervention is based on the existence of market failures; production of new knowledge is associated with positive externalities and, thus, public Research and Development policies are justified (Arrow, 1962). As Arnold (2004: 5) asserts, "*conventional, neo-classical economics started with an ideal of firms as individualistic robots with perfect information about markets and which could therefore take perfectly rational decisions*". In this sense, neoclassical economics attempts "*to reach an optimal equilibrium […] in a deterministic or quasi-deterministic environment and is endowed with perfect rationality*" (Cantner and Pyka, 2001: 760). The evolutionary approach[2] sees knowledge as an imperfect public good that does not satisfy the usual characteristic of non-excludability (David et al., 1994). If we accept the non-rival nature of knowledge, the agents generating it will only be able to appropriate a small fraction of the social benefit produced, and therefore it will be necessary to foster R&D activities at above optimal market level, thus, justifying public policies to support these activities. Supporters of the evolutionary

[2] In their 1975 contribution, Nelson and Winter established the principles of evolutionary economics, which were elaborated in their 1982 book (Nelson and Winter, 1982).

approach,[3] however, believe that this analytical framework is more appropriate for analysing those processes characterized by strong uncertainty and in which heterogeneous actors are involved (Cantner and Pyka, 2001). The reason for this is that within this context, uncertainty prevails, so optimal solutions are missing (ibid.). Besides, the evolutionary approach puts particular stress on firms as learning organizations (Arnold, 2004), what conveys it to be "*well-suited to the analysis of innovation practices because of its emphasis upon process, learning and cooperative, as well as competitive, dimensions of interfirm relations*" (Cooke et al., 1997: 476), which contrasts with the static equilibrium and utility-maximization assumptions of neoclassical economics.

Therefore, it is necessary to clarify why it is necessary for governments (regardless of the territorial unit) to define and implement these kinds of policies, that is, to demonstrate the rationale for public intervention in STI. Following Ergas (1987), a national innovation system (NIS) is connected to state interventions for two reasons: (i) in nearly all industrialized countries, technology and innovation are promoted based on considerations of national sovereignty and international competitiveness; and (ii) technology policy measures are invoked by an awareness of significant market imperfections (Cantner and Pyka, 2001). Apart from these market imperfections[4] (Nelson, 1959; Arrow, 1962), the literature is in agreement that "*the accumulated experience [in] technology policies, together with recent advances in innovation theory, have shown the limits of a simple market failure rationale to policy"* (Papaconstantinou and Polt, 1997: 11). In this sense, Gustafsson and Autio (2006) consider that there are other imperfections that provide a rationale for public intervention in innovation policies. They talk about the market, system and social-cognitive failures.[5] According to them, market failure occurs "*when firms fail to invest in research and development due to uncertainties concerning [the] outcomes of R&D efforts as well as their appropriability. The market failure argument has been most commonly evoked as justification for subsidizing R&D, as well as for creating IPR*

[3] Cantner and Pyka (2001) consider that evolutionary economics constitutes an economic paradigm. According to Patton (1975: 9) a paradigm may be defined as "*a world view, a general perspective, a way of breaking down the complexity of the real world […] paradigms are deeply embedded in the socialization of adherents and practitioners telling them what is important, what is legitimate, what is reasonable. Paradigms are normative; they tell the practitioner what to do without the necessity of long existential or epistemological considerations*".

[4] Arrow (1962), from a neoclassical perspective, describes three major sources of market failure: indivisibility, inappropriability and uncertainty.

[5] In this sense, Falk et al., (2007: 2) consider that "*while the two approaches have a quite different theoretical background, the experience of the last decade is that they come up with quite*

[Intellectual Property Rights] protection regimes" (ibid: 2). The *system failure* argument suggests that "*due to structural, institutional, and regulatory deficiencies, the yield of R&D investments may be sub-optimal even in situations where R&D investments do happen*" (ibid: 2). Hence, "*the system failure approach adds the influence of system dynamics and the distinct character of innovation systems and supportive institutional structures into the analysis of failures of efficient knowledge production and use*" (ibid: 7). Finally, Gustafsson and Autio consider that *social-cognitive failure* is explained by the dynamics of interrelation and institutional bases on the one hand, and the social construction and structuring approach to emerging technological opportunities on the other (ibid: 11). In addition, Papaconstantinou and Polt (1997: 11) consider that there is *government failure* which "*has forced evaluators to be more careful in accounting for costs of programmes as well as for benefits, including those costs that are associated with the distortions to economic incentives that policy initiatives can bring about*". Complementing these comments, Salmenkaita and Salo (2002) provide two more rationales or dimensions to policy intervention: "structural rigidities" or "inertia within innovation systems", and "anticipatory myopia". With *structural rigidities – inertia* they consider to mean that "*the development of innovation systems is constrained by path-dependencies at the level of institutions or organizations, government interventions may stimulate new development paths. That is, innovation policies may seek to create variation and flexibility in the system*" so as to overcome these potential structural rigidities (ibid: 188). *Anticipatory myopia* in their view occurs when "*individuals and organizations may under invest in the generation and assimilation of information that contributes to their ability to act with foresight. Here, the role of the government intervention is to promote the identification and pursuit of new long-term opportunities*" (ibid: 184).

Laranja et al., (2005), in their review, describe the main rationales for public intervention in regional science and innovation policies, which include diverse approaches such as neo-classical economics, industrial districts, innovative milieux, regional innovation systems, regional dynamic knowledge capabilities and evolutionary economics (see Table 2.1.-). Along similar lines, Woolthuis et al., (2005: 610) conclude that "*terminology and definitions vary among the contributions… [so] a standard is still lacking in the NIS literature [because]: (1) definitions of the various systemic failures are not yet*

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similar policy recommendations" which is in line with other recommendations in the literature suggesting some connection between these two concepts (Larsen, 2007).

crystallized out, (2) the same concepts are labelled differently and (3) different concepts (partly) overlap making it hard to distinguish one failure from the other".

Table 2.1.- Synthesis of policy rationales

	Neo-classical	**Industrial Districts Innovative Milieu**	**Regional Innovation Systems**	**Regional Dynamic Knowledge Capabilities**	**Evolutionary**
Rationale	Market failures	Uncertainty reduction	System failure, system dysfunctions	Learning failure	System failures, Learning failures, Cognitive gaps, Block-in, dysfunctions
	information transmission failures	Failure in collective learning			
Importance of space (proximity)	Reduction of information, transport, location costs	Reduces uncertainty, helps communication and learning		Proximity favours transmission of tacit knowledge	Localized, context-specific learning
	External Economies				
Policy approach	Static input resources	Static	Dynamic	Dynamic	Dynamic
Role of policy maker	Optimizer	Optimizer	Coordinating the system, help in networking	Promoting learning	Adaptive "organizer"
					Help to guide and organize systems, networks and learning
Objective of intervention	Substitute for less than optimal use of resources	Enhance local resources Education as a resource for learning	Overall coherence of the system, roles and function of actors	Enhance knowledge and learning	Enhance diversity through creativity and learning
					Enhance selectivity
Target of the intervention	Individual actors	Individual actors	System as a target	Both individual actors and groups of actors	Both individual actors and groups/networks of actors or system of innovation
Selection criteria	Technological excellence				Learning opportunity
Mode of intervention	Linear model	Measures director at input resources	Systemic measures	Measures that may help learning	Systemic (process)
Operationalization	Measures directed at input resources				Variety generation
					Selection devices
Examples of Policy tool and measures	Public investment, Subsidies, tax breaks, technology infrastructure (resources) e.g. Science Parks, Brokerage	Public investment, Subsidies, tax breaks, technology & education infrast. technology poles, cluster policies	Measures directed at collective governance	Measures as input for learning: R&D subsidies, foresight, clinics	R&D – variety through technological and learning opportunity
Level of intervention	Centralized	centralized	centralized	Decentralized	Multilevel
				centralized	Balance centralized with decentralized

Source: Laranja et al. (2005: 17) and Uyarra (2003).

This summary of rationales or failures, justifies state intervention through public policies for ensuring the performance of the IS, assuming, of course, that the state is capable of dealing with them (Arnold, 2004). This recognition of the complex nature of innovation policies, programmes and instruments (Stame, 2002), which have to encompass a wide range of activities, failures, agents' features, each with its own culture, targets, incentive mechanisms, etc., means that coordination among policies, agents, etc. is a key issue (Metcalfe, 1994).

In this chapter we show that systemic analysis of innovation uses the concept of IS to justify the existence of various agents, and the relationships among them, to carry out innovation activities (Freeman, 1987; Lundvall, 1992). The evolutionary approach is thus linked to the systemic view of the innovation process. Therefore, within an evolutionary approach, public R&D policies, to an extent, respond to the need to strengthen the role and involvement of IS agents (Lipsey and Carlaw, 1998; Metcalfe, 2002).

2.1. IS: a useful conceptual framework?

As a starting point, we focus on what is understood as innovation. Slappendel (1996) shows the perception of newness is crucial to the concept of innovation since it sets innovation apart from change. For Schumpeter (1934: 66), the concept of innovation covers five areas: (i) the introduction of new goods (*product innovation*); (ii) the introduction of new production methods (*process innovation*); (iii) the opening of new markets (*market innovation*); (iv) the use of new sources of supply of raw materials or intermediate inputs (*input innovation*); and (v) the development of new organizations (*organizational innovation*).[6] The OECD's Oslo Manual explicitly acknowledges the following firms' activities: product innovations, process innovations, organizational innovations, and marketing innovations (OECD, 2005: 16-17). From our point of view, it is mainly focused on technological product and process innovations[7], with little attention given to innovation in services (Godin, 2004). As many modern economies are based on the services sector (Fernández de Lucio et al., 2001, 2003) we consider that this deficiency will require further elaboration in the near future.

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[6] The five areas introduced by Schumpeter have been extended in recent years; Chesbrough (2003) introduced the concept of *open innovation* and *social innovation* was proposed by Moulaert et al. (2007).

Empirical studies of innovation (Zabala-Iturriagagoitia, 2007c) confirm that firms rarely innovate in isolation: they need to interact and cooperate with other economic actors (Edquist, 1997) not only to explore new sources of knowledge, but also to exploit already existing ones (March, 1991). Accordingly, the unit of analysis used rather than being the individual agent is the system in which they operate. This leads to the concept of innovation systems.

It should be noted that the IS' framework cannot be considered a theory, but rather a concept or an approach influenced by different theoretical approaches including innovation studies and evolutionary economics (Edquist, 1997). As we will see, the IS concept is an attractive approach for the evaluation of science and technology, R&D, and innovation policies because of its clear political repercussions on science and technology policy making. In this sense, we agree with Miettinen (2002) who debated whether this notion could be considered a scientific concept or a political rhetoric, while Hekkert et al., (2007) maintained that the concept was a heuristic attempt.

We have shown that the IS concept emanates from evolutionary economics, as it stresses the role of the interactions among players, the learning processes at the levels of both the individual and the institution, the dynamism of the innovation process, the technological change inferred by this dynamism, etc. Thus, in contrast to neoclassic theory, where agents are expected to have rational behaviour, the agents in an IS present bounded rationality, which drives them to learn continuously, within a changing and uncertain environment (Nelson, 2007).

The literature agrees that "*the first systematic and theoretically based attempt to focus upon national systems of innovation goes back to Friedrich List*" (Lundvall, 1992: 16; Freeman, 2002) and his book *The National System of Political Economy* (List, 1841). Sharif (2006) reviews the increasing body of literature dealing with the NIS concept, analysing how it materialized and the subsequent conceptual approaches that have emerged from it. Sharif points up the definition offered by Metcalfe, which considers a NIS as the "*set of institutions which jointly and individually contributes to the development and diffusion of new technologies and which provides the framework within which governments form and implement policies to influence the innovation process [...] it is a system of interconnected institutions to create, store, and transfer the knowledge, skills,*

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[7] Technological innovation is understood as a learning process through which new knowledge flows, competences and technological capacities are generated (Nieto-Antolín, 2003).

and artefacts which define new technologies" (Metcalfe, 1995: 462). Sharif (2006: 752) agrees with Miettinen (2002) in considering the concept to be politically rather than scientifically oriented. From this politically oriented perspective (discussed in Balzat and Hanusch, 2003), one of the first countries to adopt the NIS concept in its policy-making process was Finland in 1992 (Georghiou et al., 2003). The Finnish Science and Technology Council played a considerable role in applying the concept to the Finnish economy (Lemola, 2002) and defined a NIS as the "*whole set of factors influencing the development and utilization of new knowledge and know-how. The concept allows these factors and their development needs to be examined in aggregate. In addition, it offers a framework for analyzing interrelationships between different factors. These relationships are relevant to general development capability and they have proved to be essential for the creation of new innovations*" (Science and Technology Council of Finland, 1990: 21). However, there are many other complementary definitions of the concept:

- "*network of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies*" (Freeman, 1987: 1)

- "*all parts and aspects of the economic structure and the institutional set-up affecting learning as well as searching and exploring – the production system, the marketing system and the system of finance present themselves as sub-systems in which learning takes place*" (Lundvall, 1992: 12)

- "*National Systems of Innovation are constituted by "interconnected agents" that interact influencing on the execution of the innovation in the national economy. These interactions occur into a specific context and under certain shared norms, routines and established practices*" (Nelson and Rosenberg, 1993)

- "*the function of an innovation system is to generate, diffuse and utilize technology. Thus, the main features of the system are the capabilities of the actors to generate, diffuse, and utilize technologies that have economic value*" (Carlsson et al., 2002: 235)

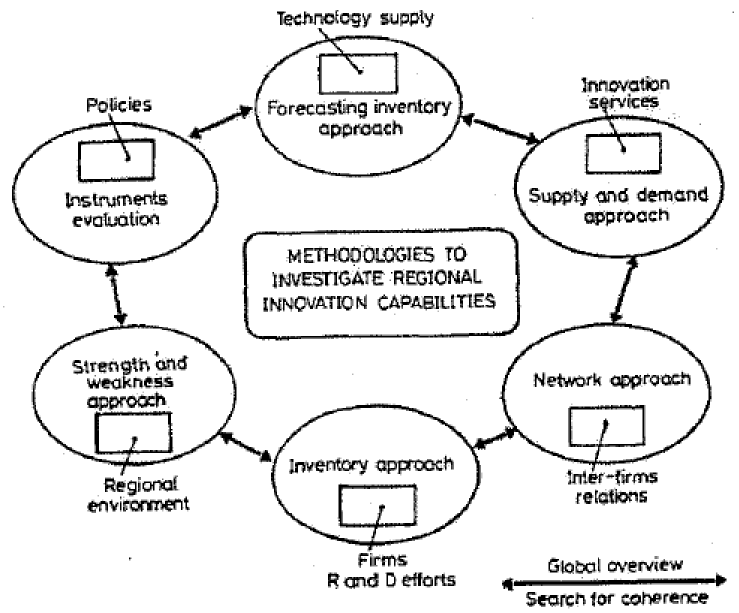
Thus, it can be concluded that the NIS concept considers knowledge, learning and institutions as key to economic performance. Hence, the economic actors are rooted in a socio-economic environment, such that the performance of individuals (firms, institutions, etc.) and that of the overall system are inter-related (Arnold, 2004).

However, the NIS approach has not developed in isolation. Some alternative approaches have been proposed which expand the context of the IS related literature. Bearing in mind that there are many excellent reviews of these topics dealing with the evolution of the IS concept and the various new approaches that have emerged (Doloreux, 2002; Doloreux and Parto, 2005; Sharif, 2006), we highlight the main issues addressed in these major approaches.[8]

One of the foremost contributions, which has had a great impact on the policy-making sphere, focuses on RIS (Cooke et al., 1997; Braczyk et al., 1998). Cooke (2004: 3) considers that a RIS is an "*interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems*". Cooke et al. (1997: 489) consider that a RIS "*can be evaluated from a dual perspective: (a) from a regionalization approach, relating the region to its competence (jurisdiction) capacity, valuing its degree of autonomy to develop policies and manage the different elements that make up the regional system, as well as financing capacity for strategic investments in infrastructures absolutely necessary for the development of innovation processes; (b) from a regionalism approach, related to the region's cultural base which gives it a certain level of systemic potential*". Autio (1998) distinguishes between two sub-systems as the main building blocks of a RIS: the knowledge application and exploitation sub-system, and the knowledge generation and diffusion sub-system. For him, the main external influences on RIS come from NIS institutions, policy instruments, other RIS and international institutions and policy instruments (ibid: 133), a perspective shared by Cooke (2004). In the RIS related literature, there are several schematic illustrations of RIS, including one by Nauwelaers and Reid (1995: 505).

[8] Other major contributions include the Sectoral Innovation Systems approach (Breschi and Malerba, 1997), the Technological Systems (Carlsson and Stankiewicz, 1991), and the approach of Fernandez de Lucio and Castro (1995) concerning the different environments within an IS, which allow us to identify the main strengths and weaknesses.

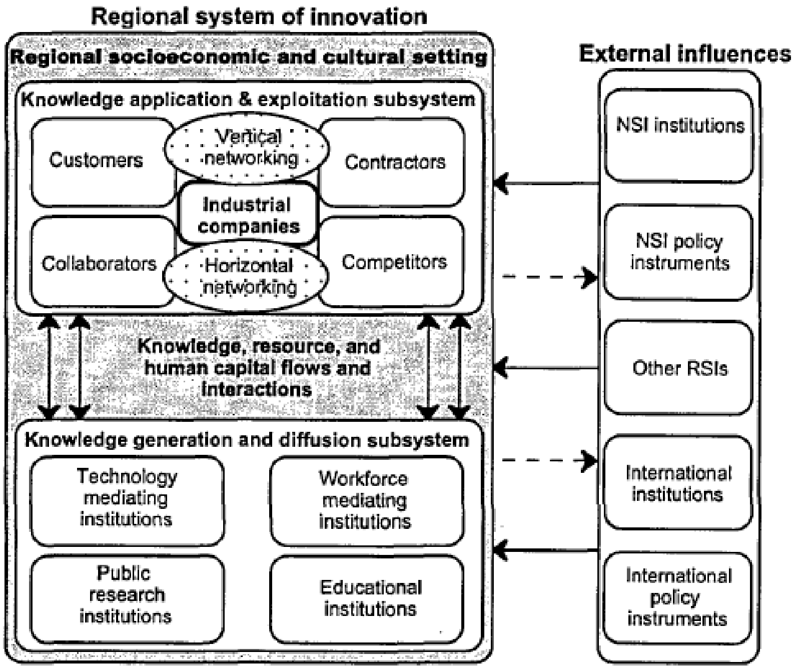
Figure 2.1.- Main dimensions of the RIS



Source: Nauwelaers and Reid (1995: 505).

The knowledge generation and diffusion sub-system, defined mainly by firms and R&D efforts and inter-firm relations, are shown in the Figure 2.1.-, along with the knowledge application and exploitation sub-system, which is constituted by policies, the regional environment and the global overview. Autio (1998: 134) complements this illustration with the inclusion of a wide set of external influences and the interactions among the two sub-systems.

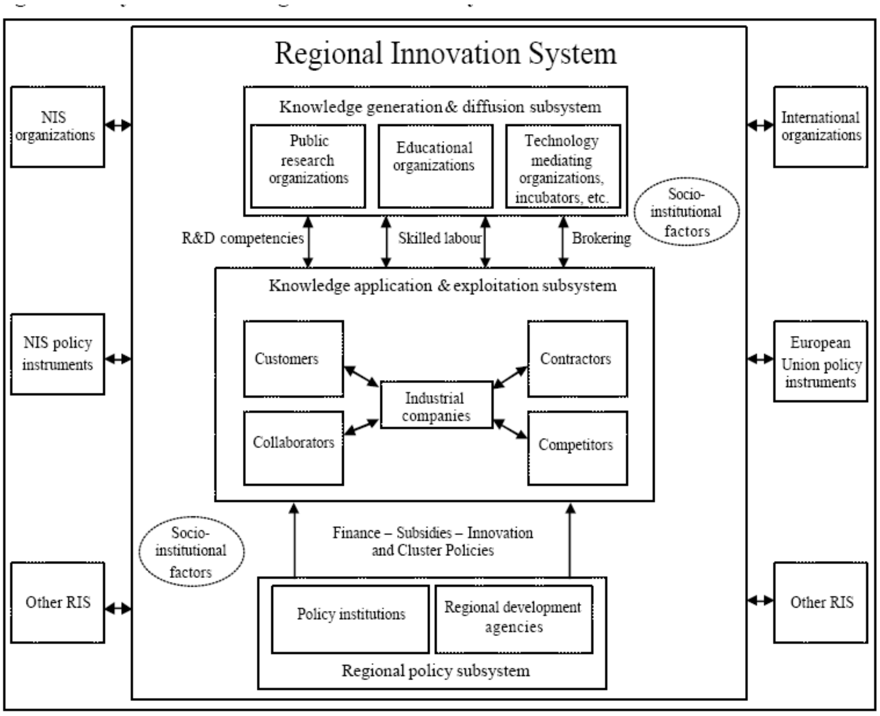
Figure 2.2.- The structuring of RIS



Source: Autio (1998: 134).

Similarly, Trippl (2006) includes a new regional policy subsystem - the role played by these policies from a financial point of view and some socio-institutional factors.

Figure 2.3.- Key elements of RIS



Source: Trippl (2006: 5).

From all these contributions it can be concluded that RIS are characterized by specific socio-institutional and cultural settings, determined to a great extent by the history of the region[9], regional policy capability and autonomy, financial institutions and interactions (regionally and globally) based on trust. In similar vein to the contribution made by Sharif in the national context, the reviews of Doloreux (2002) and Doloreux and Parto (2005) need to be underlined in relation to the regional dimension. These authors illustrate the evolution of the RIS concept over time, and offer their conclusions about the unresolved issues that this framework will face in the short run such as regional

[9] The literature talks about the path-dependence of territories (David, 1985; Arthur, 1989; North, 1990), which "*builds on the idea of stable processes of development in which pursuing a particular technological path makes it difficult to change this path radically*" (Quitzau, 2007: 352). It is considered as a new class of market failure and consequently has policy relevance (Krugman, 1994). Thus, studying the dynamics within an IS becomes crucial (Hekkert et al., 2007).

boundaries and the changing role of institutions[10]. From our point of view, one of the key points that would require further research in the previous regional framework is the impression that RIS comprise closed systems, which, when aggregated, for NIS. In this sense, we have already made some contributions (Zabala-Iturriagagoitia, 2007c) emphasizing the need to explicit the "openness degree" of RIS. This aspect has also been proposed by Niosi and Bellon, who developed the notion of "Open National Systems of Innovation" (1994) and Carlsson (2006). Hence, we acknowledge the overlapping ecology of systems and networks, and the relevance of linkages between them.

So far we have discussed the two main approaches within innovation studies, NIS and the RIS, which can be considered "twin" concepts. In our view the NIS approach (Lundvall, 1992) puts more emphasis on state issues, such as the education system, institutional learning and the interaction among national actors (i.e. personnel mobility, market transfers, co-operation agreements, etc), while the RIS (Cooke et al., 1997; Cooke, 2004) is oriented more towards regional social features comprising identity matters and hence, has more direct impact on the policy-making sphere. We believe, therefore, that the key difference between the two concepts lies not in the territorial dimension (national vs. regional) but in those key concepts that they have been built on, such as training, learning and self identity, and go beyond economic factors. It is true however that in countries where the regional dimension is almost non-existent, the RIS approach may not be the most appropriate framework, but for those countries where regional disparities are on the social agenda, the RIS concept is considered to be the essence of the regional economy.

One of the main features of a RIS referred to in the literature is innovative capacity, which is one of the focuses of this research. Innovative capacity can be described as "*the ability to produce and commercialize a flow of new-to-the world technologies over the long term*" (Furman et al., 2002). Concepts such as regional innovation potential (Nauwelaers and Reid, 1995), innovative potential (Riba Vilanova and Leydesdorff, 2001) and regional innovation capabilities (Doloreux and Parto, 2005) are encompassed by this notion. Etzkowitz and Klofsten (2005) relate the innovative capability of a territory to the networking patterns found in it. As this concept mainly has its roots in R&D and innovation statistics, it is based on a quantitative approach and the innovation policies benchmarking

[10] Similarly, Harding (2003) studies the new challenges for innovation systems, putting special emphasis on the need to coordinate the system (Zabala-Iturriagagoitia et al., 2007a): institutional coordination, policy coordination, regional (national) coordination, etc.

related literature uses a wide variety of composite indicators and methodologies to measure this capacity (den Hertog et al., 1995; NISTEP, 2001; Buesa et al., 2002; Furman et al., 2002; Leydesdorff and Scharnhorst, 2003; Yglesias, 2003; Huggins et al., 2004; Grupp and Mogee, 2004) (see further details in Chapter 5). However, there is a lack of statistical data on many aspects. Nauwelaers and Reid (1995: 506) consider thus that "*six different types of methodologies can be proposed*" according to the part of the RIS that is the focus: (i) technology supply (forecasting inventory approach); (ii) innovation services (supply-demand approach); (iii) inter-firm relations (network approach); (iv) firms R&D efforts and innovative behaviour (inventory approach); (v) regional environment (strengths and weaknesses approach); (vi) policies (instruments evaluation). In this thesis, we adopt the perspective of analysing the innovative behaviour of territories on the one hand, and complementing this an analysis of the strengths and weaknesses of their RIS on the other. To do so, we apply some of the already existing methodologies on innovative capacity benchmarking and complement them with a new approach based on efficiency measurement.

2.2. STI Policies

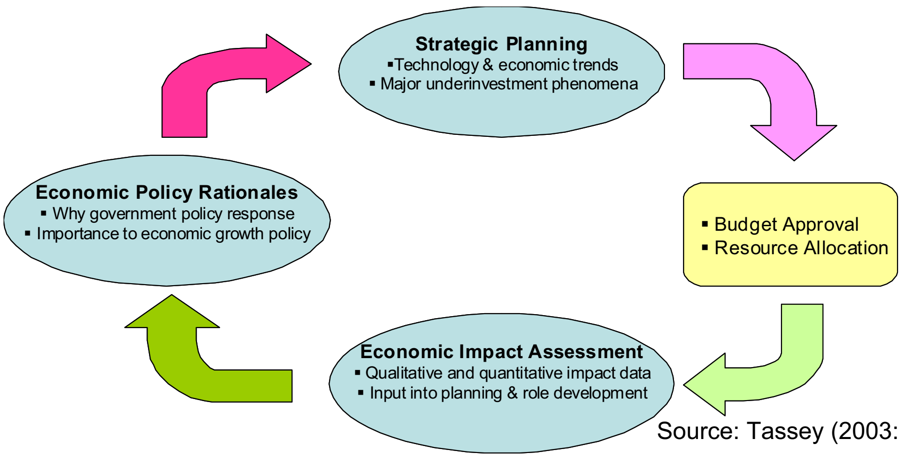
As discussed above, in the field of innovation studies, Science and Technology (S&T) policies are embedded in theoretical prospects (Miettinen, 2002). This view is shared by Molas-Gallart and Davies (2006: 65) who propose that "*both policy and program theories are strongly rooted in innovation theory*". This necessarily drives us to link the more conceptual part of the innovation studies literature reviewed above with the more politically oriented in order to observe the parallels and evolutions in these two arenas, to justify the importance of the policy recommendations that emerge from our analytical framework and results. We have seen that conceptual approaches in the innovation studies field have been (and still are) in constant evolution. Equally, there is an evolution in STI policies (Molas-Gallart and Davies, 2006). As these two approaches are strongly interconnected, Mytelka and Smith (2002) consider that both policy learning and innovation theory constitute an interactive and co-evolving process.[11] Thus, research,

[11] As will be illustrated in this chapter, policy evaluation also constitutes part of the policy-making process (Rich, 1979; Uyarra and Haarich, 2002). Hence if the IS concept and the innovation policies approach have co-evolved over time, the evaluation of these policies (as well as evaluation methodologies) should have evolved in a similar way, although there is no evidence of this (Zabala-Iturriagagoitia et al., 2008b). Hence we would advocate for a co-evolution of these three approaches (conceptual – political – methodological).

technology and innovation policies can be considered to be policies "*involving progress in science and technology, information exchange and knowledge transfer, and industry collaboration and commercialization, for these purposes of enhancing the performance of regional and national economies*" (Cozzens, 2003: 55). Complementing this view, Salmenkaita and Salo (2002: 184) define an innovation policy as "*intended to influence the behaviour of both public and private organizations in the development and commercialization of new technologies*". Such policies are thus expected to "*contribute to higher productivity and growth and to the creation of more and better jobs*" (Papaconstantinou and Polt, 1997: 9).

Within this policy-making sphere, a substantial problem arises related to the attribution of results: "*How can changes that occurred at the global level be attributed to the effectiveness of any programme, if there were so many different programmes, and if programmes were integrated?*" (Stame, 2004: 64). This attribution problem drives us to tackle those aspects related to the evaluation of STI policies. As seen, IS call for new systemic approaches to policy formulation, implementation, and evaluation (Molas-Gallart and Davies, 2006). Public policies are complex, involve many actors and activities, but especially they include public funds, which makes their evaluation essential, as public finances should be used efficiently and produce returns for society. Accordingly, evaluation is one of the steps in the policy cycle (Rich, 1979; Uyarra and Haarich, 2002; De la Mothe, 2003).

Figure 2.4.- Economic analysis for government R&D programs



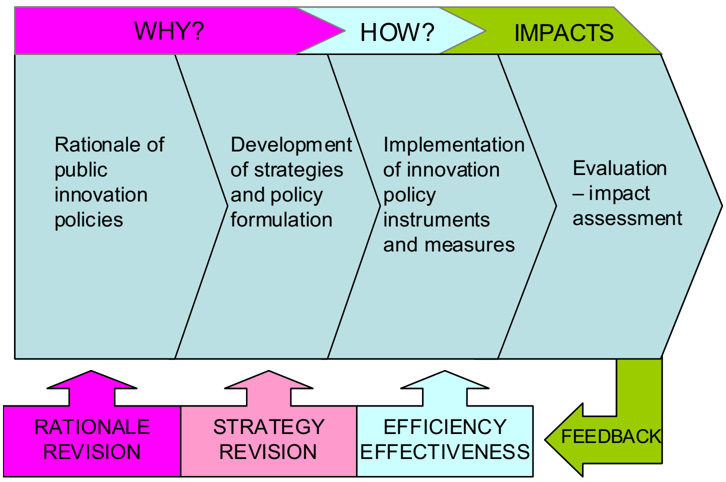
Source: Tassey (2003: 6).

Figure 2.4.- illustrates that economic analysis may have three distinct uses in the management of government R&D programmes: (i) policy rationale; (ii) strategic planning; (iii) economic assessment, which feed back into the economic rationale activity, thereby completing or closing the circular policy making process (Tassey, 2003). Accordingly, the motivations for conducting evaluation studies concerning government research programmes are that (ibid: 7):

- economic studies provide the nature and magnitude of economic impacts from the research supported,
- economic studies provide input into reassessments and better articulations of an R&D agency's roles,
- there is increasing imperative to improve the management of government research programmes which requires more and better data on the expected impacts of proposed or ongoing programmes.

Loikkanen and Kutinlahti (2005) also consider evaluation – impact assessment – as a key step in the policy formulation process.

Figure 2.5.- Where evaluation fits into the innovation policy making process



Source: adapted from Loikkanen and Kutinlahti (2005).

Figure 2.5.- shows that the definition of strategic planning stage is crucial in order to evaluate the degree of achievement of the previously defined goals. Indeed, "*the effective evaluation of the programme's results depends to a large extent on the precise definition of the programme's scientific, technical and socio-economic objectives. The*

existence of clear programme objectives has a direct bearing on the credibility of the evaluation exercise since it reduces the need for value judgements from evaluators" (Boggio and Spachis-Papazois, 1984).

According to the OECD (1987: 7), the relevance of carrying out these evaluation activities "*can be explained by several factors including slow (sometimes zero) growth research budgets, increasing supranational programming, the growing importance of R&D for all economic activities and lastly, the consequent need to lay down priorities whatever the area of research*". Also, as we will see in the next section, evaluation is developed in order to increase learning which can (in this case) be inferred from the policy-making processes (De la Mothe, 2003). In this sense, there are diverse learning processes that emerge from evaluation: learning by interacting (Lundvall and Johnson, 1994), learning by comparing, learning to learn, learning by doing, learning by using, adaptive learning (Georghiou, 1998) and learning on systems level (Rosenberg, 1982; Barré et al., 1997; Lundvall and Borras, 1998; Nauwelaers and Wintjes, 2002; Smits and Kuhlmann, 2004), etc.

From a policy-oriented perspective, in the regional context we should also highlight the contributions of Morgan (1997), Morgan et al., (2003), Landabaso and Reid (2003), Landabaso et al., (2003) and Landabaso and Mouton (2005) regarding the "learning region" concept.[12] Authors as Etzkowitz and Klofsten (2005) consider it becomes necessary to jump from the "region that learns" to the "region that innovates" as a result of their evaluation practices. Smits and Kuhlmann (2004), making an analogy with the concept of the triple helix of university, industry and government (Etzkowitz and Leydesdorff, 2000), talk about the so called "triple helix of the innovation Process, Intervention and Theory" (PIT Helix). From their PIT helix, they conclude that learning processes play a dominant role in the development of innovation processes, public intervention and innovation systems (Smits and Kuhlmann, 2004).

[12] The Enterprise DG of the EC in 2002 produced a report on "Improving Trans-national Policy Learning in Innovation".

Figure 2.6.- Interactions in the triple PIT (Process – intervention – Theory) Helix

Table 1 Interactions in the Triple PIT Helix

	Practice	*Intervention*	*Theory*
Practice		P → I Learning by doing Learning by using Learning by interacting	P → T Research Learning by interacting
Intervention	I → P[2] Impact		I → T Research Learning by interacting
Theory	T → P Formal learning Learning by interacting Conceptual use	T → I Formal learning Learning by interacting Conceptual use	

Source: Smits and Kuhlmann (2004:10).

2.3. Evaluation and Benchmarking: two complementary sides of the same coin

The literature concerning the role played by evaluation activities within the policy cycle (see Figure 2.5.-) provides several definitions of the concept of evaluation. Ruthman (1977) defines it as the process of applying scientific procedures for gaining reliable evidence on the way in which and degree to which specific activities produce concrete results – effects -. For Rich (1979: 10) evaluation can be understood as "*the process of assessing whether or not desired or undesired outcomes have been reached, of specifying or explaining the outcomes that were reached, and of suggesting new strategies and/or definitions of future problems*". However he adds that evaluation "*also represents the time at which one moves from formulating and implementing ideas/programs (the action phase) to the point of assessing/judging the success of this program was and whether it should be continued in the future*" (ibid: 13). Hence, evaluation cannot be considered merely as a stage in a problem-solving process. In 1987, the OECD published an edited book (OECD, 1991) on a selection of practices in evaluation. They consider evaluation to be "*an assessment, as systematic and objective as possible, of an ongoing or completed project, programme or policy, its design, implementation and results. The aim is to determine the relevance and fulfilment of objectives, development efficiency, effectiveness, impact and sustainability. An evaluation should provide information that is credible and useful, enabling the incorporation of* *lessons learned into the decision making process of both recipients and donors"* (ibid: 5). This definition complements the previous ones, which link evaluation to policy learning, and point to the relevance of efficiency in the context of policy evaluation.[13] In this section we develop the relevance of efficiency in the evaluation of public policies. From a more philosophical perspective, Bezzi (2006) introduces the role of the stakeholders involved, considering that the results of evaluation have to be useful and comprehensive for them: "*evaluation is not a truth provider, but a declaration of what we have established to approximate truth, in a way that the involved stakeholders found acceptable. In other words, in a participative setting (with or without real participation), evaluation has a role in helping stakeholders to describe the world (the context) as well as they can, directing them to discover the specific mechanisms they are able to define. Evaluation becomes a path to organizational learning, which circumscribes a world. Not the world, but only a world, relevant to the stakeholders involved, and likely to be effective for evaluation purposes*" (Bezzi, 2006: 67).

Joyce (1980) considers evaluation differs from evaluation research, maintaining that evaluation is "*concerned with assessing the value of programmes, activities and products […] however, it is when evaluation is concerned with outputs, outcomes or effects and is seeking to be as objective as possible that we really speak of evaluation research*" (ibid: 181). In this sense he echoes Suchman (1967: 45) who distinguished between "*evaluation as the general social process of making judgements of worth, regardless of the basis for such judgements, and evaluation research as referring to the use of the scientific method for collecting data concerning the degree to which some specified activity achieves some desired effect*". This perspective is also shared by Alvira Martin (1985) who sees one of the key features that distinguishes evaluation research from evaluation being the involvement of the researcher in the evaluation. Consequently, from the previous definitions, and making use of the literary analogy made by Boggio and Spachis-Papazois (1984: 81), it can be said that "*evaluation of research is an art rather than a skill*".

Drawing on these various contributions, we can conclude that "*evaluation research has matured into a discipline and is recognized by both academicians and practitioners as*

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[13] This approach is shared by Papaconstantinou and Polt (1997: 10) who consider that "*evaluation refers to a process that seeks to determine as systematically and objectively as possible the relevance, efficiency and effect of an activity in terms of its objectives, including the analysis of the implementation and administrative management of such activities*". Authors such as Vedung (2000: 3) and Valovirta (2002: 60) provide similar contributions.

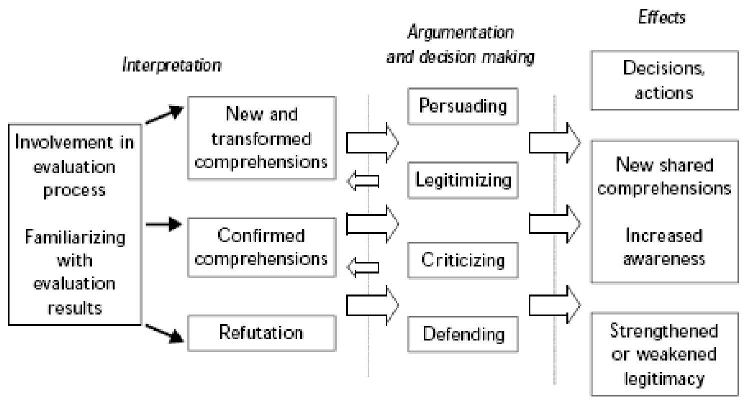
an important part of the [policy making] process" (Rich, 1979: 13). In this sense, and bearing in mind the multiple facets to be considered in an evaluation, there are some scholars who focus on a definition that takes account of those aspects that should be included in evaluation activities, such as the roles and utility of evaluation: What is the function of evaluation research? What should it tell us? What factors need to be considered in the process of evaluation research?

One of the main roles of evaluation is to provide *learning* for the policy-making process. Indeed, this is one of the main aspects stressed in the literature. Rich (1979: 80) states that a critical function of evaluation research is to aid the process of organizational learning "*in a way that would enable policy makers to avoid 'making the same old mistakes'*". In this sense, it is necessary to remember the diverse kind of learning processes that can be derived from evaluation: learning by interacting, learning by comparing, learning to learn, learning by doing, learning by using, adaptive learning and learning at systems level. Hence, "*learning is the ultimate goal and purpose of evaluation*" (Batterbury, 2006: 183). However, it is also necessary to highlight some other aspects considered in the literature.

Arnold (2004: 4) considers that "*evaluation is expected to provide accountability, learning, policy guidance*". Accountability is also stressed by Boggio and Spachis-Papazois (1984), Papaconstantinou and Polt (1997) and Díez-Lopez and Setién-Santamaria (2005) for whom evaluation must provide clear evidence of the effective and efficient use of the public resources devoted to R&D projects. For the OECD, this accountability and efficiency measurement issue must take account of the "*identification and preservation of worth [which] is one of the principal aims of evaluation*" (OECD, 1987: 14). The relevance of efficiency in the context of research evaluation is elaborated further in this section.

However, evaluation is not only seen as a means of ensuring the accountability and relevance of public R&D activities, or even as just a procedure closely linked with internal development and learning (Oksanen, 2000). For Kuhlmann (2003b: 357) "*the expectations of evaluation processes are divided between two functional poles*": (i) summative: measuring performance to provide legitimization afterwards; or (ii) formative (Scriven, 1973; Guy, 2003): utilized as a learning medium in which findings can be utilized for current or future initiatives. Oksanen (2000: 1), when analysing the contribution of information obtained from R&D evaluation to decision-making in the field of S&T policy in Finland, observed that "*the main explicit purpose of the evaluations has been to provide* *knowledge on different facets of the national R&D system for strategic policy formation and decision-making processes*". In his research, Oksanen observed that evaluation is seen as a management tool on the one hand – accountability, but also as *persuasion*. The first approach deals with "*cost-awareness both at the level of an individual research organization/programme, and at the level of the national R&D system as a whole*" (ibid: 8), while the persuasive character of evaluation refers to its political dimension. Oksanen observed that "*conclusions and recommendations in an evaluation report can be utilized in many ways, and by different actors. The same conclusions and recommendations - especially if they are positive - can be used as arguments for additional resources and other demands too […] the strategic use of evaluation information seems to be a part of business, so to say*" (ibid: 11). As illustrated in Figure 2.7.-, the persuasive approach has been further elaborated by Valovirta (2002) who also considers persuasion to be an argumentation mechanism in the utilization of evaluation results.

Figure 2.7.- The Utilization Process of Evaluation



Source: Valovirta (2002: 64).

Following Oksanen (2000), Valovirta (2002: 66) considers that "*evaluation results can always be debated and disputed […so], the final persuasiveness of evaluation will be judged by its users*". In this sense he echoes the contribution made by House (1980: 73) who suggested that "*evaluation persuades rather than convinces, argues rather than demonstrates, is credible rather than certain, [and] is variably accepted rather than compelling*".

Summing up, Batterbury (2006: 181-182) proposes that the main purposes of an evaluation are: (i) accountability and legitimacy - evaluation for accountability provides an external assessment of the effectiveness, efficiency, value for money and performance -; (ii) improving quality and performance, (iii) improving planning, (iv) building capacity, (v) learning, (vi) developing a sense of ownership among programme participants, (vii) empowerment. Similarly, regarding S&T policy evaluation Uyarra and Haarich (2002: 4), following Kuhlmann et al., (1999) point out to the following functions of evaluation:

- provide legitimization for the allocation of public money to R&D;
- enhance an adequate and effective use of funding by measuring the scientific/technological quality or the (potential) socio-economic impact;
- improve programme management and 'fine tune' S&T policy programmes;
- provide new ideas or legitimate already circulating ones about changes in R&D centres and funding agencies, thus enhancing the fulfilling of their missions;
- enhance the information basis for S&T policies, in the sense of a government-led 'mediation' between diverging and competing interests of various players within the S&T system.

To put it briefly, we may consider that just as "*the proof of the pudding is in the eating [...] the proof of the evaluation is in the policy implementation*" (Boggio and Spachis-Papazois, 1984: 84). According to Boggio and Spachis-Papazois (1984: 109), "*evaluation is not a separate function to be performed only during the late stages or after the R&D is done; it is a continuous process for which the foundation should be laid during the R&D program planning stage*". Cook and Reichardt (1986), from a more qualitative perspective, consider three main kinds of research: evaluation research, pedagogical research and action research. Within their classifications, they establish a parallel with the classical division offered by Scriven (1973) between summative and formative evaluation.

As regards the time frames within which the evaluation is carried out, three dimensions can be distinguished: ex-ante (prospective), interim (monitoring) and ex-post (retrospective) evaluations, which may produce information to be "*used in the assessment of past policies, the monitoring of ongoing initiatives or the forward planning of innovation and technology policies*" (Papaconstantinou and Polt, 1997: 10):

- *Ex-ante evaluation*: associated with the formulation and execution of research policies;

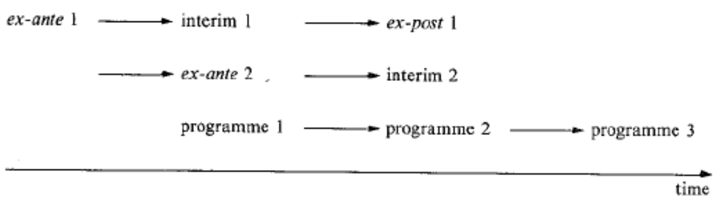
- *Interim evaluation*: whose main interest lies in the fact that it interacts with programming and can therefore be a management tool – accountability - for decision-makers, (OECD, 1987). Similarly, and according to the European Commission, its main purpose, "*is to improve the monitoring mechanism and arrive at a tool which can be useful for decision-making and effective management*" (Commission of the European Communities, 1985; Bachtler and Michie, 1997);

- *Ex-post evaluation*: "*comprises an assessment of the results obtained and an analysis of the way in which the resources and means allocated to a programme have been used as compared with the initial and any additional objectives. It queries the budgeting procedures used and is forward looking in this sense since its results are included in future programming*" (OECD, 1987: 18).

For Bachtler and Michie (1997: 849), who studied the role of evaluation in EU Regional Development Programmes, "*among the three types of evaluation…interim evaluation is […] the most important. Conducted at the mid-point […] it is the only evaluation phase that can simultaneously assess the effects of a programme and influence its operational orientation and balance. By contrast, ex-ante appraisal can only make informed projections concerning the future effect of programmes, while ex-post evaluation can rarely influence operational*". In this sense, for Guston (2003: 85) "*ex-post evaluation […] has a strong focus on goal achievement (effectiveness) and management (efficiency)*", which implies some connection between the two. From our point of view, and following the results in Zabala-Iturriagagoitia et al., (2008b) we consider that interim evaluations may be useful as a management tool, and even for analysing the efficiency of the R&D projects during their execution, as proposed by Guston, but trying to orient those projects in a concrete direction. On the other hand, ex-post evaluations may be more oriented towards assessing the whole programme or policy initiative, and not focusing only on its development, to provide "past intelligence". However, when the target is to provide learning for the beginning of a new policy cycle, then ex-ante evaluation may play a considerable role, considering that it is an essential aspect that we consider will be further elaborated in the literature. In fact, some scholars focus on impact assessment methodologies (Luukkonen, 1998; Baur et al., 2003; Tassey, 2003; Lehto, 2007) in looking for new ways to combine evaluation and foresight perspectives (Keenan and Uyarra, 2002; Miles, 2002; Tsipouri, 2002; Georghiou and Keenan, 2006). This then drives the question of whether or not evaluations are useful, and whether their assessment should be considered or not in the policy-making sphere. This aspect will be further elaborated in the discussion on the utility of evaluations and the reasons why the results of many evaluations are not used.

According to the OECD (1987), a research system should connect the results obtained from ex-post evaluation with the next phase of ex-ante evaluations, which then closes the policy cycle (Uyarra and Haarich, 2002). However, the same organization found that "*ex-ante evaluations are regular and direct and systematic while ex-post evaluations are often ad-hoc*" (OECD, 1987: 19). Zabala-Iturriagagoitia et al., (2008b) more recently found that the RIS' initiative fostered by the European Commission has not managed to create an evaluation culture within European regions.[14]

Figure 2.8.- Chronology of evaluation



Source: OECD (1987: 19).

In fact, many authors agree that there is a wide diversity of evaluation skills in Europe, in both the national and regional arenas. Bustelo (2006), for example, considers that despite the fact that substantial development of evaluation activities in Europe has been achieved in the 2000s, these attainments are distributed unequally among member states. Díez (2001), in line with Luukkonen (2002a) and Batterbury (2006) distinguishes between three levels according to the development, quality and usefulness of the evaluations carried out by European countries:

[14] Boekholt (2003: 256) agrees with the previous contribution when stating that "*one of the problems with the European initiatives was that most effort was on changing the front end of the policy life cycle* [behavioural additionality (Georghiou, 1994)]: *the formulation of user oriented policies in a setting of many regional actors, often with conflicting agendas*". However, both the regions and the EC services went through this learning process. This illustrates that it is not only those agents participating in a concrete policy who learn from their experience in the programme and the results achieved, but also the management bodies responsible for these policies learn from these practices and evaluations.

- First level: evaluation as a response to previously defined norms (regulatory use of evaluation): Greece, Spain, Portugal, Southern Italy, the new German Länders and the non-continental France,

- Second level: evaluation as a planning support system in the management of structural policies (operative use of evaluation): Luxembourg, Belgium, Austria, Finland, Northern Italy, Ireland, France and Germany,

- Third level: evaluation as a social and political act, whose conclusions are the object of public debate (political use of evaluation): Denmark, the Netherlands, Sweden, and UK.

Seeding. Many scholars have tackled the state of evaluation studies in particular countries. Shapira and Kuhlmann (2003b: 4) illustrate how "*in Europe, since the 1980s, various national governments forced the evaluation of effects and socioeconomic impacts of RIT [Regional Innovation and Technology] programs",* seeds for an emerging *«evaluation culture» (ibid)*. In the contribution by Boggio and Spachis-Papazois (1984) several references are made to the state of evaluation practices in European countries. Van der Meulen and Rip (2000) studied the evaluation of the societal quality of public sector research in the Netherlands. In Finland, Oksanen (2000) and Lemola (2002) studied the origin and convergence in national S&T policies as well as the role of evaluation within them. For the UK, Bowns et al., (2003) evaluated and ranked publicly funded R&D programmes. Bustelo (2006) analysed the potential role of standards and guidelines in the development of an evaluation culture in Spain.[15] For the US, Cozzens (1995) studied developments in their research assessment, and Cozzens (2003: 54) highlighted the framework for evaluating S&T policies.

Among these national studies, Kuhlmann (2003b: 352) observed the following trends in those countries where evaluation of STI policies took root quite early:

[15] In Spain, the National Agency for the Evaluation of Public Policies and Quality of Services, which is responsible to the Ministry of Public Bodies (Ministerio de Administraciones Públicas), was created by Law 28/2006, 18 July 2006, as the national agency responsible for improvements to public services (the "Central Government Agencies Act 2006") to promote and perform evaluation and impact analysis of public policies and programmes, support service quality management, and encourage the rational use of resources and accountability to society.

- the major rationale for evaluations has shifted and evolved from an attempt to legitimate past initiatives and demonstrate accountability, to the need to improve understanding and inform future policies,
- the focus of evaluations has broadened from a narrow view on economy and efficiency of an initiative, such as the appropriateness of a policy tool and a concern with performance improvement and strategy development,
- approaches to evaluation have evolved from the idea of 'objective neutrality' […] to more formative approaches […] in learning exercises,
- demands for well-designed systems of monitoring, evaluation and benchmarking to support policy analyses and feed back into strategy development.

So why do some regions develop evaluation practices while others do not? What are the reasons for evaluations not being developed or their results not being considered in the policy making process? According to Rich (1979: 17) the results of evaluation assessments are not employed in the policy-making context because: "*(a) it represents a threat to management; (b) management is not able to anticipate information needs; (c) current methods of evaluation are extraordinarily costly; (d) relevant data are too expensive; (e) recommendations are offered which cannot be used; and (f) research designs are used which do not reflect the realities of the operating environment*". In turn, for Boggio and Spachis-Papazois (1984: 111) "*the most common weaknesses in evaluation of mission-targeted R&D are: (i) inadequate definition of goals and expectations; (ii) failure to anticipate outcomes, including probable users and potential utilization, side effects and risk management, and technology transfer and application problems; (iii) too little involvement of potential users in initial planning; (iv) failure to delineate criteria for success and establish and independent evaluation team to monitor progress from the beginning; (v) failure to establish baseline data and a system for developing essential information and data from the beginning; (vi) inconsistent oversight and feedback"*. To the previous reasons, Tassey (2003: 4) adds that "*R&D agencies are for the most part managed by technically trained people who are unfamiliar with economic assessment tools*", what explains the difficulties faced in the "*use and interpretation of information produced by a distinctly different discipline*" from that concerning evaluation bodies. Kuhlmann (2003a: 138) also considers that "*evaluations […],as a rule, adopt the perspective of the political administration responsible for the program (or state supervisory* *bodies), but neglect the interests of other concerned parties (e.g. citizens' groups)*" and that what biases the results is not offering the reality but that it is reality that responsible bodies want to receive. As Tulkens states (1992: 377) "*well-structured information, based on well-designed and faithful indicators, obtained from detailed measurement, is the only way to provide transparency to the democratic debate on the merits and demerits of public undertakings*". However, there is a dilemma related to "data constraint" (Griliches, 1994), as some authors plead for the allocation of additional resources to data collection (Godin, 2002; Inzelt, 2004; Deen and Vossensteyn, 2006; Ertl et al., 2006), while others consider that the "*point about [lack of] data is simply not true*" as "*plenty of data are available on […] outcomes […] which are represented somewhere in the broad goals of S&T policy*" (Cozzens et al., 2002: 105). Concerning data availability, Brown and Svenson (1999) believe too much data offer as little information as no data, and we would agree with them, as quantitative data do not hold the answer to every evaluation. In our view, it is also necessary to interact with the stakeholders involved in STI policies and programmes in order to get feedback and consider their views on these policies.

Even professional evaluators recognize that "*role responsibilities and expectations between evaluator and decision maker, and the purposes to which the study will be used regardless of outcome, need to be formalized in advance to assure the utilization of the study*" (Majone, 1989: 139). That is, evaluations cannot be considered in the political sphere due to the lack of consensus among or trust in evaluators. This demonstrates that it is not only necessary for policy programmes to foster consensus making processes among national-regional actors – as the RIS' initiative proposed (EC, 1997, 1998, 1999; Oughton et al. 2002) – but also to encourage it among those in charge of defining the course of the new policies, and those evaluating them.

In order to overcome these weaknesses, Cunningham and Nedeva (1999) encourage the use of continuous evaluations (Boggio and Spachis-Papazois, 1984: 134, 145) instead of one-off practices,[16] which they believe would produce the following benefits for the policy-making process:

- the continuous (and regular) collection and assessment of information can provide a reliable basis for timely corrective actions,

[16] Their approach is in line with that of Majone (1989) who proposes a "multiple evaluation" that brings together different methodologies, actors, criteria and perspectives.

- several years into the continuous evaluation, as data accumulates, at least two types of analysis— annual and cumulative —become possible,

- large one-off evaluation exercises require that the evaluation be carried out by a team of professional evaluators while continuous evaluations can be run by an internal unit…continuous evaluations, therefore, can allow for a high level of participation by the users of results which in its turn deals successfully with problems that can arise in implementation,

- the level of control possible in continuous evaluations facilitates the collection of data which are fully compatible, consistent and reflect the complex dynamics of social processes,

- the judicious implementation of a process of continuous evaluation and monitoring can be significantly less resource intensive than commissioning an intermittent series of large exercises.

Molas-Gallart and Davies (2006: 72) refer to the need to constantly assess the policy-making process, "*evaluation has to become a process […] by which programs are constantly assessed to improve the policy process*". This approach is quite aligned with a new perspective that emerged in the late 1990s dealing with participatory evaluation.[17] According to Kuhlmann (2003b: 358), one of the main proponents of this standpoint, "*evaluation results are one piece of information among many […] therefore the evaluation process, or more exactly the communicating of the participating actors in its course, takes centre stage; the process is consciously designed to be participative*". This new conception, as Díez (2001: 909) notes, "*does not lie in the scale or degree of public intervention, but in the mode of intervention in the regional framework in order to achieve a systemic approach and effective interaction between all the regional agents*". Also Díez adds that "*this approach makes it possible to convert evaluation into an exercise contributing to achieving the very goals of new (regional) policies*" (ibid: 916).

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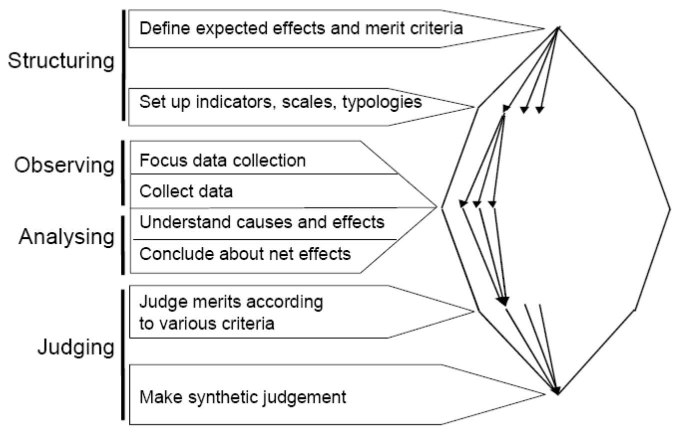
[17] In accordance with Burke (1998) the key principles of participatory evaluation are: (i) it should be context specific and built on the concerns, interests and problems of the stakeholders; (ii) the methodology should respect the knowledge and experience of stakeholders; (iii) it should favour collective knowledge generation; (iv) it must involve all stakeholders and be useful to the project; (v) it cannot be disinterested, that is, it has to be oriented towards its use and influence on organizational decision making; (vi) the evaluator – guide – shares its power – role - with the rest of stakeholders, recognizing their ability to control the evaluation process.

Likewise, there is a body of literature that focuses on the needs that should be considered by a monitoring and evaluation system in order to provide comprehensive and useful information to policy-makers.[18] The first aspect in this stream of literature focuses on the key phases of evaluation. In this sense, Williams (1999) considers four stages as important in a monitoring and evaluation system: structuring, observing, analysing and judging.

Figure 2.9.- The four key stages and eight steps of an evaluation



Source: Williams (1999) adapted from Scriven (1980).

In similar vein, Morzinski and Fisher (1996: 43) suggest an evaluation model that addresses for evaluation stages:

1. context evaluation, for assessing needs, objectives and organizational support: equivalent to the analysing phase of the previous illustration;

2. design evaluation, to assess mentor and protégé characteristics, the process for pairing the mentor and protégé, the program duration, activities and recognition/ rewards for participants: equivalent to the structuring phase;

[18] For the Spanish case, Bustelo (2006) made a considerable contribution concerning the current and future needs of a monitoring and evaluation system in Spain.

3. implementation stage evaluation, to monitor activities, feedback and revisions: equivalent to the observing phase;

4. product evaluation, to assess systematically the planned and unplanned outcomes that consist of program reactions, learning, behaviour change, and impact: equivalent to the judging phase.

These key stages are in line with Rich (1979: 73) who suggested that "*evaluation research needs to be based on an understanding of (1) the interaction among goals, context and theory; (2) the nature of program development as an ongoing, interactive, and cumulative process; and (3) the nature of the process of innovation*". More concerns in this sense can also be found in the contributions by Boggio and Spachis-Papazois (1984: 95 and 134), Uyarra and Haarich (2002) and the Treasury Board of Canada (2002) for whom the ingredients of an effective evaluation should include: (i) objectives must be well-defined; (ii) independence from programme management; (iv) design must be thoughtful and appropriate to the task; (v) customers – stakeholders - must be able to take action; (vi) adequate resources must be available; (vii) evaluation results must be articulated so that they respond to the needs of the users of the evaluation studies; (viii) a good basis for the comparison of qualitative and quantitative information.

In recent years a parallel approach to evaluation studies has emerged in the literature dealing with benchmarking of innovation. Its main aim is to allow "*territories to adjust their learning processes along with the experiences of others*" (Zabala-Iturriagagoitia et al., 2008a: 249). For the European Commission "*the benchmarking of research and innovation policies consists of a mutual learning tool for policy making, scoreboard and indicators*" (2002: 5). This is fostering learning and improving performance of concrete units – territories, research groups, countries, policy makers, etc. - by comparing the results from those units. This aspect has been studied in detail in Zabala-Iturriagagoitia et al., (2007a) which compares the performance of European regions according to their efficiency levels, Zabala-Iturriagagoitia et al., (2008a) which compares the strengths and weaknesses of the Valencian Innovation System with Spanish, Mediterranean and European regions, and Jiménez-Sáez et al., (2007) in a study of CSIC (Spanish National Research Council) research groups' performance in Spain. In this sense, we acknowledge that the concept of benchmarking is not as thorough as that of evaluation. However, the literature points to some similarities between the two concepts as both deal with learning and analysis of performance. Main (1992: 102) defines benchmarking as "*the art of finding out, in a perfectly legal and aboveboard* *way, how others do something better than you do-so you can imitate-and perhaps improve upon-their techniques*". Benchmarking thus represents a systematic process that enables improvement in key processes by comparing them with peak performance and the best-in-class or peers (Hurmenlinna et al., 2002). For Niosi "*benchmarking is the systematic observation of organizational routines and the comparison of performance with superior units at the levels of resource use and efficiency and effectiveness (inputs and outputs)*" (Niosi, 2002: 296). Similarly, according to Dou "*benchmarking could be defined as a system which allows a company and institution or an individual to compare some of their activities with those of the «best-in-class»"* (Dou, 2004: 298).

As seen, the language of benchmarking is, in words of Georghiou (2003: 68), "*close to, if not the same as, the language of evaluation*". Summing up, both concepts bring to mind similar meanings but evaluation has a broader perspective. Indeed, we believe that the key steps in Figure 2.9.- which are the steps to be covered by an evaluation, should also be considered within a benchmarking process. From this point of view, evaluation and benchmarking are equivalent. However, according to the definitions found in the literature benchmarking techniques are more oriented towards the observing and analysing stages, and less towards the judging and the structuring that may be considered key stages for closing the policy cycle. One of the main differences lies in the scope of the unit of analysis. While evaluation – of STI policies – is complex in nature and has to cope with this complexity, benchmarking exercises are used to compare the performance of the units under study according to a set of criteria. Some authors agree about the goals of evaluation but mention research as a benchmark investigation. In this sense, Niosi (2002: 300) considers that "*the definitive recognition […] and the adoption of benchmarking as a tool, may help to go beyond description towards a more policy and management-oriented evolutionary approach*" in the study of IS, and hence, in the evaluation of innovation policies (co-evolution). According to Nauwelaers and Reid (2002: 371) this could be one of the reasons why "*scholars from the EU involved in innovation policy benchmarking have developed a softer notion of benchmarking, based on learning-by-interacting processes rather than on a 'borrowing from best practice' notion. In this approach, an exchange of experiences takes place between policy-makers, who are then pushed to analyse and investigate their own policy practices in the light of the "mirror" offered by practices deployed elsewhere. No best practices are found, but lessons from successful foreign policy approaches are incorporated in the policy thinking of the country undertaking the benchmarking exercise*".

As we can see, the literature does not offer a thorough depiction of the definition, methodological approaches, requirements, problems, conceptual approaches, etc. of benchmarking processes as is available for evaluations. This lack points up on the one hand the degree of novelty of our research regarding benchmarking methodologies, and on the other the still weak theoretical foundations on which it is based. Nevertheless, a benchmarking process developed in isolation would not be useful; it should be understood as part of a more extensive evaluation process.

The main contribution of the present research can be seen as the benchmarking practice it provides, in which the results obtained (as well as the resources used) by a set of territorial units are compared, first by following particular innovative capacity measurement methodologies and second by applying a relative efficiency criterion. The main reason for adopting a benchmarking perspective and not one based on evaluation approaches is that we consider that the overall evaluation of a RIS can only be accomplished when the researcher has an in-depth involvement in the RIS and its regional policy-making sphere. In addition, a comprehensive evaluation of the performance of a RIS implies consideration of many criteria, which would need to be defined in a consensual way by those in charge of the RIS. Thus, our analysis focuses on some concrete indicators that represent some of the main features of the regions, but cannot be considered sufficient for a comprehensive RIS evaluation that discusses each institution, its role and the links between institutions, as depicted in Figures 2.2. and 2.3. Third, and according to the results obtained in the process, we consider that the focus on a particular dimension such as efficiency, which has received little attention in the literature, constitutes a more interesting research field. Also, consideration of the efficiency criterion allows us to compare the results obtained with those observed in the application of other methodologies, which allows us to modify and improve our research hypotheses. Finally, and bearing in mind that along the research we benchmark the performance of Spanish, Mediterranean and European regions, complete information on these regions is not available. Accordingly, it is more realistic to acknowledge our focus on regional benchmarking rather than engaging in a global evaluation of the different RIS, despite their connection.

We consider that appropriate evaluation of a RIS cannot be accomplished without including relative efficiency issues, which must emanate from a previous benchmarking exercise. In fact, the EIS 2007[19] for the first time makes direct reference to “innovation efficiency”. Hence, we believe that efficiency considerations should become part of every RIS evaluation, a point we stress in this research, especially in the third contribution in this thesis (see Chapter 0). With this approach we aim to illustrate the relevance and potential of the study of efficiency for dealing with the evaluation of public investments in STI policies, compared with a rather simplistic best-practice vision. This research also seeks to foster policy learning both for those institutions involved in the management of this kind of policies and for their participants in order to achieve more competitive and efficient STI policies.

To date, the literature provides no clear evidence on the qualitative requirements that evaluations should consider, such as co-ordination among policies, institutions and agents.[20] Rich (1979: 9) talks about the “coordination of complexity” which he considered to be a key concern for managers. This issue was illustrated by Georghiou (2001), Kuhlmann (2003b), Arnold (2004), and Pekkarinen and Harmaakorpi (2006), but this is a research direction that we consider needs further study.[21] Thus, the results obtained by Zabala-Iturriagagoitia et al., (2007a) link the need to coordinate (innovation) policies with the efficient performance of RIS (Frenken, 2000; Niosi, 2002), which as will be illustrated in the next section is considered to be one of the main (despite being sometimes neglected) arguments in policy evaluation, and constitutes one of the main targets of this research. These results are in line with the discourse offered by Kuhlmann (2003b: 355) for whom “*the pressure on the science and technology systems and the innovation system to function more effectively is complemented by similar pressures to function more efficiently, largely driven by the growing cost of science and technology. This will require a much better understanding of the research system itself*”. These arguments necessarily drive us to consider the reason why efficiency and productivity are considered as key issues in research/programme benchmarking and evaluation.

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[19] http://www.proinno-europe.eu/index.cfm?fuseaction=page.display&topicID=364&parentID=51

[20] As Kuhlmann (2003b: 373) reminds us, Article 130 of the Maastricht Treaty refers to the need for better co-ordination of genuine European, national and regional policy efforts.

[21] It could be considered that this need for further co-operation strengthens the principles considered by the “participatory evaluation” approach mentioned above. In this sense, Borrás and Jacobsson (2004) and Gornitzka (2005) introduced the concept of the “open method of coordination” as a new governance pattern in European policy making processes.

2.4. The Relevance of Efficiency in R&D and Innovation

For decades, R&D agencies have allocated resources largely in an unstructured process in their public STI policies. However, since the mid 1990s, this situation has begun to change, as concern over government efficiency has increased (Shapira and Kuhlmann, 2003b: 2; Kuhlmann, 2003b: 356). The reason for this greater concern over the efficiency of public policies is that "*the taxpayer, has the right to know whether public resources are used efficiently and for relevant purposes*" (Oksanen, 2000: 8).[22] Hence, it has become necessary for evaluation studies to consider efficiency as a key concept.

Hence, "*comparing programme aims and expenditure with the quality and quantity of the results obtained and assessing the appropriateness, originality and scope of the methods and instruments used as components of an evaluation, [it will be possible to] improve the efficiency of research support and thus lead to a more rational use of funds*" (Boggio and Spachis-Papazois, 1984: 31). In fact this is the aim of the present research, using a well known methodology comprising efficiency measures to gauge RIS performance. The rationale for considering efficiency measures within the context of regional innovation lies in the familiar "more is better". In accordance with most R&D and innovation statistics and national/regional innovation policies, the amount of resources available within an IS (inputs) is a crucial aspect. But what about the way they are used? Is it worth investing huge funding in innovation activities? Are all economies equipped to absorb these investments within their territories? We believe that although the identification of these resources is important, the consideration of how efficiently they are exploited is even more important. This efficiency consideration however does not mean that the methodologies oriented to benchmark territories (regions, countries) according to their innovative capacity are misleading, but that they should be complementary and allow for a better and more solid characterization of RIS.

One of the main uses of evaluation is to develop a better understanding of the working mechanisms of policy making processes in order to create more efficient ways for obtaining the effects sought (Boggio and Spachis-Papazois, 1984). Hence, combining the

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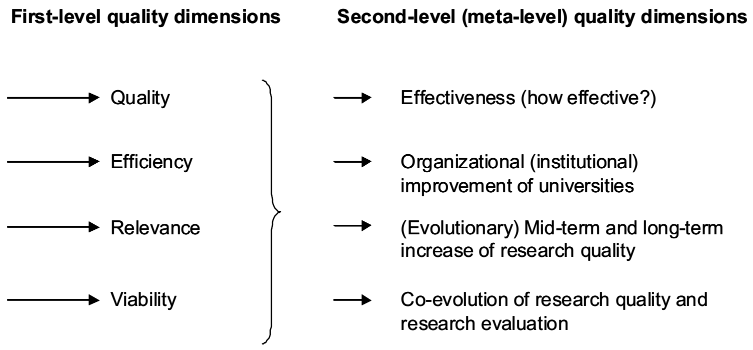
[22] The study of efficiency cannot be considered a new phenomenon. It has for long been a concern in evaluation. Feller (2003: 20) shows how the 1884 Allison Commission review of the Signal Service, Geological Survey, Coast and Geodetic Survey and the Hydrographic Office of the Navy Department, did already search for "*greater efficiency and economy of administration of the public service*".

contributions from the IS related literature (innovative capacity), the policy evaluation (benchmarking) literature and contributions on the study of efficiency and productivity, we hope to provide a balanced view.

According to Cook and Scioli (1972: 330) the "*three main requisites of policy evaluation procedures [are] performance, adequacy of performance and efficiency*". For them, "*performance refers to the relationship between the program activity (output) and the measured effects (impact) of the program […] adequacy of performance refers to the relationship between the performance to the magnitude of the program target (need) […and] the concept of efficiency refers to comparative evaluation analysis*" (ibid). In this sense, a policy programme to be fully justified, "*needs not only to be effective in changing behaviour, but also efficient from a social point of view*" (Papaconstantinou and Polt, 1997: 11).

Along with Campbell (2003: 110) the major target for policy evaluation is its effectiveness which "*should express the degree of achievement of certain (research) objectives*". In Campbell's opinion, effectiveness can be considered as a combination of dimensions such as quality, efficiency, relevance, viability, etc. allowing for specific and distinct effectiveness profiles for various institutions (or disciplines) (ibid) . However, he adds that, in practice, a robust application of this concept often proves difficult because of its qualitative character. Similarly, for Jordan and Streit (2003: 322) "*an effective organization – in our case policy - is one whose culture, structure and management is optimal to turn its resources into outputs and accomplish the purpose of the organization's effort, given the external environment in which it operates*". In this sense, we deem that in order to estimate the effectiveness of a STI policy, the study of the efficiency levels it has managed to produce on the actors participating in it may be considered an intermediate step. Nevertheless, these two concepts of efficiency and effectiveness should not be confused. There are contributions in the literature where the two concepts are used interchangeably (Kling, 2006). While efficiency refers to the relative use of the resources devoted to a particular activity in order to produce certain outputs, effectiveness considers whether the targets (in absolute terms) have been achieved or not. In this sense, a policy/programme can be effective, as its goals might have been achieved, but very inefficient, because it has required too many resources to produce low outputs.

Figure 2.10.- Typology of quality dimension in research evaluation



Source: Campbell (2003: 111).

The authors cited above embrace a definition of effectiveness that includes the concepts of productivity and efficiency. So, increasing productivity is seen as one of the main goals of policy (Fox, 2002; Oosterhaven and Broersma, 2007: 2). Hence, a set of empirical criteria need to be defined, agreed on and selected to demonstrate whether the efficiency-effectiveness-quality levels, etc. targets of the policy under analysis have been achieved (Rich, 1979).

Niosi (2002), adapting the use of the efficiency concept to the NIS literature, advocates for the need to tackle the evaluation of the efficiency of NIS.[23] This research path has already produced some preliminary results such as those obtained by Nasierowski and Arcelus (2003), Susiluoto (2003) and Zabala-Iturriagagoitia et al., (2007a). For Niosi, "*the x-inefficiency is the gap between observed performance and existing best performance (maximum output observed in equivalent organizations)*" (Niosi, 2002: 293).[24] Similarly, Kuhlmann (2003a, 2003b) adopts the term "efficient innovation systems" considering that these, "*develop their special profiles and strengths only slowly,*

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[23] "*The Systems of Innovation literature takes an ambiguous stand on efficiency*" (Niosi, 2002: 293). Thus, "*we would like to propose that the most relevant performance indicators on […] IS' […] should reflect the efficiency and effectiveness in producing, diffusing and exploiting economically useful knowledge. Such indicators are not well developed today*" (Lundvall, 1992: 6). To conclude "*aggregate statistics […] may reveal some types of efficiency or effectiveness […] it thus may be necessary to desegregate statistics, and to build new ones, to understand some observed yet unexplained x-inefficiency of the system as a whole*" (Niosi, 2002: 298).

[24] This definition is in line with Leibenstein (1978).

in the course of decades or even centuries. They are based on stable exchange relationships between the institutions of science and technology, industry and the political system" (Kuhlmann, 2003a: 139).

The relevance of efficiency measurement in evaluation studies has been addressed by several authors (Majone, 1989; Autio, 1998; Sirilli, 1999; Georghiou and Roessner, 2000; Tassey, 2003; Ekins and Medhurst, 2006). However, in the more experimental studies, the literature on this subject is not extensive (Calderon Patier et al., 2005). Scholars have applied efficiency analysis in many fields, but few efforts have adopted a methodology to study the socioeconomic impact of public R&D policies (Chelimsky, 1998; Cozzens, 2002; Batterbury, 2006) and IS. This growing stream of work has mainly been addressed to the design of efficiency measures related to university teaching and research activities (Beasley, 1990, 1995; Martinez-Cabrera, 2003; Giménez-García, 2004; Cherchye and Vanden Abeele, 2005; Diez de Castro and Diez-Martin, 2005; Bogetoft et al., 2006; Anderson et al., 2007).

Thus, when comparing the relevance of the study of efficiency for the public and private sectors, it is the private sector that classifies firms according to their efficiency, so that if a firm does not demonstrate efficient behaviour the market removes it from competition. In fact, from a purely theoretical perspective and under perfect competition there is no room for inefficient behaviour – technical or allocative (Farrell, 1957). For Cyert and George (1969: 26) "*efficiency should be viewed as a function of management rather than a function solely of the market*". Within this proposition they claim that the results of the firm/policy programme are directly affected by their management. Fox (2002: 1) considers that "*it is often more difficult for public agencies to measure their performance in achieving management goals that are common in the private sector. How should a hospital, a police force, or a government department measure its output? How should efficiency in raising revenue by the government be measured? How should the efficient allocation of scarce resources between activities be managed when it is difficult to measure the relative performance of different agencies? How should the wealth of a country, its (variable and fixed) natural resources, be efficiently managed?*". Indeed, Fox could be reproached for putting too much emphasis on the "how", but nevertheless, he illustrates that the evaluation of efficiency in the public sector is worthwhile.

Díez-López and Izquierdo-Ramírez (2005) present the objectives of some of the main evaluation methods, including those dealing with efficiency measurement (see Table 2.2.-). Efficiency analysis methods should be considered to: (i) justify the evaluated policy/programme ensuring the efficient use of the resources devoted to it; (ii) respond to the information needs of managers and policy makers in charge of the evaluated policy/programme. As we have observed, they also link the purposes of the methodologies dealing with the planning (efficiency) and those related to accountability (effectiveness), which confirms the earlier statements about these two concepts and the links between them.

Table 2.2.- Purposes and evaluation methods

Main purposes of the evaluation	Methodological frameworks
Planning and efficiency: - justify the evaluated policy/programme ensuring the efficient use of the resources devoted to it. - respond to the information needs of managers and policy makers in charge of the evaluated policy/programme.	*Resource allocation based approach*: Efficiency analysis in terms of the resources used, their planning, use and results obtained.
Accountability: - prove to what extent the programme has achieved its goals, and whether the resources have been used in an effective way. - responds to the information needs of policy makers, funding institutions, ministries and parliaments.	*Standard or target fulfilment based approach*: Judge the success and effectiveness by means of criteria fulfilment checking.
Application: - improve the application and execution of the programme and the effectiveness of its mechanisms of action (measures and instruments). - respond to the needs of the programme managers and their stakeholders.	*Formative approach oriented towards change*: Generate useful conclusions to improve the programme during its implementation and operation.
Knowledge generation: - increase the comprehension about which programmes operate, how they really operate and under what circumstances (context) so as to achieve conclusions about the effectiveness of the different behaviours. - respond to planner needs.	*Approach based on explanation/ understanding*: Investigate the impacts and success of the programme and identify causal mechanisms on what operates, when and how.
Institutional strengthening: - improve and develop the capacities of the agents participating in the programme (agencies, organisms, research centres, universities, firms, etc.) to act on their environment, networks and institutions. - respond to the needs of the programme stakeholders.	*Participative approach*: Develop networks, communities and territories from a bottom-up approach with participative methods.

Source: adapted from Díez-López and Izquierdo-Ramírez (2005: 194).

Finally, it is also necessary to highlight the critics of the use of efficiency as a tool or method of policy evaluation. In Georghiou and Roessner's (2000: 660) view the main criticisms are that: "*(i) the technical information term in the production function is only approximated by R&D expenditure data, and in any event its effect on the larger production system is not well understood; (ii) the approach does not account adequately for externalities that result from R&D activity; (iii) the intent of most public R&D is not to stimulate economic growth, but to achieve public agency missions [and hence] any contribution to economic growth is thus due to indirect knowledge transfers; and (iv) the contributions of basic and applied research are difficult to distinguish, yet these are important for many policy purposes*".

We would agree in the sense that efficiency analysis is not the answer to all the difficulties and setbacks involved in policy evaluation. The policy evaluation related literature is in agreement about the need to combine different approaches, methodologies and indicators in order to avoid biased assessments of system/policy performance, and to produce realistic evaluations (Cook and Reichardt, 1986; Purdon et al., 2001; Luukkonen, 2002b; Treasury Board of Canada, 2002; Díez-Lopez and Setién-Santamaria, 2005; Bezzi, 2006; Michelson, 2006; London et al., 2007). The present research aims to contribute in this respect by incorporating a quantitative approach based on efficiency measures, which tries to complement the conclusions reached through the use and application of other, both quantitative and qualitative methods and approaches. Accordingly, we would recommend that a combination of the methodology presented here, with qualitative analyses and other sources of information provided by empirics, should be used as the basis for decision making to provide better information at the beginning of a new policy cycle. In fact, as it will be observed in Chapter 9, this constitutes one of our main future targets: laying down the foundations of a new perspective within policy evaluation studies by using mixed evaluation methods that join the quantitative and qualitative perspectives.

CHAPTER III: OBJECTIVES

Starting from the concepts of innovative capacity and regional benchmarking, the goal of this thesis is to compare different methodologies oriented to tackling the analysis and evaluation of RIS in order to determine their robustness, and to study the possibilities that efficiency measurements could complement the framework for the measurement of the innovative capacity.

In other words, ***this thesis aims to compare benchmarking methodologies oriented towards the measurement of the regional innovative capacity to identify their strengths, weaknesses and future needs, and based on previous results, to propose efficiency measurement as a complementary methodology to cope with the needs identified, thus enabling a better in depth characterization of RIS***. In order to achieve this target a detailed study of those R&D and innovation indicators included in earlier benchmarking methodologies is required.

The rationale for considering efficiency measures as relevant, within the context of regional innovation, is that the existing methodologies are mostly based on the belief of “the more the better”, and that it is the amount of resources employed (inputs), but not how they are used that matters. They hinge upon the assumption that “you reap what you sow”, i.e. what you get is related to what you put in. The efficiency consideration does not imply that the methodologies oriented to benchmarking territories (regions, countries) according to their innovative capacity is misleading, but suggests its inclusion as a complementary factor which will allow for a better and more solid characterization of RIS.

The focus on the regional arena was based on many reasons. The role and importance of the region as a point of reference is changing rapidly and is still evolving within the EU area. This has resulted in a process of competence devolution to the regions in several EU countries, which gives them room to develop their own regional policies (Landabaso, 1995). The importance of the innovation policy both at national and

EU levels is no disputed and regional governments have profited from various regional development theories and approaches such as the "*learning region*" approach and the "*regional innovation system*" concept, which argue for the design and implementation of regional innovation policies. Therefore, consideration of the region as a geographical space with specific and different characteristics in terms of institutional, regulatory and legal frameworks, from those of the nation as a whole, has posed problems and raised concerns about the design, implementation and evaluation of regional STI policies.

We can summarize the main sequential goals of the research in this thesis, and relate them to the key stages in evaluation depicted in Figure 2.9.- as follows:

- Analyse some of the methodologies that use composite indicators for the measurement and benchmarking of innovative capacity (related to the "Observing" stage – focus on data collection);

- Examine the robustness and rigour of these methodologies (related to the "Analysing" stage – understand causes and effects);

- Examine the most adequate R&D and innovation indicators for their subsequent inclusion and exploitation in innovative capacity benchmarking methodologies (related to the "Observing" stage – focus on data collection and collect data);

- Demonstrate the need to complement the previous methodologies with efficiency criteria (related to the "Analysing" stage – conclude about net effects);

- Discuss the application of efficiency approaches in the context of regional innovation systems (related to the "Judging" stage – judge merits according to various criteria);

- Analyse the conclusions and policy recommendations that arise from an efficiency analysis as a complement to the existing methodologies on innovative capacity benchmarking (related to the "Judging" stage – make synthetic judgements).

Thus, taking the concepts of innovative capacity and regional benchmarking as our starting points, and testing for their utility, deficiencies, future needs and robustness, this research applies them in three scenarios: a peripheral European region - the Valencian

Community in Spain (paper 2), all Spanish regions (paper 1), and all European regions (paper 3).

The thesis draws together published work on indicator-based and efficiency-oriented evaluation of RIS into a single coherent framework which addresses the question of how best is it possible to understand the differential performance of regions. Based on the results obtained, one of the main contributions of this thesis consists of demonstrating the need to consider efficiency measurement as key to a better understanding of RIS performance in Europe and the possibilities of efficiency measurement methodologies for the policy making community[25].

[25] When this dissertation was being written, the EC, through its PRO-INNO platform, published EIS 2007, which highlights two aspects that directly relate the findings of this research. It includes for the first time, direct reference to innovation efficiency and provides a tool for carrying out interactive benchmarking practices, based on the indicators (in this case measured at national level) included in the Scoreboard.

CHAPTER IV: HYPOTHESES

Based on the set of goals defined above, the working plan for the thesis includes three main research paths:

1.- Benchmarking the Spanish IS.

This step consists of determining the most relevant indicators for evaluating the capacities/strengths/weaknesses of a RIS, in this case, taking the Spanish regions as the main unit of analysis. This stage will allow familiarization with the literature on benchmarking and innovative capacity and their relation with learning in the regional policy making sphere.

From a theoretical perspective, we would agree that most Spanish regions cannot be considered as 'perfect' or comprehensive RIS because of their limited system interactivity and the fact that the learning processes related to innovation in policy making are at a very early stage (Riba Vilanova and Leydesdorff, 2001). In fact, there is no direct evidence that RIS exist. So, the RIS perspective (Cooke et al., 1997) might be thought not to be useful in this context. However, this approach offers a conceptual framework that enables comparison of the relative position of the Valencian Community in innovation: thus in this step we adopt an IS perspective. Also, adoption of this common conceptual framework of analysis allows regional authorities to orient their innovation policies according to a systemic view which may account for identified needs and weaknesses as well as promoting key strengths.

2.- Benchmarking the Valencian IS.

The reasons for focusing on this particular region, i.e. the Valencian Community in Spain, are because of its structural features. Regional GDP (€81,781.4 million) is 9.8% of overall Spanish income (€840,106 million) (INE, 2004). The Valencian Community is ranked 4th among the Spanish regions after Catalonia, Madrid and Andalusia, all of which have been studied in the literature (Bacaria et al., 2001; Real Heredia, 2001; Riba Vilanova and Leydesdorff, 2001; Albert and Plaza, 2003). It also has some structural characteristics that are not found in any other Spanish region. Its most representative sectors (i.e. wood, tiles, ceramics, toy industry, footwear and textiles) are grouped in industrial districts - wood in Benicarlo, tiles in Castellon, toys in Elda, footwear in Elche and textiles in Onteniente. Second, the innovative patterns of firms are not oriented towards R&D activities – and innovation in firms is driven by the acquisition of foreign machinery (INE, 2004). This last fact explains the low–medium technological level of regional firms, which are concentrated on labour intensive sub-sectors, with a major lack of companies in the high-tech and knowledge-intensive sectors. In addition, not only are Valencian firms low technology oriented, but 66.8% of regional firms employ less than 6 people, while 96.8% have fewer than 50 employees; only 0.02% of Valencian firms have more than a 1,000 employees (INE, 2004). In the Valencian Community, universities are the main catalysers of regional research activities, but the existing structural imbalance has led to the Valencian IS being fragmented and disoriented due to a lack of co-operation between firms and the research system (Fernández de Lucio et al., 2001, 2007).

This second step in the research is conducted in three stages. First, the Valencian Community is benchmarked against Spanish, Mediterranean and European regions. By this means we aim at a more comprehensive and realistic view of the competitive position of the Valencian Community, both in Spain, and also in the Mediterranean arch and the whole of Europe. We consider that the existing high heterogeneity among regions in terms of innovation should enrich the contribution of this benchmark.

3.- Benchmarking European regions based on efficiency.

Based on the results from the previous two steps, this third stage is oriented to illustrating the need, and subsequent utility for policy managers responsible for R&D and innovation policies, of using efficiency related concepts when evaluating their (STI) policies and the performance of the RIS in which they are embedded. We benchmark the performance of European regions by comparing their multi-input/multi-output relationships (technical efficiency). The literature calls for consideration of efficiency analyses in the evaluation of public sector activities such as S&T (Georghiou, 1998; Niosi, 2002). However, very few studies on the efficiency of regions have been conducted (Susiluoto, 2003), although the criterion has been applied to other areas (Karadag et al., 2005). We hope that this research will encourage new research directions in relation to the IS and policy evaluation literature, which will provide new evidence and contribute to the literature in these areas. The evaluation of RIS performance in Europe in terms of (technical) efficiency is thus the main goal. That is, we believe that although identification of the amount of resources available within an IS, according to a “the more the resources invested the more competitive the system will be” perspective, is crucial, how efficiently these resources are exploited is even more important, as it is not evident that those regions with the highest incomes (highest value added, highest GDP, etc.) are also the most efficient (Susiluoto, 2003).

We aim by this means to demonstrate the need to complement the conclusions and information derived from the use of existing evaluation and benchmarking methodologies with those from the application of a concrete criterion such as efficiency, which we consider to be relevant in the context of the innovation literature.

To sum up, the main questions that this research tries to answer are:

- Is the concept of innovative capacity suitable to be used in the context of innovation benchmarking?
- Do innovative capacity benchmarking oriented methodologies show a robust pattern?
- Is the consideration of efficiency measures (criteria) important within the context of regional innovation?
- Is it possible to complement the information provided by innovation benchmarking studies with that from an efficiency approach?

Taking into account the previous objectives, working plan and research questions incorporated in the research, the hypotheses that the thesis will try to prove are first that ***the performance of RIS can be characterized by their efficiency***. And second that, we believe that ***the consideration of efficiency criteria complements and hence increases robustness of the policy recommendations that are drawn from the use of innovative capacity benchmarking oriented methodologies***.

CHAPTER V: METHODOLOGICAL FRAMEWORK AND MATERIALS

Within the context of increasing globalization, regional differences are becoming more apparent. The goal of marginal regions is to close the gap with the more developed regions, i.e., to enable economically underperforming regions to catch up with more prosperous ones (Landabaso, 1995). One of the core aspects of economic growth is technological progress, which it is assumed is triggered by innovation. Innovation hence has become one of the main priorities for most European regions. The agreements adopted by the Lisbon and Barcelona Councils are evidence of this (European Lisbon Council, 2000; European Barcelona Council, 2002). Consequently, as discussed in Chapter 2 innovation policy benchmarking studies constitute one of the main focuses in the literature (Hassink, 1993; Dou, 2004). Since to induce and/or manage innovations is a multi-dimensional, social, interactive and complex task, analytical studies of these issues must be wide ranging, and encompass the whole IS. Most of the existing approaches focus on the in depth examination of a particular region: to explore its RIS (Braczyk et al., 1998); investigate the internal relations among the actors involved (Koschatzky et al., 2001), and assess the importance of institutions (Tödtling and Trippl, 2004). In short, the focus is on the operation of a successful RIS (Díez, 2002; Fernandez de Lucio et al., 2003).

Against this backdrop, the regional dimension has gained in importance, demonstrated by the number of programmes aimed at promoting innovation that have been implemented in the less favoured European regions (Henderson, 2000). The great variety of these actions and the innovation policies developed, illustrate the structural and cultural diversity as well as the main political priorities of member states (Fernández de Lucio et al., 2003). The literature has associated these differences with the characteristics of the IS (Cooke et al., 1997). In addition, a process of competence transfer to the regions has been taking place in many European countries. As a consequence, regions have become increasingly important sources of innovation and economic growth.

To provide some support to regions in the development of their innovation policies, the EU in 1994 launched the RIS' initiative to promote the definition of R&D and innovation policies at regional level. The First Action Plan for Innovation in Europe (EC, 1996) provided a structure as well as an analytical method for the definition of innovation policies. Based on this, the 'Trend Chart on Innovation in Europe' has become a practical tool for designers and managers of innovation policy, and is intended to enable continuous updating and analysis of the available information on innovation policy. The results of the First Action Plan and the Trend Chart should enable less favoured territories to learn from good practice and to institute processes oriented to defining and implementing more territorially 'embedded' innovation policies (Georghiou, 1998). This justifies the increasing attention devoted to benchmarking analyses dealing with R&D and innovation in recent years (Hurmenlinna et al., 2002; Luque-Martínez and Muñoz-Leiva, 2005), as a process oriented to driving regions to learn from their and others' experience. Within this context we should stress the key role of the IRE Network[26] as a support structure for carrying out benchmarking exercises on innovation policies in European regions. It should be noted that in December 2006, the Directorate General (DG) Enterprise and Industry launched the PRO INNO[27] platform, to complement the IRE Network, aiming at contributing to the development of better innovation policies in Europe, and learning from best-practice and trans-regional cooperation (Perkmann, 2003).

It is important to measure system performance as a whole, rather than quantifying particular measures or key indicators (Leydesdorff, 2001). It should involve empirical as well as qualitative[28] assessment (i.e. both numeric, and assessment based on a normative 'better–worse' scale). One of the main focuses of research in these areas has been linked to the indicators used to represent and measure innovation. The OECD's Oslo Manual (1992, 2005) can be seen as an example. The EC's EIS and CIS are invaluable for providing indicators that increasingly are being acknowledged as measures of the performance of European countries and regions. In addition, these initiatives enable

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[26] http://www.innovating-regions.org/

[27] http://www.proinno-europe.eu

[28] In the policy evaluation literature it is commonly accepted that the effects of any policy cannot be reducible to a single criterion, so the use of both quantitative and qualitative measures is indispensable (Georghiou, 1998; Kuhlmann, 2003b).

progress in Europe, in relation to the goals defined in the Lisbon and Barcelona councils, to be monitored.

Based on the indicators provided by the most available data, (R)IS are generally seen as pure technical input-output systems, with an emphasis on the amount of resources employed. However, this simple focus on the empirical assessment of (R)IS performance (based on one or a number of fairly isolated indicators) may provide a biased picture. There is agreement in the literature as to the lack of suitable measures not only with regard to benchmarking system performance, but also for the in-depth evaluation of the particular features of the system (Kuhlmann, 2003a). Thus, when we examine the data in detail, several problems arise, and particularly in relation to cross-country benchmarking analyses, due to the heterogeneity of European regions, the multi-dimensionality of IS, and differences in the criteria applied by regional (and national) statistical offices. In this sense there is implicit recognition of the existence of deficiencies and limitations in the indicators for the measurement of R&D and technological innovation (Godin, 2002, 2003; Inzelt, 2004). There is a critical need to achieve some balance between the data provided by empirical assessment and qualitative analyses for evaluation.

As already stated, on the one hand we aim to compare benchmarking methodologies oriented towards the measurement of regional innovative capacity to identify strengths, weaknesses and future needs. The methodologies deployed in the thesis, hence, are designed to test existing approaches to the measurement of RIS and to explore the utility of new approaches based on the explicit consideration of efficiency rather than simply measure levels of inputs or outputs. Consequently, we propose efficiency measurement as a complementary methodology to cope with needs and allow for a better in depth characterization of RIS. First we should review the existing research on innovative capacity measurement and benchmarking.

The European Competitiveness Index (ECI) (Huggins et al., 2004) is based on 49 variables grouped within three categories: Creativity and the Knowledge Economy, Economic Performance, and Infrastructure and Accessibility. These groups are further sub-divided depending into inputs, outputs or outcomes of technological innovation, and economic development. The ECI also includes a set of variables to account for employment and R&D expenditure, sectoral productivity, and infrastructures such as motorways and rail links. Although this was seen to be an original approach, it could not be empirically tested based on data for the Spanish and European regions. The Japanese

NISTEP (National Institute of Science and Technology Policy) methodology (NISTEP, 2001) has similar shortcomings in that despite the great diversity of variables it employs, these cannot be applied to the regional context. The methodology proposed by a Spanish research group (Buesa et al., 2002), the IAIF (Institute of Industrial and Financial Analysis) methodology, is based on 31 variables, and uses factor analysis to obtain four factors (or principal components): Regional and Productive Environment for Innovation, Role of Universities, Role of the Civil Service, and Role of Innovating Firms, which can be seen as in line with the Triple Helix approach (Etzkowitz and Leydesdorff, 1998, 2000).

In recent years the most widely used (in Europe) methodology is the EIS. The EIS responds to EU interests in identifying the factors responsible for differences among European regions in terms of technological innovation. The Lisbon Strategy established the European Trend Chart on Innovation initiative, designed to analyse and benchmark innovation policies at European level, and yield information and statistics on innovation policies, performance and trends in the EU. One of the core tools in this initiative is the EIS, which is regarded as the main measure of competitiveness in European regions in terms of innovation,[29] and tracks the EU's progress in innovation activities based on 17 indicators divided across four categories: human resources for innovation, creation of new knowledge, transmission and application of knowledge, and innovation finance, outputs and markets.

[29] EIS (2002: 12) states that "*40 per cent of the variation in per capita regional income can be explained by differences in innovative performance*".

Table 5.1.- EIS indicators

1.- Human resources for innovation (5 indicators)
1.1.- New S&E graduates (% of 20-29 age class)
1.2.- Population with tertiary education (% of 25-64 age class)
1.3.- Participation in life-long learning (% of 25-64 age class)
1.4.- Employment in medium-high and high-tech manufacturing (% of total workforce)
1.5.- Employment in high-tech services (% of total workforce)
2.- Creation of knowledge (4 indicators)
2.1.- Public R&D expenditures (% of GDP)
2.2.- Business expenditure on R&D (% of GDP)
2.3.- EPO high.-tech patent applications (per million population)
2.4.- USPTO high-tech patent applications (per million population)
3.- Transmission and application of knowledge (3 indicators)
3.1.- SMEs innovating in house (% of manufacturing SMEs)
3.2.- Manufacturing SMEs involved in innovation co-operation
3.3.- Innovation expenditures (% of all turnover in manufacturing)
4.- Innovation finance, outputs and markets (6 indicators)
4.1.- High-tech venture capital investment (%o of GDP)
4.2.- New capital raised on stock markets (%o of GDP)
4.3.- New to market products (% of sales by manufacturing firms)
4.4.- Home internet access (% of all households)
4.5.- ICT expenditures (% of GDP)
4.6.- % of manufacturing value-added from high-technology

Source: EIS (2002, 2003).

5.1. Materials: Data

In this section we aim to identify the variables that will be used in the model developed in the next section. The 1978 Spanish National Constitution (Article 137) describes the territorial divisions in Spain as municipalities, provinces and the autonomous communities. The corresponding Nomenclature for Territorial Statistics (NUTS) adopted by the EU and Eurostat, are NUTS-II. Hence, we use the NUTS-II territorial units as the unit of reference for our benchmarking.

First, after reviewing the studies dealing with the measurement of innovative capacity, the variables suggested in the literature were compiled and compared (Appendix I: Set of variables grouped according to the European Innovation Scoreboard and Fernández de Lucio and Castro (1995)). From the variables suggested in the literature a list of 90 possible ones was obtained, which were aimed at covering all possible indicators providing information of value in a study of the innovative capacity of regions. The data acquisition phase used a variety of sources of data on the Spanish Regions, including the

Spanish National Statistical Institute (INE), University Statistics (CRUE), Spanish and Iberoamerican Patents (CIBEPAT), the Centre for the Industrial Technological Development (CDTI) and the Spanish Confederation of Innovation and Technology Companies' (FEDIT). Based on the data gathered, a set of 22 variables was compiled. Their values were normalized within a range adjusted index to enable comparison among regions.[30]

$$(1)\quad NormalizedValue_{i,j} = \left(\frac{Value_{i,j} - Value\min_i}{Value\max_i - Value\min_i} \right)$$

This involved the value of every indicator *i* for each of the *j* years to be reduced by the lowest value of *i* over the whole period, and divided by the difference between the maximum and minimum values for *i* in the 1996-2000 period.

The second contribution of our research is oriented towards providing a dynamic perspective demonstrating how the Valencian IS has evolved over time, with respect to its Spanish, Mediterranean and European counterparts. For the Spanish benchmark we use a battery of 9 indicators from the national statistics that are close to those employed by the EIS, but for the 1992-2004 period. In turn, the Mediterranean-European analysis covers the 1994-2003 period using 10 indicators obtained from EUROSTAT (Table 5.2.-)[31].

[30] This normalization process was only applied to the benchmarking of Spanish regions among each other, according to two methodologies: IAIF and EIS. Further details are provided in the next section.

[31] The leaders for each (Mediterranean/European) indicator are: Population with tertiary education (Catalonia/ Île de France); Participation in life-long learning (Andalusia-Lombardia/South East-London); Employment in high and medium high technology manufacturing sector (Piemonte/ Franche-Comté-Stuttgart); Employment in low and medium low technology manufacturing sector (Valencian Community-Veneto/La Rioja-Marche-Norte); Employment in Knowledge-intensive high-technology services (Lazio- Midi-Pyrénées/ Île de France-Stockholm); Business enterprise sector R&D expenditure (Midi-Pyrénées/Stuttgart-Eastern- Braunschweig- Västsverige); Government sector R&D expenditure (Midi-Pyrénées-Lazio- Languedoc-Roussillon/ Midi-Pyrénées- Flevoland); Higher education sector R&D expenditure (Ipeiros-Umbria- Languedoc-Roussillon- Dytiki Ellada/ Gießen-Groningen- Alentejo- Wien- Övre Norrland); Patent applications to the EPO (Emilia-Romagna/ Oberbayern-Noord Brabant- Stuttgart); High-tech patent applications to the EPO (Provence-Alpes-Côte d'Azur /Noord-Brabant).

Table 5.2.- Indicators used in the Spanish, Mediterranean and European benchmarks

1.- Indicators for the Spanish benchmark, 1992-2004:
1.1.- Population with tertiary education (% of 25-34 age class)
1.2.- Participation in life-long learning (% of 25-64 age class)
1.3.- Activity rate of the population with tertiary education (% of active population)
1.4.- Employment in high and medium–high technology manufacturing sectors (% of employed population)
1.5.- Employment in high technology services (% of employed population)
1.6.- Business R&D expenditures (% of GDP)
1.7.- Public R&D expenditures (% of GDP)
1.8.- Innovation expenditures (% of GDP)
1.9.- Patent applications to the EPO (per million inhabitants)
2.- Indicators for the Mediterranean and European benchmarks, 1993-2004:
2.1.- Population with tertiary education (% of 25-64 age class)
2.2.- Participation in life-long learning (% of 25-64 age class)
2.3.- Employment in high and medium-high technology manufacturing sector (% of total employment)
2.4.- Employment in low and medium-low technology manufacturing sector (% of total employment)
2.5.- Employment in knowledge-intensive high-technology services (% of total employment)
2.6.- Business enterprise sector R&D expenditure (% of GDP)
2.7.- Government sector R&D expenditure (% of GDP)
2.8.- Higher education sector R&D expenditure (% of GDP)
2.9.- Patent applications to the EPO (per million labour force)
2.10.- High-tech patent applications to the EPO (per million labour force)

Source: Author's elaboration of INE and EUROSTAT statistics

The third contribution of our research aims at illustrating the possible benefits that consideration of efficiency measurements could produce in the benchmarking and evaluation of RIS. To achieve this, we compiled a data base from information from the EIS, covering 161 European regions for 2002, and 187 regions for 2003 (country aggregates as benchmarks included).The EIS 2002-2003 includes seven of the 17 indicators.[32] It also includes regional GDP per capita as one of the main outputs of an IS. Due to the lack of statistical data, these indicators identify as the leaders those regions with the largest investment in high-technology sectors, and ignores regions with high potential and requiring specifically targeted innovation policies. We consider that this produces a very biased picture of the European reality; the focus is on high-technology

[32] The 7 indicators in the EIS 2002-2003 are: Population with tertiary education, Participation in life-long learning, Employment in medium-high and high-tech manufacturing, Employment in high-tech services, Public R&D expenditures, Business expenditure on R&D, EPO high-tech patent applications.

sectors, while aspects such as social and organizational innovation, entrepreneurship and the learning to be developed by low-technology sectors are underrated.

Thus, according to the data available from the EIS, based on these seven regionalized indicators, we derive two composite indicators which rank the most innovative regions: (i) the RNSII (Regional National Summary Innovation Index), which explains the position of every region within its home country,[33] and (ii) the REUSII (Regional European Summary Innovation Index), which refers to the positioning of every region compared to the European average. The indices are calculated as follows:

(2) $$RNSII_j = (100/n) * \sum_i (X_{ijk} / \overline{X}_{ik}),$$

(3) $$REUSII_j = (100/n) * \sum_i (X_{ijk} / \overline{EU_i}),$$

where X_{ijk} refers to the value of indicator *i* in region *j* of country *k*; $\overline{X}_{ik}$ is the mean value for indicator *i* in country *k*; $\overline{EU}$ refers to the average of indicator *i* for the EU; and *n* represents the number of X_i regional indicators considered. A composite RRSII (Revealed Regional Summary Innovation Index) can be obtained as the unweighted average of RNSII and REUSII. This index is designed to pinpoint 'local leaders', taking account of the region's relative innovative performance both within the EU and within the country of origin. Thus, the RRSII seems to be most appropriate measure to compare RIS efficiency scores with the corresponding EIS indicators.

Since the EIS indicators are resource-based indices, a region that invests more resources and thus obtains a higher RRSII, will be ranked higher than regions whose investments are lower. However, this does not mean that the competitiveness of the former group will be higher (i.e. that their RIS is better) than that of other regions. The efficiency measurement approach aims at providing information about the use (misuse) of

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[33] Based on the RNSII composite indicator, some of the leader regions are above the country average. Hence, it can be concluded that innovative capacity is strongly concentrated in a very few regions in these countries, confirming the existence of 'innovation islands' in Europe (Landabaso, 1997; Clairesse and Muldur, 2001). As far as the RNSII composite indicator is concerned, the leader regions in each European Country are: Wien (Austria); Bruxelles (Belgium); Bayern (Germany); Attiki (Greece); Comunidad de Madrid (Spain); Ile de France (France); Uusimaa (Finland); Southern & Eastern (Ireland); Lombardia (Italy); Noord Bravant (Netherlands);

these resources. Due to the different perspectives of these two approaches it is possible that different 'best practice examples' will be identified and could, rightly or wrongly, become the blueprints for well meaning, but perhaps mistaken policy adjustments.

5.2. Methodology and Main Results

5.2.1. What indicators do (or do not) tell us about RIS

The objective of this section is to compare approaches to measuring innovative capacity, in this case taking the Spanish regions as the main unit of analysis in the 1996-2000 period. The methodology proposed by Buesa et al. (2002), which is based on the Spanish regions, was seen as the appropriate to compare with the EIS. The most relevant features of an IS are interactions, path dependence, degree of openness of the system, and qualitative aspects such as the role of institutions (Nauwelaers and Reid, 1995; Doloreux, 2002). However, the methodologies described above do not take account of these crucial elements. Hence, they can be considered a preliminary approach to the empirical investigations, which, within the IS framework try to explain regional differences, but not as a quantitative approach to the evaluation of a RIS.

As already discussed, the IAIF methodology is based on 31 variables, grouped into four categories, which explain 85.5% of the RIS variance in Spain. The relative weight of each factor in the final index can be obtained from the total variance explained by each factor in the model. This results in four partial indices (one for each factor/component). The weighting of the variables within each partial index (factor/component) is calculated as a percentage of the degree of interrelation between the factor and a particular variable, and the factor and all the variables it includes.

Lisboa E Vale Do Tejo (Portugal); Stockholm (Sweden); Eastern (UK). In all cases, the same regions were the leaders in 2002 and 2003.

Table 5.3.- IAIF Index for regional innovation

Factors	Variables	Weighting
Factor1: Regional and Productive Environment for Innovation (37%)	Gross Value Added high and medium technology firms	9%
	Gross Value Added low technology firms	11%
	Employment high and medium technology firms	9%
	Employment low technology firms	11%
	Exports High and medium-high technology firms	9%
	Exports Medium-low technology firms	4%
	Exports Low technology firms	12%
	Spanish patents	8%
	National projects funded by the CDTI	9%
	European Patents	8%
	GDP	10%
Factor2: Role of Universities (24%)	Internal University R&D expenditure (% of GDP)	14%
	Internal University personnel (FTE) in R&D	15%
	University researchers (FTE) in R&D	15%
	Students enrolled in tertiary education	7%
	Graduated Students	8%
	Students enrolled in postgraduate courses	13%
	Defended PhD thesis	14%
	Research quality indicator of university	14%
Factor 3: Role of Civil Service (20%)	Government Expenditure on R&D (% of GDP)	24%
	Government personnel (FTE) in R&D	24%
	Government researchers (FTE) in R&D	24%
	Scientific capital stock in R&D	17%
	Venture capital investment	11%
Factor 4: Role of Innovating Firms (19%)	Firms internal R&D expenditure (% of GDP)	16%
	Internal personnel of firms(FTE) in R&D	15%
	R&D researchers (FTE) of firms	16%
	Firm's technological capital stock in R&D	12%
	Regional distribution of technology centres	15%
	Annual income of technology centres	16%
	Innovation Expenditures	10%

Source: Adapted from Buesa et al. (2002).

First we describe the main steps involved in developing a Regional Innovative Capacity Index for the Spanish regions, for 1996-2000, based on Buesa et al.'s (2002) methodology. The aim is to verify similarities in the results obtained, and test robustness. Second, we repeat the process using the EIS methodology. Finally, the results obtained are compared and the differences noted (Yglesias, 2003).

Within the first approach we aim at replicating Buesa et al.'s (2002) study to obtain an Innovative Capacity Index (IAIF') to compare with the original IAIF. Principal components factor analysis was applied to the 22 variables which explain 89.2% of the total variance in the system (Table 5.4.-).

Table 5.4.- Rotated factors matrix for the IAIF

	Components			
	1	2	3	4
Employment in High-Tech Services	**,968**		,210	
Graduated Students	**,968**			
Total workforce	**,951**		,205	
GDP	**,949**		,262	
Gross Value Added High-Tech Services	**,948**		,198	,218
R&D expenditures Universities	**,946**		,168	
Nº Universities	**,937**	,114	,110	
Nº of PhD thesis finished	**,859**	,130	-,158	
Employment in manufacturing	**,815**	,205	,411	-,290
Spanish Patent applications	**,795**	,250	,144	-,155
Gross Value Added High and Medium-high tech manufacturing firms	**,787**	,354	,444	-,137
Employment in High and Medium-High tech manufacturing firms	**,781**	,351	,451	-,181
Innovation expenditure	**,758**	,322	,432	,150
Business R&D expenditure	**,778**	,358	,374	,245
Public R&D expenditure	,739	,165		**,602**
EPO patent applications	**,621**	,340	,581	-,179
Population with tertiary education (%25-34 years age class)		**,906**	,121	,214
% Gross Value Added by manufacturing firms		**,858**	,161	-,325
% Gross Value Added by High and Medium-high technology manufacturing firms	,358	**,812**	-,105	
GDP per capita	,121	**,666**	,445	,424
Employment (%) of tertiary educated people			**,884**	,100
Nº Technology Centres	,293	,390	**,588**	-,350

Main rotated components: Rotation method, Varimax Kaiser Normalization. Bold figures indicate the factors under which the variables are grouped. We would expect this to improve factor analysis interpretation.

Source: Authors' elaboration, in Zabala-Iturriagagoitia et al. (2007b).

Table 5.3.- shows that the original IAIF index accounts for 85.5% of the total variance in the system, across four factors. Interpretation of these factors in the original IAIF index might seem self-evident. However, the four categories obtained when the analysis was replicated do not make any sense. The first factor includes almost 75% (15 out of 22) of the variables in the analysis and therefore explains almost all the variance in the system (54.39%). The ranking is led by Catalonia and the Community of Madrid. The

next regions in the ranking are the Basque Country, Andalusia and the Valencian Community. The remaining regions are relatively similarly positioned.

A comparison of the results obtained with the IAIF and IAIF' indices can be found in Appendix II: Comparison between the IAIF and IAIF' indices. This shows that both sets of indices differ in absolute terms. This is due to the fact that the variables in the original IAIF index (31 in total) do not match completely with those in the IAIF' (22). However, in spite of these slight differences, the rankings of the regions are generally similar with the exception of Castile and Leon, Castile la Mancha, Asturias, Balearic Islands and Navarre.

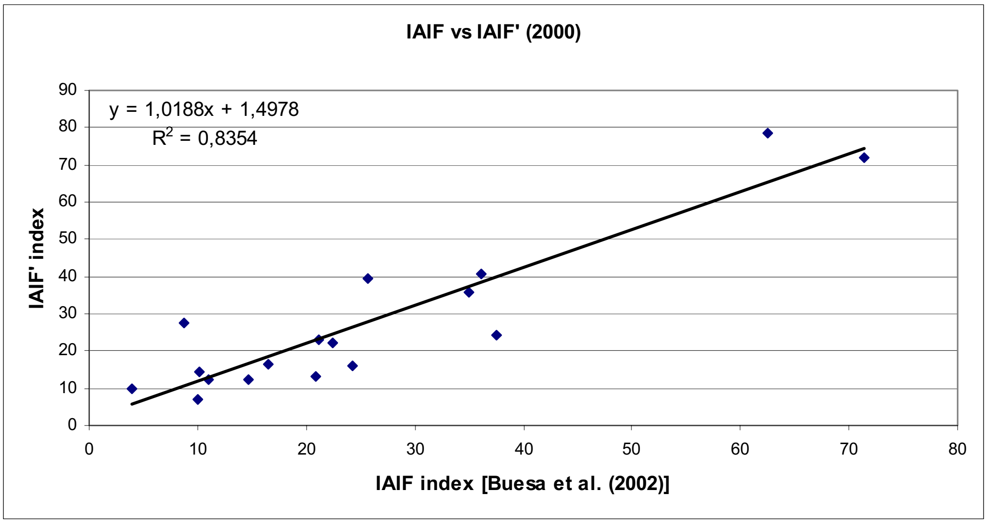
Although it might seem that the IAIF methodology depends to a great extent on the number of variables included, it is relatively robust as shown by the fact that the rankings obtained quite precisely reflect the characteristics of the Spanish regions related to innovation (Olazarán and Gómez Uranga, 2001).[34]

In order to test the robustness of this methodology, a correlation analysis was carried out between the results obtained from the two indices (IAIF vs IAIF'). As can be seen from Figure 5.1.-, the correlation for the year 2000 is not only positive, but also shows significant increase to 84%.[35] Thus, it can be concluded that the methodology based on the IAIF Regional Innovation index is robust.

[34] Based on Riba Vilanova and Leydesdorff's (2001) results, Catalonia and other Spanish regions, cannot be considered to be RIS because of their limited system interactivity and the fact that the learning processes related to innovation in policy making are in the very early stages. We acknowledge that from a conceptual perspective the Spanish regions might not be considered as examples of RIS. However, the RIS approach allows us to compare the pros and cons of different quantitative methodologies for determining regional innovative capacity.

[35] Due to the number of years considered in the analysis we show the results only for the year 2000. However, the Spearman rank correlation indices were positive for all the years with values above 80%, in all cases.

Figure 5.1.- Correlation between the IAIF and IAIF' indices for 2000



Source: Author's elaboration, in Zabala-Iturriagagoitia et al. (2007b).

We followed the same procedure for the EIS methodology. In this case, and to increase the similarities with the RNSII index, we selected the following variables from the 22 primary measures for the Spanish regions in the 1996-2000 period: Population with tertiary education (% of 25-34 age class), Employment in medium-high and high-tech manufacturing (% of total workforce), Employment in high-tech services (% of total workforce), Public R&D expenditures (% of GDP), Business expenditure on R&D (% of GDP), Spanish and EPO patent applications (per million population), and GDP per capita. As before, to test the robustness of the EIS methodology, we conducted a principal components analysis on this set of variable (Table 5.5.-).

Table 5.5.- Rotated factors matrix for the EIS

Total explained variance

Components	Autovalues			Sum of the squared saturations		
	Total	% of the variance	% accumulated	Total	% of the variance	% accumulated
1	4,989	62,363	62,363	2,510	31,378	31,378
2	1,643	20,543	82,906	2,070	25,877	57,255
3	,488	6,100	89,006	1,697	21,215	78,470
4	,355	4,435	93,441	1,198	14,971	93,441

	Components			
	1	2	3	4
Tertiary education	,341	**,863**	,157	,283
Employment in high-tech manufacturing	,531	**,804**		
Employment in high-tech services	,160	,125	**,728**	,643
Public R&D			**,988**	
Business R&D	**,564**	,484	,377	,376
Spanish Patent applicat	**,835**	,414	,131	,148
European Patent applicat	**,868**	,327		,250
GDP per capita	,563	,390		**,688**

Main rotated components: Rotation method, Varimax Kaiser Normalization.

Source: Authors' elaboration, in Zabala-Iturriagagoitia et al. (2007b).

It is possible to determine 93.4% of the total variance based on four factors. However, their explanation is not as straightforward as the EIS model would suggest, since variables such as Employment in high-tech services and Business R&D expenditure are included in several components and can be considered from various viewpoints.

Applying the EIS methodology to the eight indicators listed above, yields an analogous composite indicator (RNSII') from the original RNSII index. Most Spanish regions show a constant trend over time, with the Community of Madrid ranked 1st since 2002 and 2003, followed by the Basque Country, Navarre and Catalonia (Table 5.6.-) with fairly similar scores. These regions are followed by Aragon, which since 1999 has increased considerably, and the Valencian Community, which shows a constant trend over time, with Castile and Leon, Murcia and some other regions ranked much lower and displaying lower growth.

Table 5.6.- Comparison between the RNSII and RNSII' indices

	RNSII'	RNSII'	RNSII'	RNSII'	RNSII'	RNSII'	**RNSII**	**RNSII**
	1996	1997	1998	1999	2000	2001	**2002**	**2003**
Andalusia	54,43	55,76	56,47	54,23	57,81	56,02	**66,87**	**62,94**
Aragon	100,48	107,94	122,94	127,15	100,85	118,42	**87,21**	**96,47**
Asturias	60,88	58,26	60,91	62,14	70,96	70,72	**70,12**	**64,46**
Balearic Islands	42,53	54,89	45,25	48,36	53,77	54,12	**63,41**	**55,64**
Canary Islands	51,86	44,71	47,71	44,71	48,02	48,27	**65,38**	**64,80**
Cantabria	66,66	73,26	76,65	77,87	66,91	69,11	**79,88**	**64,08**
Castile and Leon	86,48	78,62	75,28	73,30	74,02	74,29	**82,69**	**79,16**
Castile la Mancha	44,81	53,58	48,06	43,07	53,46	46,67	**58,45**	**49,78**
Catalonia	153,30	137,55	149,22	134,91	142,33	136,31	**127,37**	**144,06**
Valencian C.	75,63	83,19	90,33	78,23	90,35	77,16	**85,46**	**91,58**
Extremadura	35,41	37,81	40,42	38,91	40,74	45,20	**55,22**	**55,14**
Galicia	62,56	60,41	63,15	61,21	60,06	64,24	**73,47**	**69,75**
C. of Madrid	144,57	157,79	142,30	137,08	156,46	153,87	**182,04**	**165,80**
Murcia	47,87	57,88	55,17	54,41	65,24	59,45	**62,05**	**74,72**
Navarre	150,32	165,68	160,77	171,00	159,61	159,20	**123,63**	**126,75**
Basque Country	146,07	175,11	154,57	144,69	140,56	155,64	**115,84**	**123,52**
Rioja (La)	73,56	71,19	79,42	73,63	87,89	63,71	**71,17**	**71,19**

Source: Author's elaboration, in Zabala-Iturriagagoitia et al. (2007b).

As can be seen from Table 5.6, there is a difference in absolute terms for all the regions except Asturias and Murcia, between 2001 (RNSII') and 2002 (RNSII). The RNSII indices for 2002 and 2003 are obtained directly from the EIS, whilst the RNSII' indices are obtained by applying the EIS methodology to a similar data set. However, the rankings for 2001 to 2002 are virtually the same in relative terms.

If the rankings of the Spanish regions obtained using the two methodologies (IAIF vs EIS) for the 1996-2000 period are compared, some significant differences appear (Table 5.7.-).

Table 5.7.- Innovative Capacity Ranking of Spanish Regions

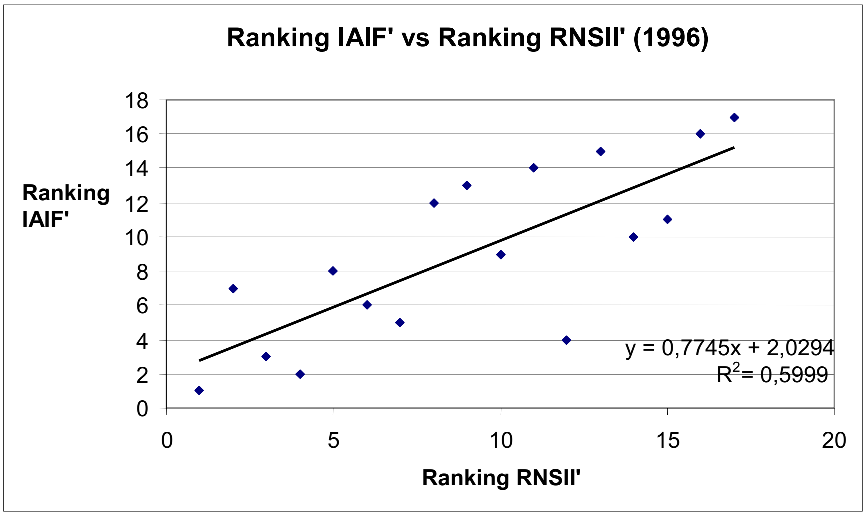
	1996		1997		1998		1999		2000	
	RNSII'	IAIF'	RNSII'	IAIF'	RNSII'	IAIF'	RNSII'	IAIF'	RNSII'	IAIF'
Andalusia	12	4	13	4	12	4	13	4	13	4
Aragon	5	8	5	8	5	8	5	8	5	9
Asturias	11	14	11	15	11	15	10	12	9	13
Balearic Islands	16	16	14	16	16	16	14	16	14	16
Canary Islands	13	15	16	14	15	14	15	15	16	14
Cantabria	9	13	8	13	8	12	7	14	10	15
Castile and Leon	6	6	7	6	9	6	9	6	8	6
Castile la Mancha	15	11	15	10	14	10	16	11	15	11
Catalonia	1	1	4	1	3	1	4	1	3	1
Valencian C.	7	5	6	5	6	5	6	5	6	5
Extremadura	17	17	17	17	17	17	17	17	17	17
Galicia	10	9	10	9	10	9	11	9	12	8
C. of Madrid	4	2	3	2	4	2	3	2	2	2
Murcia	14	10	12	11	13	11	12	10	11	10
Navarre	2	7	2	7	1	7	1	7	1	7
Basque Country	3	3	1	3	2	3	2	3	4	3
Rioja (La)	8	12	9	12	7	13	8	13	7	12

Source: Authors' elaboration, in Zabala-Iturriagagoitia et al. (2007b).

According to the data in Table 5.7.-, the Community of Madrid, Catalonia and the Basque Country have been the most innovative regions in Spain over time, and judged by both methodologies. Despite the wider fluctuations in their rankings, Navarre, Aragon, Castile and Leon and the Valencian Community have maintained their relative positions for 1996-2000. Among the remaining regions, it should be noted that the relative positions of Extremadura, Andalusia, La Rioja, Cantabria and Murcia vary depending on the methodology.

Figure 5.2.-, which is based on the preceding empirical work, shows that the two methodologies applied in the study to determine Regional Innovative Capacity are not closely related. Although their objectives are the same, they use different quantitative approaches which encompass some significant methodological differences. Each methodology on its own appears robust, but if the results (ranks) obtained are compared for the two approaches, although there is some correlation, this is not significant.

Figure 5.2.- Correlation between the IAIF' and RNSII' indices for 1996[36]



Source: Authors' elaboration, in Zabala-Iturriagagoitia et al. (2007b).

To sum up, we can say that based on our empirical evidence these two methodologies for measuring regional innovative capacity are not sufficiently robust, since the results differ depending on both the methodology and the indicators applied.

We believe, therefore, that in light of the wide social, cultural and economic disparities among regions, an index designed only to measure innovation would provide a ranking of innovation capacity, and would be feasible based on data from "macro" statistics such as those available from EUROSTAT. Nevertheless, evaluating a RIS using a unique index would incur substantial inaccuracies from an economic perspective. In this sense, there is an urgent need for compatibility among the different approaches and methods used to estimate RIS, and for the inclusion in the evaluation of more qualitative aspects (Díez, 2001, 2002).

5.2.2. Benchmarking Innovation in the Valencian Community

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[36] Due to the number of years considered in the analysis we show only the results for 1996. However, the Spearman rank correlation indices were positive for all the years with values above 50% in all cases.

This second framework of analysis aims at benchmarking the Valencian Innovation System making use of the indicators provided by EIS, EUROSTAT and national sources (INE). The main rationale for carrying out this research is that according to the results obtained in previous research, the focus on a particular territory may provide more valuable information in terms of RIS than if several regions are compared, using different methodologies.

Fernández de Lucio et al. (2001, 2007) identify the strengths and weaknesses of the Valencian Innovation System according to the main features of its structure, absorptive capacity and articulation. In our case the analysis will compare the situation of the Valencian Innovation System with Spanish, Mediterranean and European regions. For the Spanish regions, their evolution from 1992 to 2004 is analysed, while for the Mediterranean and European regions the analysis is based on the period 1994-2003.

The Valencian Community is one of Spain's peripheral regions, located on the Mediterranean coast, covering an area of about 23,000km^2, 4.6% of Spain's total area. Its population is around 4.5 million inhabitants, which is 10.5% of the total Spanish population. In 2004 regional GDP per capita was approximately €17,000, similar to the Spanish average. Its productive structure is mainly constituted by family-owned small firms or small and medium sized enterprises (SMEs) in traditional manufacturing sectors (i.e. shoes, ceramics, furniture, textiles, tiles, toys, etc.), none of which are knowledge intensive sectors. Hence, the innovation intensity of the region is low. For 2004, the activity rate relates to about 59% of the population, and the unemployment rate 11% of the active population. In 2004 R&D expenditure in the region was 0.95% of regional GDP, of which only 35% was attributable to the business sector (INE, 2004), which indicates the small role of firms in relation to public government institutions.

The Valencian Community within Spain

We first describe the position of the Valencian Innovation System relative to the Spanish regions for the 1992-2004 period, based on nine indicators (see above). To summarize the information obtained in the period under study, a comparison between the values for the Valencian Community, the Spanish average, and the leader region(s) is performed for each indicator.

In terms of ***population with tertiary education*** the results show that the Basque Country has the highest percentage of highly-educated people, with values above 50% in 2001. Navarre, Madrid and Aragon follow with very similar values (about 48%).

Extremadura, Balearic Islands and Canary Islands are the lowest ranked regions, with 25% of their populations with tertiary education. In terms of the degree of convergence with the Spanish average the values are around 80%, while with respect to the leader region, values are around 75%.

For **participation in life-long learning** Navarre and the Valencian Community are the best performers with very similar values (around 6.5%), which show substantial differences with other regions. La Rioja, Catalonia and Cantabria have values close to 2%.

For **activity rate of highly educated people** Catalonia is ranked highest (86.8% in 2004), with Aragon, Balearic Islands, Galicia and the Basque Country near this level. The Valencian Community is in an intermediate position (82% in 2004) (the national average was 99.75% in 2004 and the leader region was 94.5%); Asturias is the lowest ranked (76% employment rate). The Valencian Community has experienced negative growth over the 12 years from 1992 to 2003, but with some increase in 2004; its position in the ranking has gone down since 1992 when it was 3rd, to 11th in 2001 and 6th in 2004.

With respect to **employment in high and medium-high technology manufacturing sectors**, Navarre, with 12% of employment in 2001 and 10.5% in 2004, ranks highest, followed by Aragon, Catalonia and the Basque Country with values of 9-10%. However, in absolute values, Catalonia contributes about 30% of total employment in Spain in these sectors. In the Valencian Community, which ranks 10th, there has been negative average growth, from 4.1% in 1995 to 3.5% in 2004.

For **employment in high technology services** the Valencian Community (1.7% in 2004) is lagging, and is close to poorly performing regions such as Balearic Islands, Castile la Mancha, Castile and Leon and La Rioja. The Community of Madrid, with 5.8% employment in high technology services in 2004, is ranked highest with 40% of total employment in high technology services in Spain. Although the period studied does not allow conclusions to be drawn about improvement or deterioration in performance, it can be seen that the employment rate in Valencia is only around 27% of the leader region and 67% of the national average.

Table 5.8.- Benchmarking the Valencian Community in Spain (1992-2004)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Population with tertiary education													
VC/Spain (%)	80.6	79.0	81.0	83.9	81.0	84.6	88.1	87.2	89.9	82.9	-	-	-
VC/Leader Region (%)	51.7	48.7	73.3	73.6	75.6	72.1	69.9	71.0	81.2	77.4	-	-	-
Position of the VC	11/17	12/17	8/17	8/17	7/17	7/17	8/17	8/17	6/17	6/17	-	-	-
Participation in life-long learning													
VC/Spain (%)	-	-	-	-	-	-	-	157.24	155.9	152.99	143.37	140.30	140.95
VC/Leader Region (%)	-	-	-	-	-	-	-	85.64	100.0	100.0	98.05	100.0	100.0
Position of the VC	-	-	-	-	-	-	-	2/17	1/17	1/17	2/17	1/17	1/17
Activity rate of the population with tertiary education													
VC/Spain (%)	105.43	101.03	99.87	100.51	96.82	98.86	98.75	99.37	99.63	98.16	98.11	99.25	99.75
VC/Leader Region (%)	99.15	96.32	96.31	97.65	93.27	94.33	93.14	94.75	94.81	93.46	93.30	94.16	94.49
Position of the VC	3/17	3/17	8/17	7/17	15/17	11/17	10/17	9/17	10/17	11/17	9/17	9/17	6/17
Employment in high and medium–high technology manufacturing sectors													
VC/Spain (%)	-	-	-	75.71	75.35	74.97	73.01	72.45	70.94	63.33	65.52	69.20	72.44
VC/Leader Region (%)	-	-	-	31.56	33.74	32.86	32.05	29.85	29.33	29.35	31.44	31.80	33.36
Position of the VC	-	-	-	9/17	9/17	10/17	10/17	10/17	10/17	10/17	10/17	10/17	10/17
Employment in high technology services													
VC/Spain (%)	-	-	-	-	-	-	-	-	70.60	69.67	63.07	61.23	67.49
VC/Leader Region (%)	-	-	-	-	-	-	-	-	27.08	24.70	26.07	27.10	29.57
Position of the VC	-	-	-	-	-	-	-	-	6/17	6/17	10/17	14/17	11/17
Business R&D expenditures													
VC/Spain (%)	33.25	36.34	36.45	38.01	38.01	38.44	26.99	44.38	60.90	38.28	46.05	50.72	53.56

VC/Leader Region (%)	12.31	14.10	14.36	16.76	16.61	17.05	12.71	22.81	33.55	18.41	23.88	27.84	26.55
Position of the VC	10/17	9/17	10/17	11/17	10/17	11/17	14/17	11/17	10/17	11/17	9/17	11/17	8/17
Public R&D expenditures													
VC/Spain (%)	88.19	80.36	89.52	84.27	95.50	97.05	87.47	95.63	96.45	111.89	116.59	113.13	121.23
VC/Leader Region (%)	39.79	38.99	42.16	40.81	48.67	54.42	49.77	53.27	55.04	65.24	69.05	73.53	80.75
Position of the VC	6/17	10/17	4/17	9/17	6/17	4/17	6/17	3/17	4/17	4/17	2/17	2/17	3/17
Innovation expenditures													
VC/Spain (%)	-	-	66.22	-	70.78	-	71.61		81.64	-	-	78.24	66.39
VC/Leader Region (%)	-	-	23.24	-	32.30	-	35.49		53.10	-	-	49.50	40.53
Position of the VC	-	-	11/17	-	13/17	-	12/17		10/17	-	-	8/17	9/17
Patent applications to the EPO													
VC/Spain (%)	81.33	104.73	128.37	105.40	103.25	101.26	105.77	115.74	113.43	104.78	113.23	98.84	-
VC/Leader Region (%)	28.69	43.23	50.95	29.95	45.46	42.68	47.20	48.16	46.42	43.12	44.95	40.37	-
Position of the VC	8/17	5/17	4/17	5/17	6/17	6/17	6/17	5/17	6/17	5/17	6/17	7/17	-

Source: Author’s elaboration from INE and EUROSTAT data, in Zabala-Iturriagagoitia et al. (2008a).

In order to alleviate the weaknesses in the high-tech manufacturing and services sectors, the Valencian economy should focus on emerging sectors that could generate new technologically advanced and knowledge intensive jobs. In addition to the attempts being made by most Valencian universities in the form of entrepreneurial programmes and science parks,[37] other efforts designed to promote entrepreneurial activities will be needed. In this respect, the Valencian Business Innovation Centres might play a leading role.

Next we analyse the **business sector expenditure on R&D (BERD)**. The leader regions are the Community of Madrid and the Basque Country: both display increasing values above 1%. Catalonia and Navarre, with very similar values are ranked next. Despite the efforts being made by Valencian firms, (0.15% in 1992, 0.33% in 2004), they are growing only slowly, and it would be unrealistic to talk about any degree of convergence despite some positive trends. This low growth can be explained by the sectoral distribution of Valencian firms. As already stated, most are SMEs mainly oriented to the traditional sectors (Fernández de Lucio et al., 2001; Molina-Morales et al., 2002) where the only advantage in highly competitive markets is based on low costs, and there is little involvement in R&D activities, which are mainly developed by universities and public research centres.

Thus, regional authorities must be realistic in acknowledging that any increase in Valencian BERD is starting from a low level, and there is an urgent need to modify the regional business structure to include more technologically advanced sectors. On the other hand, in terms of **public (government) expenditure on R&D (GERD)**, although the Community of Madrid is the leader (0.76% in 2004) – mainly due to the 'capital effect' - the relative ranking of the Valencian Community (0.4% in 1992 and 0.62% in 2004) has improved significantly (6th in 1992 to 3rd in 2004). Thus, the Valencian region, which

[37] The ongoing entrepreneurial programmes in Valencian universities are (dates in brackets refer to foundation year): IDEAS (Polytechnic University of Valencia, 1992), University Graduate Entrepreneurs (Miguel Hernández de Elche University, 2000), Jovellanos Forum for the Business Promotion (Jaume I de Castellón University, 1999), Office for Employment Initiatives (University of Alicante, 1999), University-Industry Foundation (University of Valencia, 2000), Entrepreneurship Programme (San Vicente Mártir, Catholic University of Valencia, 2005) (Dalmau et al., 2003; Morell and Perelló, 2004). Note the role played by the Research Results Transfer Offices (OTRIs) of the universities in the region, as agents oriented to the promotion of academic spin-offs. In terms of Science Parks, initiatives so far include: Polytechnic City of Innovation (2002), Scientific and Managerial Park of the Miguel Hernández University (2004), Mediterranean Science Park of the University of Alicante (2006), Science Park of the University of Valencia (2007).

registered 40% of the leader region in 1992 (88% was the national average), in 2004 showed a convergence rate of over 80% (121% for Spain).

These last two indicators show that in those regions with higher rates of public R&D expenditure at the beginning of the period, such as the Community of Madrid, Navarre and Aragon, the focus has changed to BERD. This raises questions about to what extent it is necessary to increase public R&D spending in a region, and the real effectiveness (efficiency) of public R&D in its own territory (Cohen and Levinthal, 1990; Todt et al., 2007). Is it worth increasing public investment in R&D and orienting them towards high technology sectors if the existing business sector (industrial structure) cannot absorb the advances made? Is there an optimal ratio between GERD and BERD?

Innovation expenditures are illustrative of the efforts made to introduce successful products in the market. The period analysed is 1994-2000, but it should be kept in mind that the data are not homogeneous. Between 1994 and 1996 there were no changes in the number of sectors included in Spain's innovation survey. However, from 1998 onwards, new sectors, such as Telecommunication Services, began to be incorporated (and are included in 2000 figures). Thus, these results should be interpreted with a degree of caution, as growth reflects not only increasing commitment in the Spanish economy to innovative activities, but also the inclusion of new sectors. Aragon is ranked far above all the regions, and the national average. The Valencian Community, in spite of the efforts being made (average growth rate over the last ten years is 4%), cannot be said to be converging with the leader region or the national average. As already stated, in 2000 most regions show a noticeable increase in their innovation expenses. Therefore, it would be interesting to look at the evolution of this indicator in order to clarify whether the observed growth continues at the same rate, or is a consequence of the increased number of sectors.

Finally, according to the results for **patent applications to the European Patent Office** (EPO) it can be concluded that the Spanish tradition in patenting is very poor, with many regions (Canary Islands, Cantabria, Extremadura, Castile la Mancha) showing nil growth. Trends in the Valencian Community with respect to the Spanish average and the leader regions (Catalonia and Navarre) are quite uniform (about 100% with Spain and 45% with the leader regions respectively). However, there is a large gap between the leader regions and the rest. The Valencian Community ranks 7th after Navarre, Basque Country, Community of Madrid, Aragon, etc. In La Rioja, from 2000 onwards there has been a noticeable increase with more than 23 patents (per million inhabitants).

It can be seen that Valencia's competitiveness should be improved through the promotion of employment in high technology manufacturing industries and services. This will require universities to play a major role, not only in developing R&D and teaching activities in technologically advanced sectors, but in integrating the knowledge developed in the region and reducing the brain drain effect from highly trained graduates from Valencian universities migrating to other regions, such as Catalonia and the Community of Madrid. Increased employment in these high technology sectors, which would contribute to a more knowledge dependent economic structure, would also entail higher levels of BERD and innovation capacity in the region. However, we would not like to treat innovation just as synonymous with high-technology activities. In this sense, the RIS concept does also emphasize the path-dependent nature of economic and technological development. According to this, it is hard for a territory to shift to a new trajectory in the short term, and of course, there is a role for innovation policy towards the existing medium or low technology sectors, which are likely to be key for employment and wealth creation in the region. This kind of innovation policy might hence be quite different from the high-tech-oriented one detailed before. From this point of view, Valencian universities, for instance, may not have a significant contribution to well-performing traditional sectors in the region, so they could arguably better concentrate on their role in the NIS. In fact, this is suggested by the outflow of graduates from the region. This is in line with the contributions detailed in Chapter 2 concerning the openness degree of IS and the interdependencies and trade-offs between different RIS. Accordingly, the Valencian Community may not constitute a comprehensive RIS but may play a considerable role in the development of the NIS in Spain.

Next, we examine the relative position of the Valencian region in the European and Mediterranean areas.[38] The analysis focuses on comparing the relative position of the Valencian Community and its degree of convergence with the leader region(s) based on the 10 indicators applied.

[38] The regions that comprise the Mediterranean area are: 5 from Spain (Catalonia, Valencian Community, Murcia, Andalucía and Balearic Islands); 4 from France (Provence-Alpes-Côte d'Azur, Languedoc-Rousillon, Midi-Pyrenees and Corsica); 15 from Italy (Piemonte, Valle D'aosta, Liguria, Lombardia, Trentino-Alto Adige, Veneto, Emilia Romagna, Toscana, Umbria, Lazio, Campania, Basilicata, Calabria, Sicilia and Sardegna); and 13 from Greece (Anatoliki Macedonia-Thraki, Kentriki Macedonia, Dytiki Macedonia, Thessalia, Ipeiros, Ionia Nisia, Dytiki Ellada, Sterea Ellada, Peloponnisos, Attiki, Voreio Aigaio, Notio Aigaio, and Kriti).

The Valencian Community within the Mediterranean and European regions

For **population with tertiary education**, the Valencian Community ranked 29th in 1999 and 24th in 2004 among European regions. These values are in line with the EU average (close to 90%) despite the fact that compared to the leader region for this indicator (Île de France in France) the Valencian Community represented just 25% in 2004. Thus, the region is in an advanced position within Europe, with 83% of European regions ranked lower, and only 16% ranked higher. In the Mediterranean area the Valencian Community is ranked 5th, with 53% of the value of the leader region (Catalonia in Spain). Therefore, although the percentage of the population with tertiary education is quite high when compared to the Mediterranean area, within a European perspective this is not the case.

For **lifelong learning** the Valencian Community is 27th among European regions for the years analysed. The region represents 15% of the leader regions (South East and London in the UK). Its relative position is similar to that for the previous indicator, with 15% of the regions ranked higher and 85% lower. This trend is also reflected in the Mediterranean benchmark, where the values for the Valencian region correspond to about 70% of the level of Lombardi (Italy), the leader region for this indicator. Thus, the Valencian Community ranks third among the regions that constitute the Mediterranean arch (2nd in 1999 with Andalusia the leader), with 92% of regions ranked lower. These results confirm the predictions made in the national context.

Table 5.9.- Benchmarking the Valencian Community in the Mediterranean arch and Europe (1994-2003)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Population with tertiary education										
VC/Mediterranean Leader region (%)	-	-	-	-	-	53.78	54.12	52.95	51.17	52.89
Position of the VC in the Mediterranean arch	-	-	-	-	-	5/37	5/37	6/37	5/37	5/37
VC/European Leader Region (%)	-	-	-	-	-	20.19	21.41	22.25	22.23	25.12
Position of the VC in Europe	-	-	-	-	-	29/174	29/174	28/174	27/174	24/174
Participation in life-long learning										
VC/Mediterranean Leader region (%)	-	-	-	-	-	86.62	75.67	67.94	67.11	72.47
Position of the VC in the Mediterranean arch	-	-	-	-	-	2/37	3/37	3/37	3/37	3/37
VC/European Leader Region (%)	-	-	-	-	-	15.21	15.56	16.06	15.46	16.65
Position of the VC in Europe	-	-	-	-	-	27/174	28/174	25/174	26/174	28/174
Employment in high and medium high technology manufacturing sector										
VC/Mediterranean Leader region (%)	25.42	27.56	27.95	27.17	30.27	27.95	26.5	25.39	25.59	27.94
Position of the VC in the Mediterranean arch	14/37	14/37	13/37	15/37	13/37	14/37	13/37	15/37	17/37	14/37
VC/European Leader Region (%)	22.63	21	20.37	17.33	20.65	19.17	17.6	16.71	15.86	17.14
Position of the VC in Europe	67/174	116/174	119/174	126/174	137/174	121/174	128/174	131/174	133/174	131/174
Employment in low and medium low technology manufacturing sector										
VC/Mediterranean Leader region (%)	100	100	89.08	84.55	83.55	78.23	81.05	85.89	90.14	80.51
Position of the VC in the Mediterranean arch	1/37	1/37	3/37	4/37	4/37	4/37	4/37	4/37	3/37	4/37
VC/European Leader Region (%)	84.12	77.5	74.36	79.78	73.69	69.29	70.35	73.84	75.12	69.42
Position of the VC in Europe	2/174	6/174	8/174	9/174	9/174	9/174	11/174	10/174	9/174	10/174

Employment in knowledge-intensive high-technology services										
VC/Mediterranean Leader region (%)	29.67	30.51	27.88	30.18	20.85	33.45	28.39	34.76	28.57	24.69
Position of the VC in the Mediterranean arch	20/37	20/37	19/37	19/37	25/37	17/37	19/37	20/37	20/37	21/37
VC/European Leader Region (%)	22.8	22.98	19.54	21.58	15.49	26.26	18.91	23.21	18.47	17.35
Position of the VC in Europe	76/174	120/174	118/174	115/174	133/174	115/174	129/174	120/174	132/174	144/174
Business enterprise sector R&D expenditure										
VC/Mediterranean Leader region (%)	-	8.93	8.52	9.09	14.37	11.9	16.85	9.78	11.36	12.08
Position of the VC in the Mediterranean arch	-	15/37	15/37	15/37	11/37	17/37	12/37	15/37	15/37	16/37
VC/European Leader Region (%)	-	3.85	4.67	3.68	7.59	4.52	9.03	3.49	8.39	4.29
Position of the VC in Europe	-	92/174	70/174	110/174	73/174	119/174	69/174	116/174	74/174	121/174
Government sector R&D expenditure										
VC/Mediterranean Leader region (%)	-	7.21	6.72	5.69	3.31	4.08	6.25	7.86	11.49	10.41
Position of the VC in the Mediterranean arch	-	24/37	17/37	23/37	21/37	25/37	19/37	12/37	7/37	13/37
VC/European Leader Region (%)	-	7.21	3.46	3.28	2.49	3.21	2.59	5.15	6.45	6.66
Position of the VC in Europe	-	79/174	72/174	85/174	95/174	94/174	99/174	83/174	69/174	78/174
Higher education sector R&D expenditure										
VC/Mediterranean Leader region (%)	-	67.5	64.58	52.46	46.15	41.25	52.31	56.16	66.66	64.71
Position of the VC in the Mediterranean arch	-	13/37	9/37	17/37	13/37	18/37	11/37	5/37	3/37	10/37
VC/European Leader Region (%)	-	28.12	33.33	26.89	23.44	23.57	28.33	32.8	37.5	26.66
Position of the VC in Europe	-	55/174	32/174	59/174	64/174	66/174	65/174	46/174	51/174	55/174
Patent applications to the EPO										

VC/Mediterranean Leader region (%)	-	-	-	-	-	17.47	15.86	15.79	17.61	13.32
Position of the VC in the Mediterranean arch	-	-	-	-	-	15/37	15/37	15/37	15/37	15/37
VC/European Leader Region (%)	-	-	-	-	-	4.39	3.97	2.95	4.42	4.04
Position of the VC in Europe	-	-	-	-	-	128/174	129/174	129/174	128/174	130/174
High-tech patent applications to the EPO										
VC/Mediterranean Leader region (%)	-	-	-	-	-	4.29	7.36	7.07	6.7	8.99
Position of the VC in the Mediterranean arch	-	-	-	-	-	18/37	17/37	14/37	19/37	13/37
VC/European Leader Region (%)	-	-	-	-	-	0.81	1.26	0.77	0.98	2.67
Position of the VC in Europe	-	-	-	-	-	126/174	120/174	118/174	125/174	97/174

Source: Author’s elaboration from EUROSTAT, in Zabala-Iturriagagoitia et al. (2008a).

Employment in high and medium-high technology manufacturing sectors in the Valencian Community represents just 4% of the whole employed population, ranking the region very low in Europe, with 17% of the values observed for the leader regions (Franche-Comté in France and Stuttgart in Germany). 75% of the regions in Europe perform better than the Valencian Community and only 25% are ranked lower. In the Mediterranean area the Valencian Community is well below the leader region (Piemonte in Italy), which has 14% of its employed population involved in these sectors. The Valencian region is in 15th position among Mediterranean regions, with 40% of them above this level.

In contrast, the Valencian economy ranks very high for **employment in low and medium low technology manufacturing** sectors, which confirms the conclusions drawn for the Spanish benchmark. About 20% of the employed population is involved in these sectors. Within European regions the Valencian Community was 2nd in 1999 and 10th in 2003, representing about 84% of the leader region in 1999 - La Rioja (Spain) – and 69% of Norte (Portugal), the leader region in 2003. Consequently, 95% of European regions show lower levels of employment in these low technology oriented sectors. The trend is similar for the Mediterranean arch, where Veneto (Italy) is the leader region with 25% of its employed population participating in low value added activities.

The orientation towards low technology sectors in the Valencian region is reinforced by the results for **employment in knowledge-intensive high-technology services**. Stockholm (Sweden) is the most competitive region in Europe, with more than 8% of the employed population, and Lazio (Italy) is the leader region in the Mediterranean arch, with 5% of the employed population. In both cases the Valencian Community ranks very low, with just 17% of European regions ranked lower in 2003.

The above indicators for employment in high and low technology sectors highlight the main weaknesses in the Valencian IS, and consequently those areas where the public administration should make the strongest efforts. It underlines the need to promote the creation of new technology based industries and employment in high technology sectors.

BERD in the Valencian Community demonstrates the already observed deficiencies in the structure of the private sector. In 2003 this indicator was 0.29%, which is about 4% of the value observed in the European leader region (Braunschweig in Germany). In the Mediterranean area, Midi-Pyrénées (France) is the leader region with a value of 2%. This demonstrates the low levels of business investment in R&D activities in the Mediterranean area in relation to Europe.

For GERD, the Valencian Community (0.1% in 2003) is in 78th position among European regions, with 6% of the value of the leader region (Flevoland in the Netherlands – 1.5% in 2003). The trend is similar in the Mediterranean area, where it was ranked 13th in 2003, with 10% of the value of the leader region (Lazio in Italy). The latter is supplemented by higher education R&D (HERD) expenditure; thus, the Valencian Community is reasonably well ranked in Europe and in the Mediterranean area. In 2004 the region was 55th in Europe (10th in the Mediterranean), representing 26% (64%) of the leader region Övre Norrland in Sweden (Dytiki Ellada in Greece).

In terms of **patent applications to the EPO**, in 2003 the Valencian Community was ranked 130th in Europe and 15th in the Mediterranean arch. These figures were just 4% of the leader region in Europe (Stuttgart in Germany) and 13% of the Mediterranean leader region (Emilia-Romagna in Italy). Thus, just 25% of European regions (60% Mediterranean regions) perform worse than the Valencian Community. This indicator shows the severe weakness in the Mediterranean arch in relation to patent applications, compared to Europe. These values are in line with those observed for high-tech patent applications to the EPO, where Noord-Brabant (Netherlands) and Provence-Alpes-Côte d'Azur –PACA- (France) are the respective leaders. The Valencian Community represents only 2% of the value observed in 2004 for Noord-Brabant and 9% for PACA. There was a noticeable increase in the performance of the Valencian region from 2002 to 2003, from 125th position in Europe in 2002 to 97th in 2003 (19th in the Mediterranean in 2002 and 13th in 2003). These patent related measures should be interpreted with caution based on these wide year to year differences.[39]

5.2.3. RIS: How to Assess Performance (efficiency analysis)

In this third section, we measure RIS performance by comparing the multi-input/multi-output relationships (referred to as *technical efficiency - TE*) involved. The evaluation of RIS performance in Europe in terms of (technical) efficiency is the main goal

[39] The indicators for information and communication technology (ICT) and biotechnology patent applications to the EPO (per million labour force) were initially included in the benchmark analysis, but due to the low degree of homogeneity observed, were not finally integrated.

and complements the results of the study using EIS and other methodologies to benchmark regional innovative capacity.

The EIS and R&D and innovation statistics indicate that the amount of resources available within an IS plays a crucial role. That is, the more resources that are invested, the more competitive the system. However, we believe that although the amounts of these resources matters, how efficiently they are exploited is more important. The efficiency of resource use is indicated by the degree to which these inputs generate soaring returns, or output results that do not reflect the level of investment. Equally, from our efficiency analysis we should be able to determine whether a particular region – or Decision Making Unit (DMU) as it is termed in the technical Data Envelopment Analysis literature (Färe et al., 1985; Charnes et al., 1991; Fried et al., 1993) – can expect "*to increase its outputs by simply increasing its efficiency, without absorbing further resources*" (Farrell, 1957: 253).

Any estimated efficiency score refers to the spatial performance of the related RIS and, thus, can be used to evaluate the entire system, by establishing a fictitious optimum or benchmark, by linear combination of the most efficient regions (DMUs) given the ratio of their outputs to their inputs and relating observations to that level. From this point of view, RIS are depicted as a technically more or less efficient transformers of inputs into outputs. It could be argued that the very concept of efficiency operationalised here is derived from neoclassical economics, incompatible with the heterodox underpinnings of the RIS concept, with its emphasis on non-optimality. In this sense, and following the RIS literature, we claim for the consideration and introduction of efficiency criteria in policy evaluation processes. Despite it may seem that the approach employed here follows neoclassical economics, we use this DEA methodology from a RIS perspective, as already illustrated by Autio (1998), Niosi (2002), Kuhlmann (2003a, 2003b), Nasierowski and Arcelus (2003) and Susiluoto (2003) among others, considering hence efficiency estimations as another criteria used in order to better, comprehend, measure and benchmark RIS.

It should be remembered that institutional aspects play a role within this framework (Tödtling and Trippl, 2004), and may influence the performance of RIS, and explain some of variations in individual observations. Therefore, a second dimension needs to be included in the efficiency analysis.[40]

What is to be gained from comparing RIS performance? What does it mean if estimates differ? The accurate empirical evaluation and explanation of any unit's performance is a very complex task, regardless of the analytical context. Generally speaking, the notion of efficiency relates a vector of inputs to a vector of outputs. Unfortunately, in public sector analyses all three definitional elements of efficiency (inputs, outputs, and the functional relationship between the two) are affected by severe conceptual and measurement problems (Lovell, 2002). Hence, in analysing RIS, one is dealing with a multi-input, multi-output relation, in which inputs as well as outputs might be heterogeneous and sometimes not even comparable. Time, history and stochastic influence can affect the system, and output generally is lagged (Edquist, 1997). All these factors need to be considered in establishing a data base and an appropriate model for an efficiency analysis of public sector activities in general, and they are even more important with respect to RIS, since it comprises a mix of private and public activities.

There are two general approaches to measuring efficiency: (1) parametric models, such as SFA (Stochastic Frontier Analysis: see e.g. Kumbhakar and Lovell, 2000), and (2) non-parametric models, such as DEA (Data Envelopment Analysis: Cooper et al., 2000) and FDH (Free Disposal Hull: Deprins et al., 1984). Both these approaches have been developed in a straightforward way with considerable model-specific enhancements of the basic frontier concept and, depending on their individual strengths and limitations, are frequently applied to empirical analyses (Cherchye et al., 2001; Martin et al., 2004).

It has frequently been claimed that DEA has certain advantages for the analysis of public sector activities (Charnes et al., 1994; Martínez-Cabrera, 2003) and semi public activities. In the public sector, output and input measures are often unavailable, and thus outputs and inputs cannot be weighted with a priori function to calculate the efficiency ratio. DEA takes a systems approach, that takes account of the relationship between all inputs and outputs simultaneously, without requiring a weighting system that reduces these units into a single unit measure, as each input or output can be measured in its

[40] In this sense, DEA allows for the introduction in the analysis of “Non-discretionary” variables not subject to management control (Cooper et al., 2000: 63). These are understood as “*variables that cannot be varied at the discretion of individual managers but nevertheless can be taken into account in arriving at relative efficiency evaluations”* (ibid: 183). In fact, we are currently

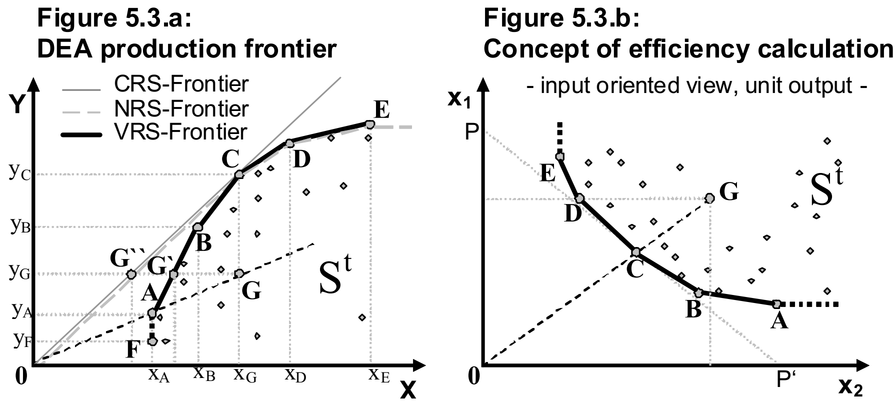
natural physical units. Also, DEA does not require parametric specification of a functional form to construct the frontier, so there is no need to impose unnecessary restrictions on the functional forms that often become a cause of distorted efficiency measures (Aramyan et al., 2006). That is, DEA does not impose any preconceived functional form on the data when determining efficient units, so the production function of efficient DMUs is estimated using piecewise linear programming on the sample data rather than making restrictive assumptions about the underlying production technology (Lim, 2006; Ramanathan, 2006). The importance of this feature is that a unit's efficiency can be assessed based on other observed performance. In turn, DEA identifies the inefficiency in a particular DMU by comparing it to similar DMUs regarded as being efficient, rather than by trying to associate a DMU's performance with statistical averages that may not be applicable to the DMU.

The principal disadvantage of DEA, however, is that it assumes the number of physical units included and other data to be free of measurement errors (Lim, 2006). DEA is thus particularly sensitive to unreliable data because the efficient units determine the efficient frontier and, thus, the efficiency values of those units behind this frontier. Thus, the number of efficient units at the frontier tends to increase with the number of inputs and output variables, which results in loss of discriminatory power of this method.

DEA, therefore, represents a new approach to learning from outliers and inducing new theories of best practice (Charnes et al., 1994), which is the reason we chose to use it for this analysis. Figure 5.3.- illustrates the general idea of the frontier concept.

studying in more detail the methodology applied here, so as to introduce these non-discretionary variables that may help us to better comprehend RIS efficiency.

Figure 5.3.- Frontier concept and efficiency calculation



Source: own illustration.

Figure 5.3.-a depicts a production frontier (isoquant) based on an XY-coordinates system where points A, …, E define the scope and shape of the frontier, S^t refers to the production possibility set in time *t,* and CRS, NRS, and VRS are frontiers with Constant, Non-increasing and Variable Returns to Scale respectively[41] (Farrell, 1957: 255-256). Points F and G lie below the frontier and illustrate inefficient input/output combinations.[42] The TE of point G can be obtained by calculating $(X_{G'})/(X_G)$. The calculation of this measure can be illustrated even better in a two-dimensional X_1X_2-frame (2 inputs applied to produce 1 output unit), as in Figure 5.3.-b. Points A, …, E again refer to (technically) efficient combinations of X_1 and X_2 needed to produce one unit of output and therefore they define the frontier. Point G corresponds to an inefficient observation since X_1 and X_2 can be reduced without any drop in output. The TE of G can be obtained by calculating $\overline{0C}/\overline{0G}$. Hence, TE has a range 0≤TE≤1, where 1 refers to the best practice, fully

[41] This might be of interest if suboptimal use of scale effects is considered to play a significant role. E.g.: VRS scale efficiency of point G is (YG→G")/ (YG→G') or (XG")/(XG').

[42] Although point F is depicted as a vertex of the frontier, the area between A and F is apparently inefficient because for a given level of XA an output of YA is possible, but only YF is achieved. In the literature, these parts of the frontier are called "slacks" or "input excess" (illustrated in Figure 5.3.-b as those parts of the frontier running parallel to the axes). Hence, the slacks should be considered even though often their importance in empirical applications is low.

efficient example.[43] Concerning point G, however, it is necessary to reduce both inputs, e.g. in the proportion 1-TE, in order to be efficient (reach the frontier).

We estimate the production set S^t and the corresponding frontier by considering:

(4)
$$S^t_{DEA} = \left\{ (x,y) \in R_+^{p+q} \;\middle|\; y \le \sum_{i=1}^{n} \gamma_i y_i \;\; ; \quad x \ge \sum_{i=1}^{n} \gamma_i x_i \quad for\ (\gamma_1,...,\gamma_n) \right\}$$
$$such\ that \sum_{i=1}^{n} \gamma_i = 1 \, ; \gamma_i \ge 0, i = 1,...,n \, ; x\ can\ produce\ y\ with\ x \in R_+^p\ and\ y \in R_+^q$$

which refers to the smallest free disposal convex set covering all the data.[44] According to the DEA methodology every convex combination of feasible production plans is also feasible (Farrell, 1957; Charnes et al., 1994). In fact, the assumption of convexity, even if widely used in economics, could be important in terms of methodological strengths and limitations (Cherchye et al., 1999). It could be argued that in this context, production technology (in this case, regional innovation) might allow increasing returns to scale (i.e. outputs increase faster than inputs). For the very highly aggregated context we are analysing here, this seems to be of minor interest[45], but for not so aggregated studies in which particular technologies are analysed (Martin et al., 2004) it could be crucial[46].

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[43] Given that prices are considered, the relative input prices (input oriented view) define the optimal input combination that has to applied in order to produce 1 unit of output (see tangent PP' with the slope of the negative price relation). Hence, points A, B, D, E are technically efficient but they are not efficient from an economics viewpoint (cost/allocative efficiency). Due to the lack of data, we have to ignore these aspects related to allocative efficiency in our analysis. Farrell considered that the allocative efficiency "*measures a firm's success in choosing an optimal set of inputs*", while TE measures the firm's "*success in producing maximum output from a given set of inputs*" (1957: 259).

[44] Accordingly, every convex combination of a feasible production plan is also feasible.

[45] The fact that any unit's performance can be obtained as the convex combination of other DMUs – providing virtual units – does not imply any lack of judgment in our analysis. In fact, policymakers play a direct role in the amount of resources being employed within each subsystem and affect the role of institutions through the definition and implementation of regional innovation policies.

[46] In the efficiency related literature concern has been expressed about the convexity restriction and its utility, although there is no consensus to date (Cherchye et al., 1999). The Free Disposal Hull (FDH) (Deprins et al., 1984) could be another suitable alternative to test the role of convexity in this context. The FDH estimator relies on the free disposal assumption of the production set, but not, as DEA does, on its convexity. Hence, FDH is a more general estimator than DEA (Park et al., 2000).

As discussed, the data base for this third analysis was compiled from information from the EIS covering 161 European regions for 2002, and 187 regions for 2003.[47] Although these indicators are supposed to adequately characterize the performance of an IS,[48] with regard to frontier analysis we need to decide what is considered to be an input and/or an output. Since increased competitiveness and better social conditions are among the common goals of political measures, and are a main objective of RIS, GDP per capita can be considered to be an output (system performance) indicator. But, what of patents, for instance? Are they inputs or outputs? Or both? In order to find answers to these questions we need to consider causal relationship: (1) are patents, in the sense of a property right, more of an input for high and/or medium-tech industries operating within a certain region than (2) a countable output of successful R&D in the sense of a satisfactory working environment, such as productive Higher Education Institutions (HEI), industry interactions, functional networks, etc., in other words, a successful RIS?

The literature suggests that patents can be considered to be one of the main outputs of a RIS (Brouwer and Kleinknecht, 1999; Ernst, 2001) but, when we tested for this in our efficiency analysis, the empirical results were very similar.[49] In other words, considering patents only as innovation outputs (which they are) and not also as inputs (benefits) for industry in general, should perhaps be reconsidered (Griliches, 1990).

Due to the lack of any other regional indicator for output in our study we use patents but following Azagra Caro et al. (2003), who argue that the acquisition of patents could increase the innovative competitiveness of industries, we consider patents also as inputs. Therefore, in the context of the measurement of RIS performance, patents might constitute more of an input than an output[50] in regional GDP.

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[47] The information concerning the EIS data employed, as well as the TE scores obtained for all European regions in both years and for both models – see footnote 49 - are detailed in Appendix III: EIS 2002 and 2003 and Technical Efficiency Scores.

[48] The 49% variation in per capita regional income can be explained by differences in innovative performance – measured by the RRSII - for 2002 and 2003 (EIS 2002, 2003).

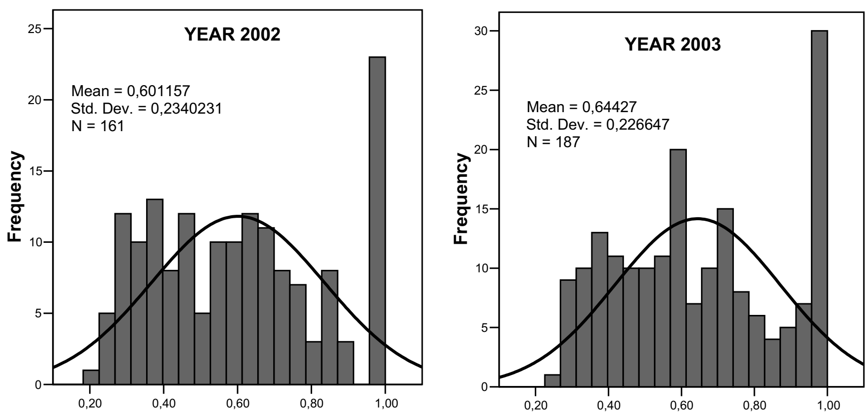
[49] Two models were estimated. In the first, both patents and GDP per capita were considered as the desired outputs of any RIS. In the second we considered patents to be an input rather than an output (ceteris paribus). The results obtained from both models, surprisingly, were quite similar and significant (the correlation between the models was 65.4% for 2002 and 63.8% for 2003).

[50] The patents granted in time "t" can be the result (output) of the efforts made previously in time "t-n". In turn, from "t" on, once the patents have been granted, they could be considered as an input for all regions/sectors (Georghiou et al., 2003; Adams and Griliches, 1996). However, the time span of our database is not sufficiently long for us to make this assumption; thus, patents are

The indicators we employ in the efficiency model are those provided by the EIS. Thus, the indicators considered as inputs for the frontier model are: higher education (% of population between 25-64 years with higher education), lifelong learning (% of population between 25-64 years participating in lifelong learning activities), medium/high-tech employment in manufacturing (% of total workforce), high-tech employment in services (% of total workforce), public R&D expenditure (% of GDP), business R&D expenditure (% of GDP), high-tech patent applications to the EPO per million population); and the measure of RIS output is regional GDP per capita.[51]

Figure 5.4.- illustrates the distribution of RIS efficiency scores obtained from the frontier estimations.

Figure 5.4.- Distribution of RIS Technical Efficiency in Europe[52]



Source: author's elaboration, in Zabala-Iturriagagoitia et al. (2007a).

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considered as an input for innovative activities in European regions due to the fact that most patents are generated by a very few regions, but the benefits spill over to all the others (Coe and Helpman, 1995). We consider this temporal issue to be a relevant point that might produce a really interesting outcome regarding the appropriability of innovation. This could have implications for policy making.

[51] We agree that the indicators considered in this analysis may not fully represent the main features of a RIS, and that more indicators could be included in the analysis. In fact, the quality of the data constitutes one of the main concerns in DEA related literature. This aspect was highlighted by Farrell (1957: 260), who in discussing data quality considered that "*it may be possible to reduce this effect by defining a larger number of relatively homogeneous factors of production, but in practice it is never likely to be possible completely to eliminate it*".

The overall mean of the calculated RIS efficiency scores rose from 0.60 in 2002 to 0.64 in 2003. Although this trend is positive, it indicates that there is huge potential for improved RIS performance. In other words, according to our empirical results, RIS potentials are widely under-exploited in Europe (by more than one-third on average). This is on the basis of already existing best practice examples and not of a hypothetical 'optimal RIS', which could shift the frontier significantly.

We found that a number of regions had highly efficient RIS (see bars at the right hand side of each histogram). Since the methodology is designed to identify best practice examples and take them as the benchmark (with respect to each of the seven input dimensions), we can expect a relatively high number of observations to show 100% efficiency, since all those regions with the lowest values for any indicator will be considered to be technically efficient. In fact, this is the case for most Greek, Portuguese and Spanish regions, where low technology sectors are very widespread and the regional institutions have few innovation policies.[53] Theoretically, most observations could be expected to be close to the frontier, and to behave as efficient units, but the histogram shows that there is wide variance in RIS performance in Europe.

With regard to the position of each region in relation to the frontier (level, near, far away) and its related TE score, all observations can be ordered by their achieved RIS efficiency. This ranking was compared with that provided by the RRSII, which according to the EIS, measures the innovation competitiveness of European regions. In Figure 5.5.- the two rankings are related: the y-axes refer to the RRSII index (region's position in 2002 and 2003 respectively), and the x-axes refer to the efficiency based RIS values (TE).

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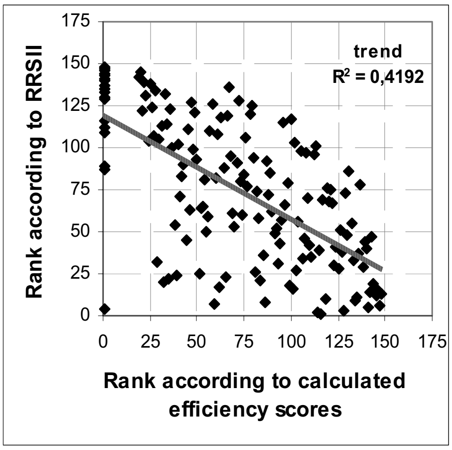
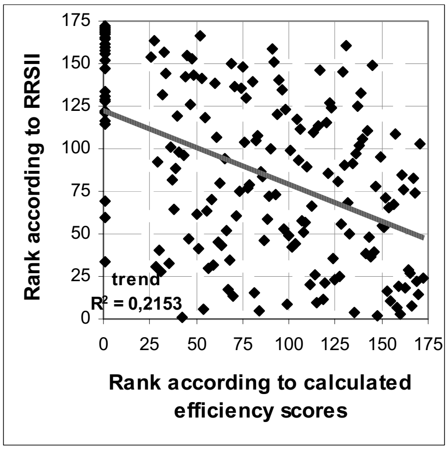
[52] We performed the procedure using XploRe, but there are alternative tools that could be used.

[53] A further step in this analysis might be to study regions with a high degree of homogeneity (i.e. the Nordic Countries, the Mediterranean area), whose institutions play similar roles, and where the technological level of firms, number of universities, etc., are similar. An alternative would be the development of an analysis with non-discretionary variables.

Figure 5.5.- Ranking of RIS performance according to RRSII and TE[54]

a) Year 2002 **b) Year 2003**





Source: author's elaboration, in Zabala-Iturriagagoitia et al. (2007a).

If the two performance indicators coincided, we could expect the majority of points to be along a 45° line. But this is not the case. Indeed, the trend line has a negative slope, which indicates a negative relationship. Rank correlation coefficients for the two indices were calculated in order to check this evidence empirically. The Spearman rank correlation coefficients for the 2002 and 2003 rankings are -0.645 and -0.453, respectively. In addition, the rank correlations for the subsequent years in each index were considered in order to check whether the variation in the scores and/or rankings was random. This yielded positive scores: 0.74 for TE ranking and 0.91 for the RRSII. Thus, both indices are consistent from an empirical point of view as the measures obtained are robust; therefore, it can be said that there is a difference in the 'best practice examples' identified. To some extent, the rankings are reversed; thus, as argued above, radically changing the 'blueprint' on which policy recommendations are based. The negative relation of these indices must result from their different conceptual settings, since the measures employed in both cases are the same. While the RRSII is created as a measure mainly oriented to the inputs in the system in the sense of 'the more the better', the efficiency measure refers to the how these resources are used relative to a particular

[54] The graphs showing the correlation between the TE scores and the RRSII index provided by the EIS for both years, and the two models estimated can be found in Appendix IV: RRSII vs Technical Efficiency Scores for 2002 and 2003.

output. The RRSII, on the other hand, takes account of the relative position of a region in relation to the national average and the EU average, whilst the efficiency index allows a comparison of the different levels of regional performance, since it compares among regions.

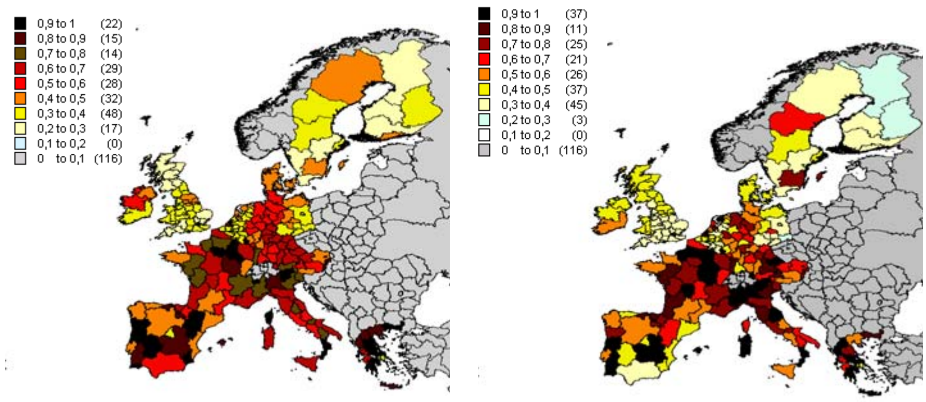
Thus, although a region that is at the top of the TE ranking, but which employs very few RIS resources might be efficient in terms of resource use (top in terms of TE), in terms of enhancing regional development, closing the gap in growth rates, social welfare, etc. this same region might be contributing very little and be classed as lagging. On the other hand, a region that invests huge amounts of resources to improve its innovation system (i.e. is top in terms of RRSII), but whose use of resources is identified as inefficient compared to the peer group of best practice regions, cannot be seen as an example of best practice. That is, a region might be really effective in its regional innovation policy implementation (targets achieved), but in contrast, how it uses its resources to achieve the targets may be inefficient. This motivates us to consider the differences between efficiency and effectiveness (see Section 0.) Hence, in order to assess the performance and institutional quality of a RIS both aspects must be considered. In this sense, the policy evaluation related literature agrees about the need to combine different approaches, methodologies and indicators to avoid a biased picture of system performance.

Bearing this in mind, we checked our estimates for those regions with a relatively high ranking in both indices; i.e. comprehensive RIS and highly efficient use of available resources. We found some regions that could be considered to be examples of *best practice* and used as blueprints for policy recommendations, including London (UK) and Ile de France (FR)[55], which were consistently among the top ranked regions with respect to both RRSII and TE scores. On the other hand, some regions such as Itae-Suomi (FIN), Chemnitz (DE) and Andalusia (ES) had a low ranking for both indices. A significant number of regions were either ranked high in terms of RRSII but low for TE (e.g. Noord-Brabant (NL), Uusimaa (FIN), Sydsverige (SE), Eastern (UK)), or vice versa (e.g. Aaland (FIN), Friesland (NL), Balearic Irelands (ES), Kriti (GR), Algarve (PT)).

[55] These two particular regions, as the main capital cities of their respective countries, are beneficiaries of national innovation policies and of the functioning of the national economy rather than of regional action. Hence, from a RIS perspective, there may probably be little to learn from the regional innovation policies of these territories. This reinforces the above mentioned point about the multi-level nature and the openness degree of innovation systems.

Figure 5.6.- Spatial distribution of calculated TE scores: RIS in Europe

a) Year 2002 **b) Year 2003**



Source: author's elaboration, in Zabala-Iturriagagoitia et al. (2007a).

Taking into account the spatial distribution of the empirical TE scores, some common clusters can be distinguished: (see Figure 5.6.-). Northern France (Champagne-Ardenne, Picardie, Haute-Normandie, Bourgogne, Ile de France and Alsace), Luxembourg, Northern Italy (Piemonte, Liguria, Lombardia, Trentino-Alto Adige, Veneto, Emilia Romagna), and Southern/Western Germany (e.g. Baden-Württemberg, Ober- and Nieder-Bayern) all of which score quite high for TE. However, there are many examples of relatively high as well as relatively low TE rankings across all European countries, which justify our approach of relating all regions to a common frontier (a peer group of regions identified as examples of best practice).[56]

The need to harmonize the RRSII and TE indices is demonstrated by the results for the Spanish RIS (see Table 5.10.-).

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[56] If there were strong evidence of national clusters (e.g. due to major differences in RIS, legal frameworks, institutional settings, technological barriers, administrative restrictions, etc.), our proposed 2nd and 3rd levels of aggregation would be more appropriate.

Table 5.10.- RRSII and TE scores and rankings of Spanish RIS (2002 and 2003)

Region	RRSII score		Rank according to RRSII		TE-score		Rank according to TE-scores	
	2002	2003	2002	2003	2002	2003	2002	2003
Galicia	60.26	59.35	115	135	0.471	0.599	96	96
Asturias	58.48	53.63	117	145	0.461	0.467	100	129
Cantabria	68.45	55.61	100	142	0.811	0.855	37	44
Basque Country	96.51	98.69	50	47	0.676	0.825	55	46
Navarre	102.91	100.09	36	45	0.554	0.724	85	62
La Rioja	61.22	57.42	114	138	0.834	0.729	34	60
Aragon	75.10	77.97	87	87	1.000	0.636	1	85
C. of Madrid	140.06	127.51	10	23	0.367	0.487	118	125
Castile and Leon	68.88	65.22	98	117	0.444	0.576	105	104
Castile la Mancha	48.78	42.01	138	163	0.894	0.981	25	27
Extremadura	47.67	43.91	139	161	0.981	0.459	22	131
Catalonia	100.24	107.58	42	36	0.425	0.488	110	124
Valencian C.	69.10	70.71	97	106	0.430	0.422	108	140
Balearic Islands	51.81	45.24	134	158	0.866	1.000	28	1
Andalusia	55.91	51.33	125	149	0.573	0.395	79	145
Murcia	52.45	59.61	133	133	1.000	0.422	1	139
Canary Islands	54.90	52.76	130	148	1.000	0.686	1	75

Source: author's elaboration, in Zabala-Iturriagagoitia et al. (2007a).

According to the published statistics (EUROSTAT, INE) Madrid is seen as the leading Spanish region in terms of RIS-related efforts. Thus, it is not surprising to find Madrid among the top ranked regions across Europe (RRSII positions: 10th in 2002, and 23rd in 2003). However, in terms of Madrid's resource allocation and use, its ranking is low (estimated TE rankings of 118th, and 125th for 2002 and 2003 respectively across all European regions). The results for Catalonia are similar.[57] In contrast, regions such as Navarre and the Basque Country[58] - both with well performing RIS – (Olazarán and Gomez Uranga, 2001) are more efficient and competitive in terms of RRSII. Some Spanish regions (e.g. Valencia) are medium/low in terms of both allocation and efficient use of resources. Some regions, such as the Balearic Islands and Castile la Mancha,

[57] RRSII/TE respective rankings: 42nd/110th for 2002, and 36th/124th for 2003.

[58] RRSII/TE respective rankings in Europe: 36th/85th and 45th/62nd (Navarre), and 50th/55th and 47th/46th (Basque Country) for years 2002 and 2003 respectively.

invest comparatively small amounts of resources to RIS, but use them in a highly efficient way.[59]

Having identified both the best and the least efficient regions, there remains the question of how to close the gap. Or, in other words, how to identify what hampers or restricts the efficiency of a RIS. The solution is direct action in terms of regional development and regional policies. In fact, this is one of the aspects that are given special attention by European Institutions (Landabaso, 1995, 1997). This is the rationale that explains the emergence of policies and initiatives such as the RIS', RITTS, RTP, etc. that have been promoted by the EC and that have "teached regions [how] to fish" instead of "giving them the fish".

Our results might perhaps be explained by the complexity of innovation and thus the need to coordinate the activities promoted by innovation policies (Frenken, 2000). Those countries with higher R&D expenditure levels, that have a tradition of good science and are therefore oriented towards the high-tech industries, tend to risk more in terms of their innovation policy proposals (Carayannis et al., 2006). As a result, the systems in these countries receive more inputs and make more efforts to be better coordinated and, consequently, are likely to be ranked as less efficient, since management activities absorb a great deal of attention (Georghiou, 2001). Similarly, those territories with lower absorptive capacity and fewer resources adopt the embodied knowledge and the innovations of others, which involves lower levels of development, but at the same time is efficient since risk is avoided, and the 'new' knowledge is rapidly adopted (Fernández de Lucio et al., 2003).

When we focus on the national level in relation to Spain, the results follow the above patterns. Those regions, such as Madrid and Catalonia, that devote greater amounts of resources to R&D and Innovation activities, are considered, based on the RRSII scale, to have the most comprehensive RIS. Their innovation policies are oriented to a great variety of emerging sectors, requiring a great deal of coordination among institutions and agents. These initiatives render the systems very dynamic, but the high levels of coordination required reduce their levels of efficiency. Those regions with fewer resources to invest have to pay much more attention to how they are used. They cannot

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[59] Balearic Islands: RRSII-position: 134th/158th, and TE-scores of 0.87 (28th) and 1.0 (10th), respectively. Castile la Mancha: 138th/163rd (RRSII ranks), and TE: 0.89 (25th), and 0.98 (27th) for 2002/2003 respectively.

afford to squander the scarce resources dedicated to innovation activities. Their more cautious behaviour produces unexpected and unforeseen efficiencies. Accordingly, their policy coordination capacity will be lower than that from those regions focused on great varieties of emerging, innovative and risky sectors. This coordination between and within ministries aims at providing policy consistency and overall orientation to the territory, but the more programmes/plans/policies considered in a territory, the more difficult this task will become. The costs of policy coordination will hence imply a lower efficient pattern in regions with a more chancy approach in their RIS.

The importance of the innovation policies in their territories should not be overlooked (Díez, 2002). Therefore, it can be said that innovation policies as well as territories, agents and institutions are path-dependent, and thus policies based on best practice examples will only be successful under certain conditions (Georghiou, 1998; Díez, 2002). Thus, it is crucial that regions learn from evaluations (Shapira and Kuhlmann, 2003) in order to orient their policies to their particular circumstances.

In Europe there are several efforts that are encompassed by the ‘new governance’ (Scott and Trubek, 2002). The open method of co-ordination (Borrás and Jacobsson, 2004) is one such, and is a new model for coordination, learning and policy integration. These new governance methods see efficiency as the key issue in the analysis and evaluation of policies.[60] Evaluation of the efficiency of public (S&T) policies constitutes one approach to analysing a region’s ability to use its basic productive resources to improve the welfare of the region (Susiluoto, 2003).

Thus, efficiency estimates provide direct answers when considering an inadequate allocation of resources (too much of x_n, not enough of x_{n+1}, etc.). The calculation can be broken down to show efficiency in relation to each (input) dimension.[61] The following could be applied to analyse existing inefficiencies, arising from under- or over-allocation of a particular input:

(5) $$1 - TE = \left| \mathrm{E} - \mathrm{X} \right| / \mathrm{X},$$

[60] An example of the application of the Open Method of Co-ordination in education policy can be found in Gornitzka (2005).

[61] According to the methodology, any “under-use” of inputs will occur only in very particular cases where achieving a certain amount of output with less input might be considered as a more efficient input/output-relation and, therefore, would shift the frontier.

where ***X*** is a i x j matrix of inputs as defined above, and E is a i x j matrix of input efficiency levels. Hence, if E = ***X*** it follows that $TE = 1$. $E \neq 0$ refers to $TE < 0$.

Therefore, we can empirically measure whether a certain input is allocated and used to the best advantage with respect to the frontier, which may serve as a useful empirical indicator for the formulation of policy recommendations. Since we have data for 161 regions in 2002 and 181 in 2003, and seven inputs for each RIS, for space reasons we cannot present this measurement in detail.[62] Institutional restrictions have to be considered, and their role could be analysed by regressing the TE scores for the effects of an ad-hoc selection of explanatory variables reflecting the current status of the institutions in each system. This will be the subject of future study.[63]

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[62] Since the study aimed at a European wide comparison and testing the availability of an efficiency approach in this framework, this task cannot be presented in detail. However, in this context, our proposed 2nd and 3rd levels of aggregation would be more appropriate, allowing decision makers and stakeholders to reorient the resources being used in their RIS.

[63] Due to the huge size of the data base that would be needed for a European wide analysis of these issues we intend to conduct these future analyses at national level (probably based on Spain), when the second level of the analysis has been accomplished.

CHAPTER VI: SUMMARY OF THE PAPERS IN THE COMPENDIUM

6.1. FIRST PUBLISHED PAPER: What indicators do (or do not) tell us about RIS

- *Title*: What indicators do (or do not) tell us about RIS.

- *Authors*: Jon Mikel Zabala-Iturriagagoitia, Fernando Jiménez-Sáez, Elena Castro-Martínez, Antonio Gutiérrez-Gracia.

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- *Journal:* Scientometrics, 70(1): 85-106.

- *Impact factor:* 1.363 (Web of Knowledge, 2008)

- *Abstract:*

This paper analyses some of the methodologies and R&D and innovation indicators used to measure Regional Innovative Capacity in Spain for the period 1996-2000. The results suggest that the approaches examined are not sufficiently rigorous; they vary depending on the methodology and indicators employed.

Therefore, we would suggest that the right balance between quantitative and qualitative approaches could produce a better evaluation of innovation system performance and would be more useful for policy makers and other stakeholders.

6.2. SECOND PUBLISHED PAPER: Benchmarking Innovation in the Valencian Community

- *Title*: Benchmarking Innovation in the Valencian Community.

- *Authors*: Jon Mikel Zabala-Iturriagagoitia, Antonio Gutiérrez-Gracia, Fernando Jiménez-Sáez.

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- *Journal:* European Urban and Regional Studies, 15(3): 249-263.

- *Impact factor:* 1.189 (Web of Knowledge, 2008)

- *Abstract:*

Benchmarking of innovation policies allows less developed territories to adjust their learning processes against the experience of others. There are successful territories in Europe where innovation policies have become key to development, but there are others where this is not the case, e.g., most Spanish regions. The purpose of this paper is to benchmark the Valencian Innovation System, at three levels of analysis: a) Spanish regions; b) Mediterranean regions; and c) European regions.

Our results highlight the main strengths and weaknesses, which are indicative of the deficiencies in the Valencian industrial structure and the difficulties involved in absorbing newly qualified, highly-educated people. The Valencian Community shows relative

strengths in those aspects related to public funding while its weaknesses are related to private activities. This structural imbalance drives us to categorize the Valencian Innovation System as weak, unarticulated and unbalanced, which questions the existence of a real RIS in the Valencian Community.

We consider that support from regional government should be oriented first towards the definition of some common consensus based targets involving the main regional actors. and second, at fostering entrepreneurial activities which may link the existing industrial structure to the public research system in the region, and third towards structural change in Valencian universities, to put greater emphasis on co-operation with regional firms, and knowledge transfer to SMEs in order to increase their competitiveness.

6.3. THIRD PUBLISHED PAPER: RIS: How to Assess Performance

- *Title*: Regional Innovation Systems: How to Assess Performance.

- *Authors*: Jon M. Zabala-Iturriagagoitia, Peter Voigt, Antonio Gutiérrez-Gracia, Fernando Jiménez-Sáez.

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- *Journal:* Regional Studies, 41(5): 661-672.

- *Impact factor:* 1.162 (Web of Knowledge, 2008)

- *Abstract:*

This paper applies Data Envelopment Analysis (DEA) methodology to the evaluation of RIS performance based on information provided by the EIS for 2002 and 2003.

We find that those European regions ranked in the EIS as showing better performance in high-technology areas, are ranked somewhat differently according to DEA. The results of

our study show that the higher the technological level of a region, the greater is the need for system coordination. Where this is lacking there is a loss of performance efficiency compared to other similar regions.

Policy making in relation to RIS in the past has depended on systemic analysis. Here, we propose a methodology that combines quantitative and qualitative analyses to enrich the knowledge base for future policy decision making.

CHAPTER VII: DISCUSSION

In the policy evaluation literature, two main streams of work can be distinguished: The first adopts a quantitative approach (measurement) towards STI policies; the second is more oriented to a qualitative view of the evaluation process. The policy evaluation related literature agrees about the need to combine both approaches, as well as the methodologies and indicators employed by each in order to avoid biased assessments of systems performance, and to produce realistic evaluations. However, in practice, this trend is not that widespread. In this thesis, we have adopted a quantitative approach, which encompasses the main perspectives within the IS framework, based on two main concepts highlighted in the IS literature: benchmarking and innovative capacity.

From a quantitative standpoint, traditional indicators seem to offer a partial view of the state of an IS. Our research shows that the use of these indicators within different methodological frameworks yields differing, but not necessarily contradictory results. They provide a partial picture of the phenomenon being examined, and so different approaches should be seen as being complementary. Policy makers, therefore, will need to consider the results of different and complementary analyses to obtain a comprehensive picture of a RIS. The sum of these partial views will then provide a clearer picture than is provided by each in isolation.

Taking the concepts of innovative capacity and regional benchmarking as starting points, one of the main contributions of the thesis consists of demonstrating the need to consider efficiency measurement as the key to a better understanding of RIS performance in Europe and as illustrating the possibilities of efficiency measurement methodologies for the policy making community. Based on the approach defined in this research, we do not aim at a rather simplistic best-practice vision, but want to illustrate the relevance of the study of efficiency for public investments in STI policies. The aim also is to foster learning for the institutions and individuals involved in the management of these policies, in order to achieve more competitive and efficient STI policies.

To accomplish this, we divided our research into three different but complementary stages, each depending and building on the one before. The first stage aimed at examining the robustness and rigour of some of the methodologies developed for the measurement of innovative capacity. IAIF methodology was compared with EIS methodology, using Spanish regions as the unit of analysis. Our results show that even when the objectives of two methodologies applied in the study of Regional Innovative Capacity are the same, the different quantitative approaches and methodologies mean that the results are not fully comparable. In both cases, due to the lack of statistical data, the indicators employed differ, producing different results (ranks). Nevertheless, we consider that due to the fact that both methodologies aim at the same target, and despite statistical differences, they should be quite robust. The results obtained show that although there is some correlation between the two approaches, this is not significant. Thus, we believe that an index designed to measure regional innovation would provide a ranking that would also be feasible based on macro statistical data, such as are available from EUROSTAT, so the contribution to the regional policy making sphere of these approaches is not that clear. In addition, evaluating a RIS using a unique index would incur substantial inaccuracies from an economic perspective. Hence, for the second step of our research we considered it might be more rigorous to focus on a particular region, benchmarking it in different contexts, using different units, in order to observe the main strengths and weaknesses.

The second analysis was oriented towards benchmarking innovation in a peripheral European region, the Valencian Community in Spain, and was carried out at three levels of analysis (Spanish, Mediterranean and European regions) to produce a more comprehensive view of the relative position of the Valencian Community, both in Spain, an in the whole of Europe. Our results highlight that the Valencian Community has some relative strengths in those aspects related to public funding while its weaknesses are related to private activities. The low employment rates in high technology sectors are indicative of the deficiencies in the Valencian industrial structure, based on traditional hand-made sectors, such as ceramics, shoes, furniture, toy industry, tiles, etc., and the difficulties involved in absorbing newly qualified, highly-educated people on the other. The structural imbalance in the Valencian IS can thus be characterized as weak, unarticulated and unbalanced. It is weak due to its low technology orientation. It is unarticulated due to the lack of co-operation among the diverse set of regional actors. And it is unbalanced due to the fact that the advances made by the public research system cannot be exploited by the private sector.

These conclusions lead us to critically question the existence of a real RIS in the Valencian Community. In fact, universities and firms in the region constitute two sides of the same coin. Most European regions are in agreement that the research and business spheres must become more integrated and collaborative. However, in the Valencian Community, due to the traditional character of its SMEs (micro firms) it is almost impossible to get them to recognize the advantages of co-operating with the research sphere. This lack of interaction constitutes one of the area's main weaknesses, compromising the future development of regional innovation. We consider first that support from the Valencian regional government and the local institutions should be directed towards the definition of common regional targets through a consensual process involving the main regional actors, and similar to the process followed in the RIS' promoted by the European Commission since 1994. Despite the region being involved in the RITTS initiative between 1998 and 2000, it seems that a consensual process of developing regional policies did not become embedded in regional policy making. Second, entrepreneurial activities should be fostered, in order to link the existing industrial structure to the region's public research system. This orientation could produce an increase in employment and investment in R&D by high technology oriented sectors. Thus, a complete renovation of the strategic orientation of sectors such as furniture, ceramics, tiles, toys and shoes, might be achieved. Third, similar structural change must be promoted in Valencian universities, accompanied by greater emphasis on co-operation with regional firms, and knowledge transfer to SMEs to increase their competitiveness. It is imperative that the Valencian Community achieves these objectives if it is to continue the growth so far achieved, and not to lose ground in relation to other European regions.

Why do structural imbalances occur? Universities and public research organizations are without doubt the major regional actors in R&D activities. Does it really make sense to have an inclusive public research system if the existing industrial structure cannot absorb its advances, graduates, researchers and applications? To what extent is it necessary to increase public R&D spending in a region with firms that have a low innovative profile? These key questions motivated an examination of how resources devoted to R&D and innovation activities are used. That is, whether there is a structural imbalance between the public and the private sectors in innovation, which would make a clear difference to how they use their resources and capabilities. This provoked consideration of the concept of efficiency within the context of regional innovation.

The third step in the research was directed towards evaluating RIS performance in terms of TE. Based on the indicators provided by most available data, (R)IS are generally seen as pure technical input-output systems, with an emphasis on the amount of resources employed. There is agreement in the literature as to the lack of suitable measures not only with regard to benchmarking system performance, but also for in-depth evaluation of the particular features of the system. Thus, when we examine the data in detail, several problems arise, and particularly in relation to cross-country benchmarking analyses, due to the heterogeneity of European regions, the multi-dimensionality of IS, and differences in the criteria applied by regional (and national) statistical offices. There is an urgent need to achieve some balance between the data provided by empirical assessment and qualitative analyses, through evaluation. Underlying this research is the fact that although the amounts of resources within a RIS are important it is not evident that those regions with larger amounts of resources are also the most efficient ones. This makes necessary to emphasize the clear difference between the concepts of effectiveness and efficiency. While efficiency refers to the relative use of the resources devoted to an activity in order to produce certain outputs, effectiveness considers whether the targets (in absolute terms) have been achieved or not. In this sense, a policy/programme/region can be effective because the goals have been accomplished, but very inefficient in terms of the amounts of resources input to produce low outputs. In this sense, we consider that in order to estimate the effectiveness of a STI policy, and the level of efficiency it has managed to produce in the actors participating in it may be considered an intermediate step in the evaluation of the effectiveness of a regional policy.

Since EIS indicators are resource-based indices, a region that invests more resources and thus (supposedly) obtains higher performance, will be ranked higher than regions whose investments are lower. However, this does not mean that the competitiveness of the former group will be higher (i.e. their RIS is better) than that of other regions. The efficiency measurement (DEA) approach aims at providing information about overall relative performance and the use (misuse) of these resources. The results obtained from efficiency analysis were compared with those obtained using the RRSII index recommended by EIS to measure the EU's progress in innovation activities. The EIS indicators identify those regions with high investment in high-tech related activities as "leading regions", ignoring the regions with potential and those that require specific innovation policies. Due to the different perspectives of these two approaches it is possible that different best practice examples will be identified and could, rightly or wrongly, become the blueprints for well meaning but perhaps mistaken, policy adjustments. The EIS demonstrates that the results based on efficiency measures reflect that in general terms RIS are widely under-exploited in Europe and that there are important variations among regions. We have shown that regions with fewer resources devoted to innovation achieve outstanding levels of efficiency and, contrary to what the EIS predicts, regions with consolidated innovation systems do not show efficiency levels commensurate with their expected competitiveness. This confirms the above statements in the sense that efficiency can be considered as an intermediate step towards achieving effectiveness, but that there is a clear distinction between these two concepts.

Similarly, according to our results, we consider that the higher a region's technological level, the greater is the need for coordination of its RIS. Thus, those regions where higher coordination efforts are needed show lower efficiency levels in comparison to other regions with similar investments (in terms of RRSII). Territories with lower absorptive capacity and fewer resources adopt the embodied knowledge and the innovations of others, which constitutes a less risky strategy as this "new" knowledge can be rapidly adopted by traditional sectors and in an efficient way.

As discussed above, our research was oriented to deepening understanding about three key aspects within the RIS literature. The first is related to testing the robustness of those benchmarking methodologies oriented to capturing regional innovative capacity. To date, and mainly due to the lack and inaccuracy of statistical data, we have concluded that is more feasible and accurate to focus on the performance of one particular region. This approach allows the researcher to employ both quantitative and qualitative information, and to get information and opinions from relevant regional stakeholders and policy makers. Accordingly, the second stage in our research focused on the region of Valencia, analysing its main features using quantitative statistics. The conclusions from this stage drove us to think about the utility of the resources employed in a RIS, i.e. to seek for efficient behaviours, which constituted our third mission. While the first two contributions are oriented more towards analysing previous studies in the literature, this third contribution aimed at contributing to the scientific literature, claiming for consideration of efficiency analyses in regional policy evaluation. This aspect, in spite of its relevance, and agreement among scholars in terms of the need for its consideration, has not been studied in detail in the literature. Indeed, we consider that our contribution has already had some impact on the community as illustrated by the new understanding of the EIS 2007. In this sense, we should emphasize that efficiency analysis is not a panacea, but it does constitute a "must" for policy evaluation. Hence, policy evaluation that ignores this efficiency analysis will not achieve answers to the issues. We would claim for its complementarity with other methods, both quantitative and qualitative.

Based on our research, we consider that a combination of the methodologies employed here, with qualitative analyses and other sources of information provided by empirics, should be used as the basis for decision making to provide better information at the start of a new policy cycle within RIS. These types of evaluations should provide useful information not only for those responsible for defining new innovation support policies, but also for the whole set of agents participating in the RIS. This should ensure an interactive process enabling regions to develop from being passive innovation producers (adopters) to becoming new learning and social systems. Both innovation support policies, and territories, are path-dependent and therefore identified best practice cannot be replicated everywhere. Innovation support policies must be customized to support the particularities of each unit of analysis (i.e. sector/region/country). That is, innovation support policies need to be embedded in the territory. This means that it is crucial that regions learn from evaluation exercises in order to redefine their policies, and assess the performance and the institutional quality of their RIS with greater accuracy.

CHAPTER VIII: CONCLUSIONS

The research in this thesis was aimed at comparing benchmarking methodologies oriented towards the measurement of the regional innovation capacity to identify strengths, weaknesses and future needs, and proposing efficiency measurement as a complementary methodology to cope with needs identified, allowing for a better in depth characterization of RIS. The main hypotheses are that the performance of RIS can be characterized by their efficiency and that consideration of efficiency criteria complements, and hence increases the robustness of the policy recommendations that are drawn from the use of innovative capacity benchmarking oriented methodologies. In this sense, we consider that the thesis makes an important addition to the literature in that it explicitly considers the question of efficiency in the context of evaluation of IS.

For decades, R&D agencies have allocated resources in a largely unstructured process within their public STI policies. However, since the mid 1990s, this situation has begun to change as concern over government efficiency has increased. Combining the innovation systems related literature (innovative capacity), the policy evaluation (benchmarking) literature and works dealing with the study of efficiency and productivity, produced three linked papers, in which we try to find a balance between them.

The objective of the first paper was to compare approaches to measuring innovative capacity, taking the Spanish regions as the unit of analysis between 1996-2000. The methodology (IAIF) proposed by Buesa et al. (2002), based on Spanish regions, was considered the most adequate to be compared with EIS. According to our results, the definition of a composite index that reflects regional innovative capacity requires further research and more exhaustive regional data, as well as a clearer theoretical definition of the concept being measured. One of the major weaknesses in the methodologies examined is the employment of identical criteria for the measurement of innovative capacity in different territories. Because of the wide diversities at both national and European levels, the criteria applied to different territories should reflect their socio-economic structures. However, although in the IAIF methodology the factors grouping several indicators are weighted which does reflect some of the socio-cultural and economic heterogeneity of the territories involved, the weights are the same for all Spanish regions. In our view, this is a problem that needs to be resolved in future work. In terms of the data, the main difficulty lies in their reliability. In most cases the data are based on representative national level samples, and hence their representativeness at regional level is poor, which is likely to introduce substantial sample errors. In addition, due to changes made by national statistical offices in criteria definition there are differences in the R&D and innovation data depending on the time period, which makes it difficult to obtain comparable time series data. In this sense, and since innovation is a relatively new phenomenon, and thus paucity of robust statistical data will be a limitation for some time to come, we consider that the consideration of individual RIS will provide more accurate characterizations. In conducting benchmarking studies we would recommend using general statistics, such as those provided by EUROSTAT or national statistical offices, to identify regions with similar characteristics. This would allow comparison among regions with similar sectoral distributions, social features, historical and/or technologic trajectories, and/or among regions with similar innovation policies. Taking into account that innovation requires policies to be socially rooted, we consider that identifying similar territories would ease this embeddednes requirement. It would also allow institutional aspects to be studied and compared that take account of the impact of the legal and institutional frameworks in place, and might produce novel and directly applicable results for the definition and implementation of better grounded innovation policies, contributing new methodological and conceptual knowledge to the literature in this field.

Following the conclusions from previous research, our second paper aimed at benchmarking the Valencian IS. In this case our analysis compares the situation of the Valencian Community within Spanish, Mediterranean and European regions. For the Spanish regions, their evolution from 1992 to 2004 is analysed, while within the different Mediterranean and European contexts the analysis is based on the period 1994-2003. According to the indicators included in the analysis we conclude that Valencian competitiveness could be improved through promotion of employment in high technology manufacturing industries and services. This will require universities to play a major role, not only in developing R&D and teaching activities in technologically advanced sectors, but by integrating the knowledge developed in the region and reducing the brain drain effect from highly trained graduates from Valencian universities migrating to other regions.

Finally, evaluation of RIS performance in Europe in terms of TE constitutes the main goal of our third contribution, as a means to complement previous conclusions from the EIS and other methodologies oriented to benchmarking regional innovative capacity. The data base was based on information from the EIS covering 161 European regions for 2002, and 187 regions for 2003. The rationale for considering efficiency measures within the context of regional innovation as relevant drives is that the existing methodologies are mostly based on a “more is better” basis, on the amount of resources employed (inputs), but not how these resources are used (including their assumed input-output linear and deterministic impact on the RIS and the economy in general). The results show that there is wide variation in RIS performance across Europe, with regions that employ very few resources but are efficient in terms of their use, and regions that invest huge amounts of resources to improve their IS, but whose use of resources is identified as inefficient compared to peer regions. Hence, in order to assess the performance and institutional quality of a RIS both effectiveness and efficiency must be considered. In this sense, and to explain the observed results we link the need to coordinate the activities promoted by innovation policies with demonstration of efficient performance. Those countries with higher R&D expenditure levels, that devote greater amounts of resources to R&D and innovation activities, which have a tradition of good science and are therefore oriented towards high-tech industries, tend to risk more in terms of their innovation policy proposals. Hence, and based on the scale provided by the EIS (see RRSII index, Section 3.1.), they are considered to have the most comprehensive RIS. Their innovation policies are oriented to a large variety of emerging sectors, requiring a great deal of coordination among institutions and agents. These initiatives render the systems very dynamic, but the high levels of coordination required reduces their levels of efficiency. Similarly, those territories with fewer resources to invest have to pay much more attention to how they are used, as they cannot afford to squander the scarce resources dedicated to innovation activities. Hence, they could assume a strategy based on adopting the embodied knowledge and the innovations of others, which involves lower levels of development, but at the same time is more efficient since risk is avoided. Accordingly, their more cautious behaviour produces unexpected and unforeseen efficiencies.

This efficiency consideration however does not infer that methodologies oriented to benchmarking territories (regions, countries) according to their innovative capacity are inaccurate, but rather that it should be used as complementary to allow for a better and more solid characterization of RIS. In our view, the use of efficiency measures in assessing R&D efficiency and allied public policy issues has not reached its full potential within the innovation management research community. We consider that the research path opened by this research will provide interesting theoretical and methodological possibilities.

Finally, we believe that the opposite, and sometimes conflicting, quantitative and qualitative approaches should be combined. This proposal in the literature often appears to be more a declaration of intent rather than a clear intention. It seems that the proponents of one stream of work may have a hidden interest in challenging the other. Indeed, supporters of both approaches can demonstrate the advantages of their perspectives; but there is no in depth examination of their implications in the literature. Thus, proponents of the qualitative approach consider that the conclusions of the quantitative approach are pretentious and too general and also they consider these conclusions and policy recommendations emanate from the use of mostly non-robust data. On the other hand, defenders of the quantitative approach claim that the qualitative approach is not sufficiently robust enough, describing it as discursive, non scientific, etc.

In our view, consideration of qualitative approaches would have allowed us to gain insights into regional performance. However, due to the large number of regions studied, this was not realistic in the short term. However, we are currently working on qualitative assessment, from both a regional point of view (deepening the qualitative aspects on which the RIS' initiative is based, stressing regional innovation policy making processes) and from a political point of view (focusing on a particular science programme in Spain, the Spanish Food Technology Programme (SFTP), involving researchers and policy managers to obtain their views on their own targets and those of the programme). This is the first phase of our future research agenda. We agree that the differences between the quantitative and qualitative standpoints cannot be reconciled with a single study and will require a full research programme, something that we intend to complete in the near future. We consider it essential to produce a contribution that theoretically and empirically combines the benefits of the two approaches and this is an objective of future research, to demonstrate that it is possible to evaluate a particular policy/programme/region from both points of view, thereby laying the foundations for a new perspective within policy evaluation studies.

CHAPTER IX: FURTHER RESEARCH

Public support for R&D, innovation and technology transfer activities is part of the European landscape. However, the evaluation of these activities has not been internalized within the policy cycle. The evaluations conducted so far deal with the elaboration of static indicators that do not provide an accurate picture of how these activities and their results are evolving over the time. An important plea made by policy makers and scholars with respect to these activities' outcomes and impacts is for a long term perspective. This implies that the results of an evaluation of these activities might be too late to be useful for policy reorientations. Therefore, an evaluation methodology that provides a dynamic overview of the results of R&D and technology transfer activities would capture, on the one hand, the agents' behavioural evolution participating in the policy (i.e. the micro-level perspective) and, on the other, the complexity of the economic order that S&T policies impose on a given IS (i.e. the macro-level perspective). Interim evaluations may be useful as a management tool, to analyse the efficiency of projects during their execution and to orient them towards the concrete targets defined by the policy/programmes under evaluation. Ex-post evaluations should be oriented towards assessing the whole programme or policy initiative, and not focusing on its development. However, when the target is to enable learning for a new policy cycle, then ex-ante evaluation may play a useful role. In the last few years, some scholars have focused on impact assessment methodologies, looking for new ways to combine evaluation and foresight perspectives. We consider that this ongoing research joining well-known evaluation methodologies and foresight approaches constitutes an essential piece of the future literature.

In similar vein, we deem that a dynamic evaluation framework for (regional) innovation support policies may provide interesting conclusions both for the policy-making sphere and the social agents involved in these policies. In the literature, specific methodologies have been proposed for multiple period analyses of efficiency trends, e.g. Cooper et al. (2004) mention the use of so-called Window Analysis and Malmquist Productivity Indexes. In order to offer such a dynamic view we would propose the use and consideration of the Malmquist productivity indices (Grosskopf, 1993; Färe et al., 1994; Førsund, 1997; Ray and Desli, 1997; Zofio and Lovell, 1998; Zofio, 2007), as these indices help us to understand how policy is affecting and is being affected by the decision making units participating over time (micro-level perspective), and accordingly gauge the extent to which the policy is contributing to consolidate the RIS (macro-level perspective). In this sense, it would be more feasible to study the characteristics of efficient and non-efficient units over time and explore the reasons for these patterns. What are the key variables (institutions, norms, laws, policies, etc.) that affect these differences in regional innovation performance? How can they be measured? What is their role in overall system performance? We are currently applying Malmquist productivity indices to the evaluation of the research groups involved in the SFTP, to gain knowledge about the benefits of dynamic efficiency analysis as a complement to a static approach based on technical efficiency analysis, on a yearly basis.

Another concern that arises from our research is the availability and reliability of data. We have observed that there are great differences in the criteria used over time, even by the same national statistic office, so that the statistics collected for one year are not necessarily comparable with those for other years. In order to overcome these problems, the literature proposes the use of robust methods (Daraio and Simar, 2006a) oriented to minimizing the effects of possible outliers and errors of measurement. In this context, one of the more promising methods would seem to be bootstrapping (Daraio and Simar, 2006b). Bootstrapping methods are data-based simulation methods that search for statistical inferences, allowing the introduction of a stochastic component within the efficiency analysis to contrast the significance of the results achieved (Simar and Wilson, 1998, 1999, 2003). These methods deal with the uncertainty produced due to sampling variation by estimating bias, confidence intervals, testing hypotheses, etc. which could be useful to confirm the consistency of the results from using quantitative approaches to evaluation and benchmarking.

Finally, in order to fully comprehend the behaviour, strengths, weaknesses, etc. of a particular RIS and the set of policies implemented, the scope of the research should be reduced in order to achieve greater homogeneity. We acknowledge that this research implies the use of less data, and probably implies statistically less robust conclusions. However, we consider that the comprehensive evaluation (benchmarking) of a particular region/policy cannot be achieved only through quantitative approaches. We call for consideration and use of more qualitative studies, e.g. interviews with the socio-economic and political agents in the regions. We agree that the acquisition of information in this more qualitative arena is more costly and difficult. However, when the objective is to provide policy-makers with accurate evaluations of the present and future needs of regions, we consider that these qualitative studies would both further the research and be a great opportunity for science. We are currently working on the evaluation (both quantitative and qualitative) of the SFTP, focusing on the role played by research groups belonging to the CSIC. The SFTP is a particular science programme in Spain, launched in 1988 within the 1st National R&D Plan and has been an element in all its subsequent announcements. Its main target lies in the promotion of relationships among the agents participating in the various initiatives it encompasses, making up an “articulated” food innovation system. Through this research we aim to include the qualitative views and judgements of researchers and R&D managers in quantitative R&D evaluation methodologies. We are conducting semi structured interviews with researchers and R&D managers. These qualitative assessments will be included in a generalized distance function oriented to weigh up the efficient performance of the research groups under analysis. In addition, and so as to search for the dynamic performance of these units, Malmquist productivity indices will be defined and used in line with the previous efficiency approach. We consider that this work will contribute to the scientific literature and start to link quantitative and qualitative assessment methodologies.

To overcome the differences between quantitative and qualitative approaches will need more than one study, and constitutes a major research strand. We hope to make a major contribution which both theoretically and empirically combines the benefits of the two approaches and showing that it is possible to evaluate a particular policy/programme/region from both points of view, laying down the foundations of a new perspective within policy evaluation studies.

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APPENDICES

Appendix I: Set of variables grouped according to the European Innovation Scoreboard and Fernández de Lucio and Castro (1995)

INPUT		**Human Resources for Innovation**	**Creation of Knowledge**	**Transmission and application of knowledge**	**Innovation finance, outputs and markets**
Scientific Environment	Input	• Total R&D personnel (FTE) in the Higher education sector • Total Researchers (FTE) in the Higher education sector • Total R&D personnel (FTE) in the Government sector • Total Researchers (FTE) in the Government sector • Nº of students enrolled in the Tertiary Education • Nº of students enrolled in PhD studies	• Public expenditure in the Higher Education Sector • Total intramural R&D expenditure in Higher Education Sector • % of Total intramural R&D expenditure performed the Higher Education sector by source of funds (Business enterprise, Government, Higher education, Abroad, Private non-profit sectors) • Total intramural R&D expenditure Government Sector • % of Total intramural R&D expenditure performed the Government sector by source of funds (Business enterprise, Government, Higher education, Abroad, Private non-profit sectors)	• Nº of Interface Structures • Nº of Tech Transfer Offices	
Technological Environment	Input	• Employment in R&D services • Employment in Knowledge-intensive high-technology services		• Nº of Technology Centres	

INPUT		Human Resources for Innovation	Creation of Knowledge	Transmission and application of knowledge	Innovation finance, outputs and markets
Productive Environment	Input	• Employment in Manufacturing Sectors • Employment in High and medium high technology manufacturing sectors • Employment in Low and medium low technology manufacturing sectors • Total R&D personnel (FTE) in the Business Enterprise sector • Total Researchers (FTE) in the Business Enterprise sector • Life long learning	• % Total Innovation Expenditure in intramural R&D • Nº of firms received public funding from central government, regional or local authorities • Total intramural R&D expenditure Business Enterprise Sector • % of Total intramural R&D expenditure performed the Business sector by source of funds (Business enterprise, Government, Higher education, Abroad, Private non-profit sectors)	• % of Enterprises with innovation activities/ Number of total enterprises • High and medium high technology Imports • Low and medium low technology Imports • Nº of firms Cooperation arrangements on innovation activities	• Innovation expenditures • Innovation expenditures in High and medium high technology manufacturing sectors • Innovation expenditures in low and medium low technology manufacturing sectors • Creation of private capital/GDP (%) • Creation of fixed capital/GDP (%)
Financial Environment	Input				
Institutional Framework	Input	• Employment rate of university graduates • Population with tertiary education (% of 25-34 years age class)			• Nº of new created firms • Nº of new created High and medium high technology firms • Nº of new created low and medium low technology firms
Path Dependence	Input	• Nº of universities • Nº of university campus • Active population • Occupied population • Inhabitants		• Investment in ICT • Nº of internet accesses	

OUTPUT		Human Resources for Innovation	Creation of Knowledge	Transmission and application of knowledge	Innovation finance, outputs and markets
Scientific Environment	Output	• Tertiary education graduates • Graduates in humanities • Graduates in engineering, manufacturing and construction • Graduates in health and welfare • Graduates in social sciences • Graduates in science, mathematics and computing • PhD theses defended • Nº of publications in ISI journals			
Technological Environment	Output			• Degree of penetration of technological advances (ICT) in firms	• Gross Value Added Knowledge-intensive high-technology services

OUTPUT		**Human Resources for Innovation**	**Creation of Knowledge**	**Transmission and application of knowledge**	**Innovation finance, outputs and markets**
Productive Environment	Output				• Gross Value Added High and Medium High technology manufacturing firms • Gross Value Added low and Medium low technology manufacturing firms • High and medium high technology Exports • Low and medium low technology Exports • Gross Value Added Manufacturing Sector (%) • Gross Value Added High and Medium High technology manufacturing firms/Gross Value Added Manufacturing Sector (%) • % exports due to new or improved products to the market • % exports due to new or improved products to the firm • % Turnover of new or significantly improved products to the firm/total turnover • % Turnover of new or significantly improved products new to the market/ total turnover
Financial Environment	Output				• Venture capital investments • Venture capital entities

OUTPUT		**Human Resources for Innovation**	**Creation of Knowledge**	**Transmission and application of knowledge**	**Innovation finance, outputs and markets**
Institutional Framework	Output		• Patent applications to the OEPM • High Tech patent applications to the OEPM • Patent applications to the EPO • High Tech patent applications to the EPO		• GDP • GDP per capita • Commercial balance • Technology balance High and Medium High Technology Firms • Technology balance Low and Medium low Technology Firms

Source: Author's elaboration

Appendix II: Comparison between the IAIF and IAIF' indices

	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)
	1996			1997			1998			1999			2000		
Andalucía	**27,75**	*31,27*	*-12,68*	**29,41**	*33,358*	*-13,42*	**26,69**	*36,131*	*-35,37*	**26,79**	*36,801*	*-37,37*	**25,61**	*39,633*	*-54,76*
Aragón	**20,57**	*19,59*	*4,76*	**22,89**	*19,692*	*13,97*	**22,13**	*21,654*	*2,15*	**22,03**	*21,974*	*0,25*	**22,37**	*22,279*	*0,41*
Asturias	**15,79**	*10,263*	*35,00*	**17,26**	*9,955*	*42,32*	**15,48**	*10,223*	*33,96*	**15,77**	*12,057*	*23,54*	**20,93**	*13,094*	*37,44*
Baleares	**4,51**	*6,3*	*-39,69*	**3,87**	*7,13*	*-84,24*	**4,14**	*8,407*	*-103,07*	**4,19**	*9,364*	*-123,48*	**4**	*9,697*	*-142,43*
Canarias	**12,85**	*9,284*	*27,75*	**13,11**	*10,94*	*16,55*	**15,23**	*11,324*	*25,65*	**13,47**	*11,424*	*15,19*	**14,65**	*12,521*	*14,53*
Cantabria	**13,29**	*10,914*	*17,88*	**12,95**	*12,45*	*3,86*	**16,35**	*12,981*	*20,61*	**12,58**	*11,72*	*6,84*	**11,01**	*12,427*	*-12,87*
Castilla y León	**7,11**	*23,298*	*-227,68*	**9,51**	*24,34*	*-155,94*	**7,12**	*25,299*	*-255,32*	**7,28**	*25,921*	*-256,06*	**8,73**	*27,55*	*-215,58*
Castilla-La Mancha	**22,46**	*11,336*	*49,53*	**25,96**	*13,055*	*49,71*	**25,65**	*13,909*	*45,77*	**25,79**	*14,275*	*44,65*	**24,27**	*16,198*	*33,26*
Cataluña	**57,73**	*63,442*	*-9,89*	**59,89**	*64,951*	*-8,45*	**60,79**	*73,889*	*-21,55*	**60,66**	*73,659*	*-21,43*	**62,55**	*78,419*	*-25,37*
C. Valenciana	**34,1**	*26,495*	*22,30*	**36,6**	*29,191*	*20,24*	**34,98**	*31,677*	*9,44*	**35,43**	*32,124*	*9,33*	**35,05**	*35,764*	*-2,04*
Extremadura	**5,99**	*5,35*	*10,68*	**9,43**	*5,542*	*41,23*	**8,95**	*6,586*	*26,41*	**7,93**	*6,502*	*18,01*	**10,08**	*7,065*	*29,91*
Galicia	**16,82**	*18,057*	*-7,35*	**21,17**	*19,378*	*8,46*	**19,49**	*20,901*	*-7,24*	**19,87**	*21,753*	*-9,48*	**21,1**	*23,153*	*-9,73*
Madrid	**67,1**	*58,323*	*13,08*	**70,3**	*62,384*	*11,26*	**66,86**	*64,83*	*3,04*	**67,42**	*68,09*	*-0,99*	**71,41**	*72,039*	*-0,88*
Murcia	**14,33**	*11,627*	*18,86*	**16,51**	*13,039*	*21,02*	**15,68**	*13,316*	*15,08*	**16**	*15,141*	*5,37*	**16,47**	*16,396*	*0,45*
Navarra	**36,56**	*21,424*	*41,40*	**37,43**	*22,692*	*39,37*	**36,45**	*23,352*	*35,93*	**37,7**	*24,996*	*33,70*	**37,55**	*24,374*	*35,09*
País Vasco	**37,5**	*33,478*	*10,73*	**39,4**	*36,719*	*6,80*	**40,46**	*38,707*	*4,33*	**38,52**	*38,641*	*-0,31*	**36,12**	*40,725*	*-12,75*
La Rioja	**8**	*11,265*	*-40,81*	**7,79**	*12,902*	*-65,62*	**7,69**	*12,317*	*-60,17*	**9,77**	*12,056*	*-23,40*	**10,18**	*14,318*	*-40,65*

Source: Author's elaboration

Appendix III: EIS 2002 and 2003 and Technical Efficiency Scores

	Human Resources				Knowledge Creation				Innovation Finance, Output and Markets				Efficiency Scores	
INDICATORS	Tertiary education	Lifelong learning	Medium-high tech employment in manufacturing	Hig-htech employment in services	Public R&D	Business R&D	High Tech patent applications to the EPO	All Patent Applications to the EPO	GDP per capita	RNSII	REUSII	**RRSII**	EF FSCORE (2 output)	EFFSCORE (1output)
2002EU	22,00	9,56	6,53	3,33	0,64	1,14	22,28		19229, 15					
2002AUSTRIA	**14,52**	**8,18**	**6,77**	**2,80**	**0,65**	**1,28**	**9,80**		**22584**				0,55	0,54
2002Burgenland	10,16	5,61	4,31	2,00	0,65	1,28	0,00		14105	67	65	65,94	0,53	0,87
2002Niederoesterreich	13,00	7,61	5,84	3,02	0,65	1,28	6,50		17793	90	82	86,06	0,47	0,47
2002Wien	19,56	9,32	6,80	4,89	0,65	1,28	20,00		33924	135	115	124,77	0,69	0,65
2002Kaernten	12,89	7,51	8,62	2,22	0,65	1,28	26,60		18399	118	96	106,60	0,56	0,49
2002Steiermark	12,29	6,02	7,05	1,99	0,65	1,28	5,00		18237	83	77	80,23	0,55	0,55
2002Oberesterreich	13,27	8,98	8,47	2,12	0,65	1,28	3,60		21097	92	86	88,77	0,55	0,63
2002Salzburg	15,90	8,09	5,03	2,07	0,65	1,28	9,70		25041	96	86	90,68	0,60	0,59
2002Tirol	13,49	8,67	4,94	2,02	0,65	1,28	3,03		22462	84	79	81,73	0,59	0,76
2002Voralberg	14,76	11,61	8,28	1,49	0,65	1,28	5,80		22646	97	90	93,57	0,61	0,62
2002BELGIUM	**27,82**	**7,27**	**6,90**	**3,60**	**0,55**	**1,35**	**17,70**		**21936**				0,39	0,36
2002Bruxelles	34,08	8,15	3,72	3,87	0,55	1,34	29,30		33292	114	115	114,68	0,62	0,56

2002Vlaams Gewest	28,10	8,19	8,32	3,79	0,55	1,44	21,80		22698	109	110	109,78	0,40	0,36
2002Region Wallonne	25,47	5,31	4,85	3,14	0,55	1,15	6,90		17329	78	81	79,61	0,34	0,34
2002GERMANY	**23,84**	**5,25**	**11,18**	**3,03**	**0,75**	**1,54**	**30,40**		**23421**				0,52	0,49
2002Baden Wurttemberg	25,06	5,84	18,30	3,49	0,86	2,90	41,80		26671	131	160	145,39	0,57	0,55
2002Bayern	23,12	4,76	13,54	3,47	0,64	2,08	88,80		26743	131	161	146,10	0,71	0,66
2002Berlin	33,61	8,61	6,24	4,29	1,83	1,58	27,70		22142	129	142	135,45	0,36	0,31
2002Brandenburg	32,39	5,15	4,58	2,32	0,89	0,60	9,30		15412	76	82	78,79	0,33	0,31
2002Bremen	19,53	6,37	9,02	3,03	1,05	1,02	7,50		31237	94	104	98,95	0,73	0,75
2002Hamburg	25,39	7,46	5,80	3,64	0,77	1,18	28,20		40267	108	119	113,55	0,86	0,83
2002Hessen	24,74	5,45	12,06	4,43	0,46	1,76	22,70		28593	104	121	112,44	0,65	0,64
2002Mecklenburg-Vorpommern	27,85	4,38	3,80	2,73	0,82	0,15	2,80		15331	65	68	66,54	0,39	0,45
2002Niedersachsen	19,95	4,19	10,77	2,35	0,68	1,06	16,90		21664	81	95	87,72	0,56	0,54
2002Nordhein-Westfalen	19,34	5,09	10,19	2,76	0,63	1,06	19,00		23887	85	98	91,21	0,61	0,56
2002Rheinland-Pfalz	20,88	4,90	12,65	2,55	0,45	1,66	11,40		21228	84	99	91,81	0,49	0,47
2002Saarland	17,85	5,71	8,76	2,34	0,63	0,33	6,50		21533	70	77	73,26	0,62	0,62
2002Sachsen	31,69	5,44	7,89	2,01	1,12	1,07	11,40		15471	87	98	92,46	0,35	0,32
2002Sachsen-Anhalt	27,12	3,52	6,63	2,25	0,77	0,51	3,00		14778	65	73	69,26	0,33	0,42
2002Schleswig-Holstein	21,47	4,87	8,17	2,97	0,64	0,44	10,80		22167	75	83	78,98	0,60	0,58

2002Thueringen	30,49	5,25	8,06	1,50	0,81	0,89	5,30		15159	75	84	79,21	0,38	0,37
2002GREECE	**17,08**	**1,35**	**2,22**	**1,62**	**0,38**	**0,13**	**0,60**		**10319**				0,46	0,57
2002Anatoliki Makedonia, Thraki	12,58	0,87	1,20	1,62	0,35	0,06	0,00		8655	64	30	47,05	0,63	1,00
2002Kentriki Makedonia	17,90	1,57	2,14	1,38	0,43	0,09	0,00		10576	86	38	61,87	0,44	0,85
2002Dytiki Makedonia	13,12	0,89	2,22	1,62	0,35	0,07	0,00		9373	72	33	52,55	0,60	0,84
2002Thessalia	15,44	0,57	1,35	0,94	0,09	0,05	0,00		8969	50	24	36,92	0,81	1,00
2002Ipeiros	14,43	0,61	2,22	1,62	0,62	0,07	0,00		6546	76	36	56,38	0,59	0,81
2002Ionia Nisia	11,22	0,34	2,22	1,62	0,18	0,02	0,00		8743	55	27	40,69	0,81	0,99
2002Dytiki Ellada	11,46	1,09	1,19	1,24	0,52	0,07	1,40		8228	98	32	64,84	0,61	0,66
2002Sterea Ellada	9,67	0,39	2,44	1,62	0,02	0,10	0,00		13148	63	27	44,96	1,00	1,00
2002Peloponnisos	12,66	0,35	1,35	1,27	0,10	0,09	0,00		8230	52	23	37,56	0,78	1,00
2002Attiki	21,46	1,96	3,56	2,43	0,45	0,23	1,40		11527	153	50	101,51	0,35	0,39
2002Voreio Aigaio	10,47	0,28	2,22	1,62	0,36	0,02	0,00		9478	61	30	45,29	0,88	1,00
2002Notio Aigaio	9,75	0,16	2,22	1,62	0,05	0,02	0,00		12044	52	25	38,44	1,00	1,00
2002Kriti	13,34	1,19	2,22	1,38	0,87	0,05	0,00		10450	90	43	66,48	0,56	0,90
2002SPAIN	**22,66**	**4,67**	**5,37**	**2,23**	**0,43**	**0,47**	**2,50**		**13308**				0,30	0,34
2002Galicia	19,54	5,11	4,26	1,20	0,36	0,17	1,50		10526	73	47	60,26	0,42	0,47
2002Asturias	19,98	3,50	3,96	1,74	0,31	0,23	0,90		11846	70	47	58,48	0,38	0,46
2002Cantabria	23,55	2,25	7,58	1,51	0,38	0,45	0,00		12499	80	57	68,45	0,38	0,81

2002Basque Country	31,76	4,90	9,62	2,05	0,25	0,99	0,50		16211	116	77	96,51	0,37	0,68
2002Navarre	30,63	5,91	12,74	2,23	0,32	0,51	1,90		17453	124	82	102,91	0,42	0,55
2002La Rioja	23,50	2,30	4,91	2,23	0,20	0,30	0,00		15254	71	51	61,22	0,48	0,83
2002Aragon	24,66	3,62	10,54	1,15	0,31	0,39	0,00		14424	87	63	75,10	0,50	1,00
2002Madrid	31,56	3,79	6,77	5,68	0,75	0,85	9,10		18075	182	98	140,06	0,37	0,37
2002Castile and Leon	22,97	5,64	5,65	1,72	0,36	0,16	1,20		12144	83	55	68,88	0,37	0,44
2002Castile la Mancha	16,34	4,86	2,27	1,35	0,19	0,29	0,00		11005	58	39	48,78	0,52	0,89
2002Extremadura	15,52	3,27	5,37	0,95	0,36	0,07	0,00		8250	55	40	47,67	0,50	0,98
2002Catalonia	23,66	3,32	9,07	2,49	0,38	0,69	5,10		16462	127	73	100,24	0,39	0,43
2002C. Valenciana	19,85	6,91	3,70	1,57	0,38	0,25	1,80		12675	85	53	69,10	0,37	0,43
2002Balearic Islands	16,73	3,96	0,99	1,90	0,22	0,07	1,40		16365	63	40	51,81	0,76	0,87
2002Andalusia	18,77	4,84	2,41	1,48	0,46	0,22	0,30		9508	67	45	55,91	0,37	0,57
2002Murcia	21,08	5,05	1,97	1,05	0,36	0,21	0,00		11055	62	43	52,45	0,46	1,00
2002Ceuta and Melilla	22,09	5,39	5,37	2,23	0,43	0,47	0,00		11074	87	59	73,03	0,30	0,55
2002Canary Islands	18,42	6,69	0,88	1,44	0,47	0,06	0,00		12701	65	44	54,90	0,50	1,00
2002FRANCE	**22,59**	**2,72**	**7,24**	**3,86**	**0,82**	**1,35**	**21,30**		**22095**				0,73	0,72
2002Ile de France	33,32	3,40	6,65	6,46	1,10	2,33	56,00		32658	156	160	158,18	1,00	1,00
2002Champagne-Ardenne	15,53	2,16	4,63	2,30	0,15	0,39	1,50		20075	52	50	51,19	0,81	1,00
2002Picardie	15,34	1,90	8,67	1,60	0,15	0,94	6,90		18130	63	63	62,71	0,73	0,74

2002Haute-Normandie	19,63	2,31	10,74	2,35	0,20	1,35	3,90		19701	77	77	76,98	0,69	0,76
2002Centre	15,27	2,74	9,04	2,87	0,34	1,16	7,70		19587	77	77	77,15	0,66	0,66
2002Basse-Normandie	17,42	2,96	8,60	2,21	0,27	0,60	4,20		18403	68	65	66,27	0,56	0,58
2002Bourgogne	17,56	2,25	8,27	2,70	0,26	0,78	1,80		19503	66	66	66,31	0,71	0,85
2002Nord-Pas-de-calais	16,39	2,08	6,59	2,40	0,31	0,36	3,70		17299	58	57	57,41	0,63	0,64
2002Lorraine	18,03	2,20	8,77	2,65	0,49	0,54	7,80		18212	71	72	71,39	0,63	0,64
2002Alsace	21,16	2,81	12,89	1,87	0,62	0,73	19,10		22643	93	93	93,09	0,80	0,78
2002Franche-Comte	19,14	3,42	14,91	2,50	0,22	1,81	10,70		19020	97	96	96,59	0,51	0,50
2002Pays de la Loire	19,20	2,27	8,11	3,18	0,32	0,65	3,10		19063	69	69	68,88	0,66	0,72
2002Bretagne	22,54	3,23	7,47	3,36	0,58	1,00	23,80		18051	93	91	92,39	0,48	0,45
2002Poitou-Charentes	17,49	1,84	5,46	2,73	0,34	0,42	2,40		17476	57	57	56,90	0,66	0,71
2002Aquitaine	20,34	2,72	5,20	4,05	0,41	0,98	2,80		19456	74	73	73,57	0,60	0,65
2002Midi-Pyrenees	26,07	3,53	6,88	5,11	2,04	1,66	14,60		19263	125	131	127,87	0,46	0,45
2002Limousin	17,01	2,82	4,38	3,18	0,21	0,53	1,40		17485	59	56	57,42	0,54	0,65
2002Rhone-Alpes	24,76	2,59	8,57	4,00	0,76	1,54	29,90		21803	109	112	110,38	0,72	0,70
2002Auvergne	19,77	3,55	5,26	2,21	0,46	1,68	3,80		17812	78	75	76,91	0,45	0,54
2002Languedoc-Rousillon	19,29	2,21	2,43	3,74	1,54	0,56	3,90		16464	77	82	79,58	0,52	0,57
2002PACA	20,91	2,33	3,46	3,66	0,80	1,23	25,70		19596	90	92	90,76	0,70	0,67
2002Corse	17,79	1,33	7,24	3,86	0,23	0,02	0,00		16679	54	56	54,93	1,00	1,00

2002FINLAND	**32,47**	**19,25**	**7,23**	**4,39**	**0,95**	**1,94**	**84,10**		**22393**				0,40	0,25
2002Uusimaa (Suuralue)	26,36	16,16	6,96	7,11	1,34	2,39	187,80		31350	131	254	192,90	0,73	0,41
2002Etelae-Suomi	29,30	16,96	8,45	3,37	0,73	1,90	59,40		20498	89	150	119,07	0,36	0,27
2002Itae-Suomi	28,87	17,60	4,00	2,58	0,75	0,54	4,30		16478	60	91	75,25	0,30	0,32
2002Vacli-Suomi	40,01	22,68	7,83	2,99	0,46	1,27	9,90		18389	78	119	98,63	0,30	0,29
2002Pohjois-Suomi	30,83	18,98	7,16	3,51	1,03	2,79	107,70		19199	105	193	148,92	0,43	0,24
2002Aaland	29,21	15,28	7,23	4,39	0,00	0,03	0,00		27440	62	85	73,38	1,00	1,00
2002IRELAND	**23,66**	**7,66**	**6,97**	**4,04**	**0,38**	**1,01**	**10,30**		**20859**				0,40	0,38
2002Border, Midland and Western	17,87	6,14	6,84	2,69	0,38	1,01	3,10		20859	81	75	78,28	0,49	0,59
2002Southern and Eastern	25,62	8,17	7,01	4,47	0,38	1,01	12,50		20859	106	95	100,26	0,38	0,36
2002ITALY	**10,03**	**5,06**	**7,62**	**2,92**	**0,47**	**0,54**	**4,90**		**16870**				0,62	0,61
2002Piemonte	9,31	4,62	14,00	3,59	0,25	1,42	7,00		19744	133	89	111,13	0,79	0,78
2002Valle D'aosta	7,06	5,15	7,62	2,92	0,02	0,15	0,00		22492	67	53	60,08	1,00	1,00
2002Liguria	12,23	3,64	7,18	3,59	0,84	0,44	1,20		17773	100	72	86,30	0,64	0,68
2002Lombardia	10,15	4,59	11,91	3,35	0,30	0,88	16,50		22434	145	87	115,75	0,87	0,84
2002Trentino-Alto Adige	9,23	8,33	3,09	2,32	0,22	0,18	1,10		22698	77	52	64,58	0,96	1,00
2002Veneto	9,56	6,21	9,77	1,77	0,26	0,24	2,90		19858	85	61	73,31	0,76	0,76
2002Friuli-Venezia Giulia	8,63	7,01	8,88	2,45	0,43	0,64	4,20		19373	104	71	87,57	0,72	0,73

2002Emilia Romagna	11,16	5,98	9,52	2,94	0,40	0,43	3,50		21715	102	72	87,29	0,70	0,70
2002Toscana	9,12	6,30	5,45	2,66	0,63	0,31	2,80		18435	92	63	77,57	0,68	0,68
2002Umbria	9,59	6,13	6,65	2,99	0,57	0,11	1,20		16284	84	61	72,35	0,70	0,71
2002Marche	11,29	3,92	7,34	1,82	0,30	0,23	2,10		16972	75	53	63,93	0,65	0,67
2002Lazio	13,39	5,24	4,17	5,60	1,22	0,66	3,60		18914	131	89	110,16	0,57	0,57
2002Abruzzo	9,23	4,88	6,45	2,22	0,44	0,82	3,10		14306	93	61	76,91	0,59	0,58
2002Molise	9,14	4,99	6,00	2,92	0,19	0,13	0,00		12936	64	48	55,72	0,69	0,73
2002Campania	8,81	3,86	4,46	2,05	0,54	0,29	0,50		10525	67	47	56,97	0,57	0,58
2002Puglia	9,36	4,66	3,99	2,19	0,30	0,15	0,50		10971	60	42	51,08	0,62	0,64
2002Basilicata	6,59	5,30	9,00	2,92	0,36	0,08	3,30		11826	77	56	66,76	0,79	0,77
2002Calabria	10,21	5,09	1,21	2,54	0,26	0,00	0,00		9983	52	36	44,18	1,00	1,00
2002Sicilia	9,47	4,18	2,30	2,12	0,48	0,03	4,90		10798	69	43	55,82	0,68	0,66
2002Sardegna	8,27	5,99	2,26	1,83	0,58	0,09	1,20		12407	66	45	55,61	0,62	0,62
2002NETHERLANDS	**23,96**	**16,27**	**4,44**	4,11	**0,89**	**1,05**	**36,10**		**20728**				0,39	0,32
2002Groningen	23,66	17,33	3,03	3,72	1,39	1,25	10,70		26692	100	120	109,96	0,45	0,45
2002Friesland	18,59	12,25	4,36	1,83	0,89	1,05	3,20		17194	73	84	78,59	0,36	0,47
2002drenthe	17,40	14,10	5,53	2,30	0,89	1,05	6,40		17069	80	91	85,60	0,36	0,36
2002Overijssel	19,53	14,48	5,13	2,43	0,47	0,79	11,20		17835	74	85	79,27	0,39	0,36
2002Gelderland	22,47	14,42	3,77	4,28	1,22	1,12	10,00		18096	91	109	99,89	0,31	0,30
2002Flevoland	18,06	16,25	4,43	5,97	2,08	0,35	6,50		14369	97	120	108,40	0,32	0,30

2002Utrecht	32,60	18,95	2,14	6,49	1,33	0,74	24,60		24954	108	136	122,18	0,40	0,47
2002Noord-Holland	29,50	18,23	2,56	5,54	0,91	0,80	14,40		23881	95	117	105,84	0,39	0,44
2002Zuid-Holland	24,66	17,41	3,51	4,64	1,33	0,83	16,00		21439	97	119	108,14	0,37	0,36
2002Zecland	19,29	14,26	4,69	4,11	0,08	0,61	2,70		19024	68	76	71,85	0,52	0,57
2002Noord-Brabant	22,37	15,95	7,12	3,37	0,30	2,01	163,40		20495	151	193	172,08	0,68	0,34
2002Limburg	19,53	14,46	8,95	2,05	0,26	2,11	21,90		17928	100	107	103,50	0,47	0,42
2002PORTUGAL	**9,12**	**3,35**	**3,66**	**1,20**	**0,48**	**0,14**	**0,40**		**10006**				0,56	0,67
2002Norte	7,34	2,77	3,39	0,74	0,30	0,10	0,30		8738	77	30	53,30	0,74	0,97
2002Centro	7,62	4,11	4,34	0,90	0,51	0,14	0,00		8584	86	39	62,49	0,66	1,00
2002Lisboa E vale Do Tejo	12,45	3,63	4,63	2,14	0,64	0,21	0,90		12545	148	52	100,08	0,44	0,49
2002Alentejo	9,92	3,78	3,66	1,20	0,35	0,05	0,00		8779	77	35	56,23	0,63	0,89
2002Algarve	4,95	2,92	3,66	1,20	0,26	0,02	0,00		10078	64	30	46,92	1,00	1,00
2002Acores	6,78	2,36	3,66	1,20	0,54	0,00	0,00		6881	66	33	49,63	1,00	1,00
2002Madeira	5,15	3,33	3,66	1,20	0,48	0,14	0,00		7618	79	35	56,84	0,95	0,99
2002SWEDEN	**29,71**	**21,58**	**7,90**	**5,13**	**0,93**	**2,75**	**52,40**		**24153**				0,35	0,28
2002Stockholm	30,16	22,61	5,79	8,41	0,93	3,88	150,30		32377	138	256	196,93	0,62	0,39
2002Oestra Mellansverige	38,70	22,85	10,49	4,47	0,93	2,28	32,80		21869	99	165	131,84	0,26	0,22
2002Smaaland Med Oearna	27,95	21,23	8,98	2,99	0,93	0,66	6,20		23695	75	116	95,61	0,45	0,49
2002Sydsverige	29,21	23,95	7,49	4,58	0,93	2,81	48,00		21662	97	170	133,36	0,32	0,26

2002Vacstsverige	23,48	16,96	10,51	4,67	0,93	4,27	23,90		21339	96	166	131,02	0,32	0,29
2002Norra Mellansverige	23,97	22,46	6,80	3,24	0,93	0,95	14,20		22478	74	119	96,50	0,38	0,35
2002Mellestra Norrland	30,16	22,43	6,31	5,51	0,93	0,76	7,80		23193	79	125	102,09	0,32	0,35
2002Oevre Norrland	20,05	17,25	4,08	4,07	0,93	0,89	42,50		23046	73	124	98,65	0,52	0,43
2002UNITED KINGDOM	**28,56**	**21,66**	**7,36**	**4,34**	**0,62**	**1,21**	**19,10**		**21307**				0,31	0,29
2002North East	22,35	19,29	9,45	3,34	0,37	0,62	2,70		16451	72	95	83,35	0,31	0,36
2002Yorkshire & the humber	26,22	21,58	6,25	3,19	0,44	0,45	2,80		18561	70	94	82,12	0,36	0,43
2002East Midlands	24,70	20,98	8,19	3,45	0,38	1,39	7,70		19773	85	110	97,72	0,32	0,34
2002Eastern	24,40	20,41	7,63	5,34	0,62	3,02	52,90		21666	142	164	153,10	0,38	0,29
2002South East	24,42	21,61	8,00	6,16	0,88	2,00	39,10		23060	132	157	144,39	0,37	0,31
2002London	26,77	21,55	2,81	5,71	0,63	0,42	18,10		32960	94	119	106,17	0,71	0,86
2002South West	39,96	25,18	8,31	3,48	0,69	1,40	32,30		19588	117	144	130,78	0,32	0,25
2002West Midlands	31,35	23,12	10,90	3,77	0,47	1,02	6,90		19312	92	120	106,11	0,29	0,32
2002North West	29,79	22,98	8,19	4,01	0,34	1,41	7,10		18665	89	116	102,40	0,27	0,31
2002Wales	25,62	18,27	8,00	2,91	0,48	0,38	6,10		18065	72	93	82,68	0,38	0,37
2002Scotland	30,64	20,12	6,33	3,62	0,89	0,60	11,30		20298	90	113	101,32	0,33	0,30
2002Northern Ireland	22,18	14,47	5,54	2,65	0,39	0,45	2,40		15963	59	76	67,47	0,35	0,41

Source: EIS 2002 and author's elaboration.

	Human Resources				Knowledge Creation				Innovation Finance, Output and Markets				Efficiency Score	
INDICATORS	Tertiary education	Lifelong learning	Medium/high tech employment in manufacturing	Hightech employment in services	Public R&D	Busines s R&D	High Tech patent applications	All Patent Applications to the EPO	GDP per capita	RNSII	REUSII	**RRSII**	EFFSCORE (2 output)	EFFSCORE (1output)
2003EU	**22,47**	**9,69**	**6,00**	**3,55**	**0,63**	**1,33**	**37,29**	**165,45**	**24600,33**					
2003AUSTRIA	**16,89**	**7,46**	**6,59**	**3,47**	**0,65**	**1,13**	**18,80**	**174,20**	**25529**				0,61	0,58
2003Burgenland	12,66	4,33	4,00	3,14	0,05	0,14	7,10	89,60	16362	51	46	48,45	0,78	0,80
2003Niederoesterreich	15,36	7,17	6,75	3,13	0,05	0,59	20,40	135,60	21616	79	69	73,93	0,63	0,61
2003Wien	20,81	8,68	5,41	6,95	1,38	1,82	41,00	156,20	35068	149	130	139,58	0,71	0,66
2003Kaernten	16,13	5,46	6,48	2,63	0,22	0,87	24,90	118,00	21440	82	71	76,33	0,62	0,56
2003Steiermark	15,75	5,59	6,81	2,60	1,01	1,53	11,80	183,90	21418	99	91	95,00	0,58	0,56
2003Oberesterreich	16,03	8,26	9,67	2,56	0,20	1,07	6,10	205,50	24446	89	82	85,57	0,56	0,60
2003Salzburg	16,43	6,98	4,70	2,72	0,36	0,30	15,00	158,40	29221	79	71	74,59	0,88	0,87
2003Tirol	17,30	8,43	5,14	1,71	0,85	0,79	8,50	145,60	25203	86	78	82,05	0,69	0,67
2003Voralberg	16,14	10,53	6,40	1,50	0,04	0,88	8,80	453,30	26347	97	90	93,23	1,00	1,00
2003BELGIUM	**28,11**	**5,95**	**6,59**	**3,77**	**0,57**	**1,60**	**23,40**	**151,80**	**24153**				0,46	0,45
2003Bruxelles	37,29	6,89	3,03	4,98	0,57	0,67	31,60	170,40	48920	113	106	109,67	1,00	1,00
2003Vlaams Gewest	27,86	6,73	7,86	3,64	0,57	1,94	30,10	160,30	23839	109	104	106,71	0,43	0,40

2003Region Wallonne	25,83	4,23	4,98	3,67	0,57	1,53	8,90	203,40	17585	86	85	85,87	0,37	0,36
2003GERMANY	**22,31**	**5,80**	**11,36**	**3,33**	**0,74**	**1,70**	**48,80**	**309,90**	**24700**				0,58	0,50
2003Stuttgart	23,79	6,42	21,24	3,55	0,46	4,36	94,70	719,20	31135	154	205	179,17	0,74	0,65
2003Karlsruhe	24,02	6,36	16,39	4,74	1,46	1,89	56,30	492,90	29113	134	169	151,45	0,64	0,59
2003Freiburg	22,36	7,03	14,92	3,05	0,70	1,26	46,10	474,10	24408	107	136	121,22	0,60	0,47
2003Tübingen	25,20	5,83	18,72	2,85	0,75	3,47	54,50	480,70	25554	127	165	145,87	0,63	0,52
2003Oberbayern	26,16	5,51	13,87	5,32	1,00	3,72	282,10	824,20	35828	204	266	235,08	1,00	0,87
2003Niederbayern	16,95	3,79	15,61	1,93	0,08	0,38	27,30	187,90	22574	64	83	73,73	0,96	0,92
2003Oberpfalz	15,46	4,54	13,24	2,59	0,37	1,38	77,70	375,40	25030	95	123	109,12	0,88	0,71
2003Oberfranken	17,42	4,31	11,81	2,28	0,32	0,81	25,40	252,10	24045	72	90	81,11	0,75	0,67
2003Mittelfranken	22,04	5,23	14,11	3,56	0,52	2,08	103,90	517,80	29318	123	160	141,63	0,80	0,71
2003Unterfranken	19,07	4,91	15,59	2,63	0,56	1,14	21,80	359,60	24069	87	113	100,31	0,62	0,58
2003Schwaben	19,02	6,17	14,47	2,84	0,09	0,93	41,20	326,30	24963	85	107	95,85	0,76	0,59
2003Berlin	30,40	9,59	5,85	5,17	1,80	1,88	59,10	217,30	22198	127	143	134,94	0,42	0,31
2003Brandenburg	28,04	5,44	4,87	3,35	1,04	0,56	24,70	80,50	16118	75	83	79,05	0,39	0,30
2003Bremen	18,14	7,13	9,46	2,99	1,05	1,07	15,60	99,00	33166	87	98	92,27	0,79	0,77
2003Hamburg	23,21	6,81	6,33	4,27	0,72	1,08	30,90	216,80	42128	97	109	102,82	1,00	0,95
2003Darmstadtd	25,10	6,69	13,49	5,11	0,38	2,70	49,20	490,70	34526	123	154	138,43	0,73	0,71
2003Gieben	20,60	7,97	9,70	2,89	0,97	0,77	30,10	258,00	22058	90	106	98,24	0,54	0,45
2003Kassel	19,27	6,22	12,42	2,26	0,24	0,47	7,90	104,80	23518	64	75	69,48	0,66	0,65

2003Mecklenburg-Vorpommern	27,05	4,94	4,65	2,37	0,90	0,11	6,80	46,60	16102	60	64	62,22	0,51	0,50
2003Braunschweig	18,74	6,75	17,54	3,00	1,71	4,50	42,10	263,20	24617	135	168	151,37	0,60	0,54
2003Hannover	19,19	3,98	9,51	3,31	0,60	1,37	48,70	236,90	25124	86	106	96,13	0,75	0,72
2003Lüneburg	21,05	6,54	8,45	2,09	0,19	0,35	22,10	160,30	18220	62	72	67,18	0,66	0,54
2003Weser-Ems	17,20	4,74	9,20	1,58	0,20	0,34	5,40	104,20	20910	52	60	55,94	0,78	0,77
2003Düsseldorf	18,02	5,18	9,50	3,70	0,34	1,13	25,30	339,70	28126	84	103	93,10	0,76	0,70
2003Köln	22,13	5,96	10,73	4,00	1,33	1,96	54,60	394,90	26800	118	145	131,35	0,61	0,56
2003Münster	19,41	6,47	9,86	2,48	0,43	0,43	23,70	210,20	20363	71	85	77,99	0,59	0,50
2003Detmold	17,42	6,02	9,13	2,42	0,27	0,76	51,80	240,30	24484	78	94	85,72	0,82	0,61
2003Arnsberg	15,96	5,27	10,44	2,31	0,50	0,70	18,90	218,80	23143	71	86	78,30	0,69	0,63
2003Koblenz	19,32	4,19	9,73	3,12	0,07	0,75	10,80	176,70	20778	62	74	67,91	0,58	0,55
2003Trier	20,21	6,20	5,19	2,77	0,49	0,32	13,30	98,40	19817	61	66	63,72	0,53	0,49
2003Rheinhessen-Pfalz	21,14	6,26	15,42	3,78	0,69	2,73	26,20	494,50	24366	113	145	129,10	0,54	0,51
2003Saarland	16,48	5,03	9,45	3,66	0,60	0,36	6,90	144,70	22476	68	78	72,99	0,69	0,68
2003Chemnitz	27,09	4,49	9,21	1,95	0,65	0,89	7,10	55,30	15303	64	73	68,54	0,36	0,34
2003Dresden	30,92	6,73	7,58	2,76	1,69	1,78	76,30	215,10	16628	114	135	124,83	0,51	0,27
2003Leipzig	28,41	6,65	5,78	3,30	1,33	0,61	9,60	54,00	17415	79	86	82,58	0,34	0,31
2003Dessau	24,61	3,59	8,02	1,61	0,08	0,57	2,80	30,40	14892	46	52	48,84	0,49	0,61
2003Halle	27,60	4,07	7,74	2,36	1,21	0,50	9,60	62,80	16246	70	80	75,11	0,40	0,37

2003Magdeburg	23,99	3,98	6,50	2,08	0,84	0,31	10,60	52,10	16043	59	66	62,67	0,47	0,43
2003Schleswig-Holstein	19,91	5,63	7,60	3,11	0,64	0,45	16,80	156,50	22323	71	81	75,68	0,62	0,57
2003Thueringen	28,58	5,56	8,94	2,18	0,82	0,79	14,90	105,00	16148	73	84	78,30	0,36	0,32
2003DENMARK	**27,42**	**18,42**	**6,33**	**4,74**	**0,75**	**1,65**	**42,10**	**211,00**	**32576**				0,50	0,44
2003GREECE	**17,62**	**1,16**	**2,20**	**1,76**	**0,48**	**0,19**	**2,10**	**7,70**	**11661**				0,47	0,50
2003Anatoliki Makedonia, Thraki	12,47	1,09	0,98	0,52	0,43	0,11	3,30	1,80	9408	72	25	48,34	0,89	0,84
2003Kentriki Makedonia	18,65	1,42	1,68	1,56	0,52	0,10	2,10	9,80	11701	98	35	66,72	0,45	0,51
2003Dytiki Makedonia	13,19	0,63	0,52	1,11	0,06	0,01	2,10	3,30	11551	53	19	35,87	1,00	1,00
2003Thessalia	14,27	0,50	1,34	0,80	0,24	0,05	2,10	2,70	10574	59	23	41,02	0,68	0,77
2003Ipeiros	14,33	0,73	0,55	1,11	0,86	0,03	0,70	0,70	8112	60	32	45,86	0,59	0,94
2003Ionia Nisia	10,29	0,13	0,14	0,57	0,12	0,01	2,10	7,70	10193	47	15	31,29	1,00	1,00
2003Dytiki Ellada	11,31	1,16	1,18	1,23	0,80	0,11	3,60	7,30	8799	95	34	64,22	0,63	0,60
2003Sterea Ellada	7,48	0,46	2,98	0,75	0,01	0,17	2,10	1,50	13159	65	20	42,63	1,00	1,00
2003Peloponnisos	12,81	0,36	0,95	0,85	0,02	0,41	0,10	4,80	9934	63	20	41,42	1,00	1,00
2003Attiki	22,87	1,56	3,69	2,75	0,63	0,33	3,20	12,60	13287	147	50	98,63	0,38	0,42
2003Voreio Aigaio	10,88	0,38	0,46	1,56	0,57	0,01	2,10	7,70	11297	69	28	48,70	1,00	1,00
2003Notio Aigaio	9,71	0,53	0,94	1,23	0,22	0,02	2,40	7,30	13742	66	22	44,39	1,00	1,00
2003Kriti	16,11	0,78	0,24	0,96	0,04	0,04	1,30	11,70	11390	63	20	41,23	1,00	1,00
2003SPAIN	**24,36**	**4,97**	**5,35**	**2,50**	**0,46**	**0,50**	**3,60**	**24,10**	**15261**				0,33	0,36

2003Galicia	21,53	5,96	5,71	1,48	0,50	0,19	0,40	4,10	12011	70	49	59,35	0,34	0,60
2003Asturias	23,50	3,30	3,11	1,80	0,39	0,28	1,00	7,80	13156	64	43	53,63	0,36	0,47
2003Cantabria	24,61	2,56	6,40	1,70	0,34	0,21	0,20	4,20	14901	64	47	55,61	0,51	0,85
2003Basque Country	34,18	7,33	9,42	1,83	0,31	1,04	1,10	35,00	18836	124	74	98,69	0,45	0,83
2003Navarre	32,83	7,08	11,24	1,40	0,30	0,71	3,00	43,10	19546	127	73	100,09	0,57	0,72
2003La Rioja	26,62	2,70	4,46	1,31	0,19	0,29	3,60	7,50	16930	71	44	57,42	0,69	0,73
2003Aragon	25,43	4,12	9,64	1,75	0,32	0,37	1,50	33,40	16316	96	59	77,97	0,47	0,64
2003Madrid	33,92	3,75	5,92	6,62	0,79	0,97	9,10	36,10	20412	166	89	127,51	0,45	0,49
2003Castile and Leon	24,48	6,95	4,29	1,85	0,38	0,42	0,60	10,20	14089	79	51	65,22	0,35	0,58
2003Castile la Mancha	17,91	5,27	2,72	1,23	0,20	0,12	0,10	4,10	12391	50	34	42,01	0,57	0,98
2003Extremadura	17,86	3,00	0,77	1,10	0,53	0,05	3,60	3,50	9838	55	33	43,91	0,50	0,46
2003Catalonia	24,96	3,03	10,36	2,77	0,36	0,73	8,20	61,60	18468	144	71	107,58	0,47	0,49
2003C. Valenciana	20,73	7,00	3,37	1,62	0,51	0,19	4,30	25,50	14705	92	50	70,71	0,43	0,42
2003Balearic Islands	18,94	4,57	0,93	1,59	0,22	0,03	0,70	13,80	18249	56	35	45,24	1,00	1,00
2003Andalusia	19,77	4,76	2,14	1,65	0,44	0,17	1,80	7,10	11353	63	40	51,33	0,37	0,40
2003Murcia	22,92	5,33	3,59	1,34	0,35	0,31	2,80	12,30	12750	75	44	59,61	0,40	0,42
2003Ceuta and Melilla	20,43	5,42	0,10	1,02	0,46	0,50	3,60	24,10	12650	80	40	60,13	1,00	1,00
2003Canary Islands	22,25	7,36	0,86	1,26	0,41	0,12	0,90	10,80	14393	65	41	52,76	0,57	0,69
2003FRANCE	**23,52**	**2,71**	**6,82**	**4,06**	**0,80**	**1,38**	**30,30**	**145,30**	**23385**				0,80	0,79
2003Ile de France	35,00	3,29	5,69	7,81	1,06	2,44	80,70	311,80	26616	161	152	156,69	0,91	0,77

2003Champagne-Ardenne	15,54	2,09	3,82	1,23	0,14	0,35	7,80	78,60	21873	50	44	46,71	1,00	1,00
2003Picardie	16,26	2,57	7,81	1,98	0,15	0,93	0,90	89,80	19040	62	57	59,59	0,64	1,00
2003Haute-Normandie	20,60	2,47	11,38	2,21	0,19	1,42	2,70	102,60	22023	78	74	75,87	0,82	0,96
2003Centre	16,63	3,01	9,06	2,99	0,34	1,22	3,30	121,30	20997	78	73	75,41	0,68	0,72
2003Basse-Normandie	19,71	2,98	7,28	1,93	0,29	0,62	13,60	66,10	19735	67	60	63,77	0,64	0,59
2003Bourgogne	18,35	1,67	7,28	2,24	0,25	0,70	16,00	92,10	21442	66	62	64,06	1,00	1,00
2003Nord-Pas-de-calais	17,54	2,27	6,31	2,81	0,32	0,36	8,50	48,00	18652	59	55	56,59	0,68	0,67
2003Lorraine	18,24	2,07	7,33	3,07	0,49	0,53	5,20	77,10	19312	65	63	64,32	0,73	0,77
2003Alsace	22,43	2,46	13,04	2,63	0,60	0,67	16,80	175,70	23791	94	90	91,92	0,89	0,89
2003Franche-Comte	19,33	2,91	17,44	2,77	0,23	1,98	11,90	148,90	20265	102	97	99,40	0,63	0,63
2003Pays de la Loire	20,41	2,34	6,98	2,65	0,31	0,71	5,30	61,70	20826	64	61	62,50	0,74	0,82
2003Bretagne	23,25	3,02	6,36	3,36	0,53	0,99	54,10	108,10	19933	96	87	91,57	0,68	0,56
2003Poitou-Charentes	18,14	2,33	6,46	2,64	0,31	0,43	4,20	70,70	19180	60	56	57,66	0,67	0,70
2003Aquitaine	20,44	2,32	5,15	3,46	0,41	1,03	3,40	48,10	20899	66	63	64,29	0,76	0,87
2003Midi-Pyrenees	26,45	3,14	6,78	4,65	2,01	1,69	32,90	106,90	20478	121	120	120,17	0,57	0,55
2003Limousin	16,67	3,28	3,71	3,33	0,23	0,46	0,10	50,70	18960	56	49	52,77	0,60	1,00
2003Rhone-Alpes	26,98	2,87	8,63	3,89	0,73	1,55	42,30	243,60	23852	117	110	113,87	0,77	0,74
2003Auvergne	19,28	2,71	4,10	2,11	0,44	1,61	7,50	129,40	20006	74	68	70,98	0,65	0,66
2003Languedoc-	19,89	2,37	2,15	3,63	1,55	0,52	9,30	57,40	17969	75	74	74,50	0,59	0,58

Rousillon														
2003PACA	20,55	2,45	3,99	3,38	0,81	0,92	43,90	113,70	21001	89	83	86,05	0,79	0,74
2003Corse	14,94	4,01	1,86	4,21	0,27	0,15	30,30	14,40	17589	64	53	58,09	0,75	0,69
2003FINLAND	**32,42**	**18,90**	**7,39**	**4,74**	**0,98**	**2,42**	**136,10**	**337,80**	**25337**				0,49	0,28
2003Itae-Suomi	26,78	17,10	4,36	3,30	0,84	0,64	12,00	79,50	18168	58	89	73,07	0,30	0,28
2003Vacli-Suomi	29,32	15,66	7,98	3,00	0,51	1,46	17,70	156,60	20574	66	103	84,68	0,34	0,30
2003Pohjois-Suomi	28,34	16,63	7,59	3,71	1,07	3,29	151,10	323,40	22297	100	182	140,81	0,55	0,29
2003Uusimaa (Suuralue)	40,49	22,32	6,64	7,86	1,34	2,87	286,30	582,40	34898	142	270	206,03	1,00	0,32
2003Etelae-Suomi	30,31	18,69	8,88	3,30	0,76	2,49	112,30	327,90	23395	93	164	128,13	0,54	0,30
2003Aaland	23,30	12,16	1,23	5,86	0,09	0,08	136,10	155,60	33927	63	115	88,96	1,00	1,00
2003IRELAND	**25,40**	**7,66**	**6,89**	**4,30**	**0,37**	**0,80**	**30,70**	**85,60**	**27089**				0,60	0,54
2003Border, Midland and Western	19,64	6,14	7,08	2,61	0,37	0,80	16,10	65,60	19711	80	69	74,85	0,48	0,44
2003Southern and Eastern	27,36	8,17	6,83	4,87	0,37	0,80	36,50	94,20	29734	107	95	100,98	0,64	0,58
2003ITALY	**10,36**	**4,61**	**7,37**	**3,02**	**0,54**	**0,53**	**6,50**	**74,70**	**20165**				0,76	0,75
2003Piemonte	9,60	4,43	13,17	4,06	0,29	1,35	10,10	110,10	23635	137	84	110,58	0,94	0,93
2003Valle D'aosta	6,98	5,93	3,76	1,82	0,02	0,72	8,20	66,30	24341	87	47	67,07	1,00	1,00
2003Liguria	11,54	2,80	5,93	3,16	0,61	0,50	6,70	62,80	21360	95	61	77,96	0,90	0,88
2003Lombardia	11,04	4,51	10,74	3,58	0,30	0,85	19,20	168,60	26589	149	83	115,92	0,99	0,95
2003Trentino-Alto Adige	9,49	6,26	3,84	1,82	0,25	0,22	4,00	68,30	26941	79	49	64,12	1,00	1,00

2003Veneto	9,54	5,51	10,01	2,19	0,28	0,25	4,80	109,90	23526	95	63	79,05	0,90	0,89
2003Friuli-Venezia Giulia	9,41	6,18	9,89	3,28	0,63	0,55	4,70	92,50	22560	111	74	92,29	0,79	0,78
2003Emilia Romagna	11,77	6,37	10,41	2,85	0,46	0,50	5,60	176,70	25523	124	79	101,38	0,80	0,78
2003Toscana	9,84	4,97	5,45	2,38	0,71	0,30	4,70	67,70	22442	91	59	75,07	0,87	0,86
2003Umbria	11,46	6,19	5,66	1,71	0,76	0,16	0,80	32,80	19883	78	55	66,52	0,76	1,00
2003Marche	11,41	4,57	7,45	1,68	0,38	0,14	1,00	55,50	20173	72	51	61,74	0,85	1,00
2003Lazio	13,05	4,58	3,85	5,67	1,34	0,61	5,90	41,50	22312	121	80	100,32	0,73	0,72
2003Abruzzo	11,46	4,68	5,90	2,29	0,52	0,45	1,80	55,00	16543	81	54	67,60	0,57	0,57
2003Molise	10,59	4,54	6,61	1,33	0,30	0,11	1,50	7,70	15574	58	41	49,51	0,71	0,71
2003Campania	8,96	3,36	4,54	2,76	0,66	0,35	1,00	10,40	12908	66	47	56,38	0,58	0,60
2003Puglia	9,45	3,98	3,15	1,64	0,49	0,13	0,70	8,10	13270	53	37	44,87	0,56	0,61
2003Basilicata	8,07	4,81	8,92	1,86	0,64	0,17	1,70	4,20	14511	69	52	60,37	0,68	0,68
2003Calabria	8,81	4,39	1,61	2,67	0,28	0,01	0,20	5,60	12286	46	32	38,98	1,00	1,00
2003Sicilia	9,97	3,49	2,48	1,96	0,66	0,21	4,90	13,20	12935	66	41	53,39	0,55	0,54
2003Sardegna	7,87	5,73	3,28	2,15	0,64	0,06	2,50	12,90	14926	64	43	53,70	0,90	0,93
2003LUXEMBURG	**18,64**	**7,71**	**1,22**	**2,24**	**0,13**	**1,58**	**10,90**	**211,30**	**47200**				1,00	1,00
2003NETHERLANDS	**24,88**	**16,42**	**4,49**	**4,11**	**0,83**	**1,58**	**68,80**	**242,70**	**25286**				0,51	0,38
2003Groningen	24,51	18,21	4,83	3,52	1,40	0,51	26,10	94,20	28264	88	109	98,44	0,65	0,59
2003Friesland	19,14	13,38	5,75	1,44	0,04	1,26	1,80	62,00	20794	57	65	61,35	0,79	1,00
2003Drenthe	16,68	13,97	4,88	2,86	0,83	0,68	8,30	92,80	19986	67	80	73,67	0,44	0,42

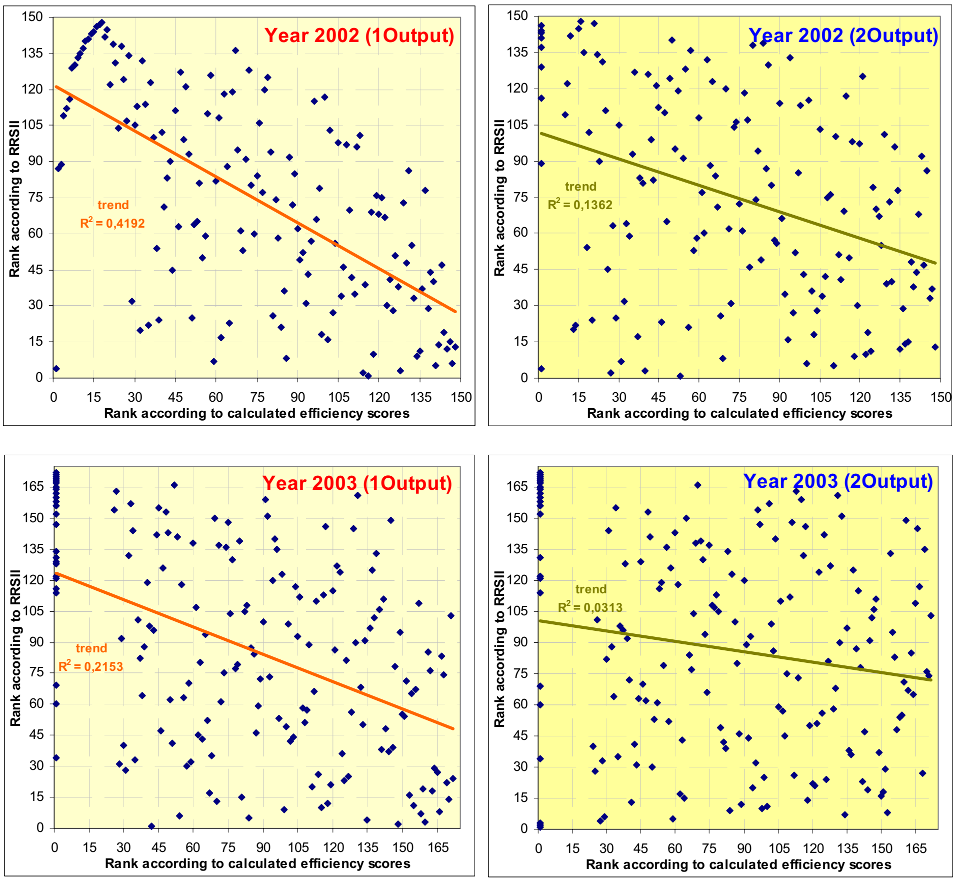
2003Overijssel	19,88	14,42	5,12	2,92	0,60	0,91	27,10	135,20	21472	74	90	81,86	0,45	0,39
2003Gelderland	23,87	15,44	4,30	4,11	0,99	1,05	14,30	146,50	21969	82	101	91,42	0,37	0,35
2003Flevoland	23,08	19,81	2,70	7,33	2,38	0,89	20,10	109,20	18170	105	133	118,85	0,35	0,31
2003Utrecht	33,81	16,71	2,43	6,43	1,41	0,43	35,40	178,20	31900	100	126	112,79	0,61	0,73
2003Noord-Holland	30,67	18,09	2,08	4,21	0,93	0,76	24,00	140,40	29609	84	106	94,65	0,58	0,62
2003Zuid-Holland	25,50	17,62	3,30	5,06	1,01	0,50	22,30	149,70	26310	84	105	94,81	0,51	0,57
2003Zeeland	18,12	14,97	7,63	1,68	0,10	1,03	4,90	106,90	22173	66	75	70,12	0,66	0,73
2003Noord-Brabant	23,24	15,67	7,49	3,70	0,38	2,39	341,90	822,00	25018	175	250	212,65	1,00	0,38
2003Limburg	19,95	15,07	7,83	2,49	0,43	2,72	30,40	213,00	22198	95	113	103,86	0,48	0,42
2003PORTUGAL	**9,36**	**2,85**	**3,33**	**1,45**	**0,57**	**0,27**	**0,70**	**5,50**	**11244**				0,55	0,61
2003Norte	7,10	2,04	3,15	0,93	0,43	0,16	0,60	5,90	9260	80	28	53,94	0,73	0,80
2003Centro	9,11	3,40	3,38	0,88	0,62	0,20	0,10	6,30	8959	86	35	60,07	0,55	0,94
2003Lisboa E vale Do Tejo	12,43	3,52	4,35	2,66	0,72	0,42	1,40	6,50	15024	145	50	97,68	0,54	0,57
2003Alentejo	10,57	4,14	2,41	0,67	0,44	0,06	0,30	0,60	9066	68	29	48,44	0,61	0,99
2003Algarve	6,85	2,01	0,46	0,68	0,31	0,02	0,60	2,60	10908	55	20	37,37	1,00	1,00
2003Acores	4,84	0,96	0,10	0,90	0,56	0,01	0,70	2,00	8547	52	21	36,16	1,00	1,00
2003Madeira	5,07	1,80	0,18	0,29	0,27	0,05	0,70	8,20	12309	63	17	40,17	1,00	1,00
2003SWEDEN	**26,35**	**18,39**	**7,28**	**5,23**	**0,96**	**3,31**	**100,90**	**366,60**	**29323**				0,54	0,38
2003Stockholm	34,76	17,96	4,78	8,78	0,96	4,33	246,00	610,30	40454	138	260	198,97	0,96	0,44
2003Oestra	24,27	18,41	9,89	4,97	0,96	2,79	80,00	362,50	25165	97	167	131,85	0,45	0,33

Mellansverige														
2003Sydsverige	26,39	18,08	6,67	4,97	0,96	3,12	141,70	435,50	27096	103	189	145,98	0,59	0,35
2003Norra Mellansverige	20,07	19,06	5,89	2,84	0,96	1,35	24,50	210,60	25038	69	113	90,92	0,50	0,46
2003Mellestra Norrland	20,92	20,83	5,38	4,59	0,96	0,29	5,90	132,20	26716	66	101	83,46	0,57	0,69
2003Oevre Norrland	24,38	18,45	5,62	3,58	0,96	0,95	78,10	223,80	25309	77	130	103,19	0,64	0,39
2003Smaaland Med Oearna	20,29	16,82	8,31	2,41	0,96	0,65	5,00	128,10	26725	64	97	80,61	0,63	0,72
2003Vacstsverige	26,33	18,96	9,35	4,57	0,96	5,27	48,00	343,40	27871	102	177	139,51	0,43	0,36
2003UNITED KINGDOM	**29,36**	**22,29**	**6,72**	**4,47**	**0,60**	**1,28**	**35,60**	**133,50**	**26096**				0,40	0,34
2003North East	22,41	20,43	8,82	3,14	0,38	0,35	6,00	64,60	20136	67	86	76,26	0,44	0,44
2003North West	24,80	21,22	7,22	3,59	0,34	1,52	12,20	103,40	22670	82	101	91,58	0,36	0,36
2003Yorkshire & the humber	25,09	21,76	5,59	3,16	0,46	0,40	15,30	86,90	22927	71	90	80,53	0,51	0,48
2003East Midlands	24,29	21,12	7,93	3,96	0,38	1,45	13,50	108,90	24411	86	105	95,26	0,38	0,37
2003West Midlands	25,45	21,41	10,49	4,28	0,46	0,78	11,80	97,30	23919	86	106	95,52	0,38	0,36
2003Eastern	26,96	23,04	7,60	5,35	0,55	3,11	94,20	261,30	27031	147	164	155,79	0,49	0,34
2003London	41,66	25,20	2,45	6,23	0,64	0,41	41,00	112,50	38230	102	125	113,53	0,79	0,97
2003South East	33,78	24,11	7,28	6,26	0,78	2,49	74,60	233,20	28754	143	163	153,18	0,40	0,31
2003South West	29,34	22,98	6,98	4,10	0,60	1,37	49,60	145,40	23675	105	124	114,46	0,41	0,31
2003Wales	26,13	19,94	6,58	2,69	0,49	0,34	10,40	69,90	20959	67	85	76,30	0,50	0,47

2003Scotland	32,83	21,88	5,75	3,28	0,82	0,62	18,00	91,20	25290	86	105	95,20	0,52	0,47
2003Northern Ireland	25,23	14,69	5,75	2,60	0,38	0,69	7,70	42,50	20224	60	75	67,66	0,43	0,42

Source: EIS 2003 and author's elaboration.

Appendix IV: RRSII vs Technical Efficiency Scores for 2002 and 2003



Source: author's elaboration.

SUMMARY

Summary: Spanish

El principal objetivo de la presente tesis radica en la comparación de diferentes metodologías de benchmarking para comparar el nivel de desarrollo de los sistemas regionales de innovación. Una de las principales aportaciones que se pretende realizar con ello es determinar por un lado el grado de robustez que las metodologías de evaluación de la capacidad innovadora ofrecen en la esfera regional. Ello conlleva un estudio detallado de los indicadores de I+D e innovación que vayan a ser incluidos en dichas metodologías. Finalmente, y una vez haber observado las principales características así como las debilidades de dichos métodos, se pretende analizar las posibilidades que ofrece el análisis de eficiencia como método complementario en el estudio de la capacidad innovadora. El por qué de la utilización del concepto de eficiencia como propuesta alternativa a las existentes en la bibliografía radica en que las metodologías existentes están principalmente basadas en el concepto de “cuanto más mejor”, ya que su principal fundamento está en la cantidad de recursos utilizados, pero no en la forma en la que son empleados. En este sentido, creemos que la otra gran aportación de la tesis consistirá en mostrar la necesidad de incorporar criterios de eficiencia a las metodologías de evaluación (o benchmarking regional) de la capacidad innovadora.

La metodología de actuación está constituida por tres principales líneas de actuación que se han definido como prioritarias para la consecución de los objetivos planteados con anterioridad:

1.- Comparar metodologías orientadas hacia la determinación de la capacidad innovadora regional en las comunidades autónomas españolas.

Esta primera etapa, a través de la utilización de metodologías orientadas hacia la medición de la capacidad innovadora, pretende analizar en detalle los sistemas regionales de innovación de las comunidades autónomas españolas. Ello nos permitirá por un lado profundizar en el conocimiento de las fortalezas y debilidades de las metodologías seleccionadas, así como aproximarnos a la realidad en la que se encuentran las comunidades autónomas en materia de innovación.

2.- Realizar un benchmarking sobre el Sistema Valenciano de Innovación.

El objetivo de esta segunda etapa radica en determinar los principales indicadores que podrían ser utilizados a la hora de evaluar las capacidades/debilidades de un sistema regional de innovación en una región periférica de la UE. Ello también permitirá acercarnos a la relación existente entre el benchmarking y el aprendizaje en política de innovación regional.

3.- Mostrar la necesidad de complementar las metodologías de evaluación de la capacidad innovadora regional empleando para ello criterios de eficiencia.

En este caso, en base a las conclusiones que se hayan podido obtener de las etapas anteriores, se pretende mostrar la necesidad, y la consiguiente utilidad para los gestores de las políticas de innovación, de manejar conceptos de eficiencia al evaluar las políticas de innovación que se desprenden de los sistemas regionales de innovación estudiados. Con ello, no se pretende ofrecer una metodología alternativa, sino mostrar la necesidad de complementar la información que se pueda concluir de las metodologías existentes con aquella proveniente de la aplicación de un criterio concreto y que consideramos relevante en el estudio de los sistemas de innovación.

Summary: Valencian

El principal objectiu d'aquesta tesi doctoral radica en la comparació de diferents metodologies de "benchmarking" pel que fa al nivel de desenvolupament dels sistemas regionals d'innovació. Una de les principals aportacions que es pretén realitzar amb això es determinar d'una banda el grau de robustesa que les metodologies d'avaluació de la capacitat innovadora ofereixen a l'esfera regional. Això comporta un estudi detallat dels indicadors de Recerca i Desenvolupament (R+D) i innovació que vagen a ser inclosos en les metodologies esmentades. Finalment, i una vegada s'han observat tant les principals característiques com les debilitats dels mètodes esmentats, es pretén analitzar les possibilitats que ofereix l'anàlisi d'eficiència com a métode complementari en el estudi de la capacitat innovadora. El per què de la utilització del concepte d'eficiència com a proposta alternativa a les existents en la bibliografia radica en que aquestes estan basades en el concepte de "quant més millor", ja que el seu principal fonament està en la quantitat de recursos emprats, però no en la forma en que aquests són emprats. En aquest sentit, creiem que l'altra gran aportació de la tesi consistirà en mostrar la necessitat d'incorporar criteris d'eficiència a les metodologies d'avaluació (o benchmarking regional) de la capacitat innovadora.

La metodologia d'actuació está constituïda per tres principals línies d'actuació les quals s'han definit com a prioritàries per a la consecució dels objectius plantejats amb anterioritat:

1.- Comparar metodologies orientades cap a la determinació de la capacitat innovadora regional a les comunitats autònomes espanyoles.

Aquesta primera etapa, a través de la utilització de metodologies orientades cap a la medició de la capacitat innovadora, pretén analitzar en detall els sistemes regionals d'innovació de les comunitats autònomes espanyoles. Això ens permetrà, d'una banda aprofundir en el coneixement de les fortaleses i debilitats de les metodologies seleccionades, així com aproximar-nos a la realitat en què es troben les comunitats autònomes en matèria d'innovació.

2.- Realitzar un benchmarking sobre el Sistema Valencià d'Innovació.

L'objectiu d'aquesta segona etapa radica en determinar els principals indicadors que podrien ser emprats a l'hora d'avaluar les capacitats/debilitats d'un sistema regional

d'innovació en una regió perifèrica de la UE. Això també permetrà acostar-nos a la relació existent entre el benchmarking i l'aprenentatge en política d'innovació regional.

3.- Mostrar la necessitat de complementar les metodologies d'avaluació de la capacitat innovadora regional emprant per això criteris d'eficiència.

En aquest cas, sobre la base de les conclusions que s'hagen pogut obtindre en etapes anteriors, es pretén mostrar la necessitat, i la conseqüent utilitat per als gestors de les polítiques d'innovació, d'emprar conceptes d'eficiència a l'hora d'avaluar les polítiques d'innovació que es desprenen dels sistemes d'innovació estudiats. Amb això, no es pretén oferir una metodologia alternativa, sinó mostrar la necessitat de complementar la informació que es puga extraure de les metodologies existents, amb aquella provinent de l'aplicació d'un criteri concret i que considerem relevant en el estudi dels sistemes d'innovació.

Summary: English

The main goal of this thesis lies in the comparison of diverse benchmarking methodologies aimed at comparing the development state of regional innovation systems. One of the main contributions intended with it is determining the robustness of innovative capacity evaluation methodologies in the regional arena. This involves a detailed study of those R&D and innovation indicators to be included in the above mentioned methodologies. Finally, once the main features, lacks and weaknesses of the previous methods have been observed, we aim at analysing the interest offered by the efficiency analysis as a complementary methodology towards assessing the innovative capacity. The rationale for using efficiency as a complementary proposal to those already existing in the scientific literature lies in the fact that these methodologies are mainly based on a “the more the better” rationale, as their main foundation is the amount of resources employed, but not the way they are used. In this sense, we consider that the fact of illustrating the need of incorporating efficiency criteria in the evaluation (or regional benchmarking) of innovative capacity related methodologies constitutes the other main contribution of this research.

From the set of goals defined above, the working plan of the thesis has been constituted by three main research paths:

1.- Benchmark the Spanish Innovation System.

This first step, by using methodologies oriented to the measurement of the innovative capacity, aims at analyzing the most relevant features of a regional innovation system, in this case, taking all the Spanish regions as the main unit of analysis. It will allow us to deepen first in the understanding of the strengths and weaknesses of the studied methodologies, to then approach the reality of Spanish regions as regards innovation activities.

2.- Benchmark the Valencian Innovation System.

The main target of this second step lies in determining the most suitable indicators to evaluate the capacities/weaknesses of a regional innovation system in a European peripheral region. It will also allow us to approach the relationship between benchmarking practices and the learning in regional innovation policy making processes.

3.- Illustrate the need to complement innovative capacity evaluation methodologies by using efficiency criteria.

According to the conclusions achieved in the previous steps, this stage aims at showing the need, and the subsequent usefulness for innovation policy makers and managers, of using efficiency concepts when evaluating regional innovation policies. With it we do not expect offering an alternative methodology, but showing the need to complement the conclusions to be inferred from the application of the existing methodologies with that coming from the application of a specific criterion that we consider to be crucial in the future study of innovation systems.

PAPERS

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What indicators do (or do not) tell us about Regional Innovation Systems

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This paper analyses some of the methodologies and R&D and innovation indicators used to measure Regional Innovative Capacity in Spain for the period 1996-2000. The results suggest that the approaches examined are not sufficiently rigorous; they vary depending on the methodology and indicators employed.

Therefore, we would suggest that the right balance between quantitative and qualitative approaches could produce a better evaluation of innovation system performance which would be more useful to policy makers and other stakeholders.

Introduction

Innovation has become one of the core issues in European policy. The agreements adopted in the Lisbon and Barcelona Councils (EUROPEAN LISBON COUNCIL, 2000; EUROPEAN BARCELONA COUNCIL, 2002) reflect this trend. Accordingly, innovation policy benchmarking studies constitute one of the main research focuses (BALZAT & HANUSCH, 2003). The results of these studies should allow less favoured territories to learn from the good practice developed by others, and to institute processes oriented towards the definition and implementation of more “embedded” innovation policies (GEORGHIOU, 1998; DÍEZ, 2002).

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The wide sociocultural and economic diversities across regions and countries result in vast differences in the welfare of citizens (FERNÁNDEZ DE LUCIO et al., 2003). There are some regions and sectors that are very active in terms of innovation but at the same time there are others where the number of available qualified personnel is not sufficient to justify investment in the resources and infrastructures necessary to enable high value added activities. The literature (CARLSSON et al., 2002) has suggested a number of reasons for these differences, mainly related to the characteristics of the so called Innovation Systems (IS),[1] and the governance models and public policies (SCOTT, TRUBEK, 2002) that influence these systems. Policies are accordingly needed that are designed to compensate for weaknesses in the innovation system, and to foster capabilities and enable opportunities to be exploited (LUUKKONEN, 2000).

Against this background, the regional dimension has gained in importance, demonstrated by the number of programmes aimed at promoting innovation – RIS (Regional Innovation Strategies), RTP (Regional Technology Programmes), RITTS (Regional Innovation Technology Transfer Strategies), etc. – that have been implemented in the less favoured European regions since 1994 (MORGAN & NAUWELAERS, 2003).

One of the main focuses of research into this framework has been that linked to the indicators employed in the depiction of IS (OSLO MANUAL, 1992, 2005; FRASCATI MANUAL, 1994, 2002; DEN HERTOG et al., 1995; LEYDESDORFF, 2001). Based on the indicators used by the European Commission and various national statistics offices, IS are mostly seen as input-output systems based on the amount of available resources (SAISANA et al., 2003). Thus, there is implicit agreement that there is a gap in terms of the indicators to measure R&D and technological innovation, which are required to study IS in depth (DEN HERTOG et al., 1995; INZELT, 2004; WAGNER-DÖBLER, 2005).

Several studies have proposed methodologies for the measurement of innovative capacity (FURMAN et al., 2002; ARCHIBUGI, COCO, 2004; FABER, HESEN, 2004). The European Commission is introducing a *European Innovation Scoreboard* (EIS) and has implemented the *Community Innovation Surveys* (CIS), which include indicators designed to capture innovative capacity (*European Innovation Scoreboard*, 2002, 2003).

However, much work remains to be done since the existing studies and the available statistics do not take account of institutional aspects, interactions, cooperation agreements, etc. which are considered to be crucial elements of an IS (LUNDVALL, 1992; EDQUIST, 1997; ETZKOWITZ & LEYDESDORFF, 2000). Consequently, it is important to examine the consistency among those methodologies used to determine innovative capacity, so that efforts can be directed towards overcoming their weaknesses.

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[1] LUNDVALL (1992), EDQUIST (1997), OLAZARÁN & GÓMEZ URANGA (2001); FERNÁNDEZ DE LUCIO et al. (2003).

The aim of this paper is to analyse some of the methodologies that use composite indicators (YGLESIAS, 2003; GRUPP & MOGEE, 2004) for the measurement of innovative capacity, taking the Spanish Regions as the main unit of analysis for the period 1996–2000.

The paper is organised as follows. The first section provides a brief introduction to the existing works on IS and the construction of an index to determine their innovative capacity index. The second part describes the process followed to analyse and compare methodologies, and the third part presents the main results of the analysis. The paper concludes by highlighting the most relevant findings.

Methodology

From a theoretical point of view, innovative capacity could be described as "the ability to produce and commercialize a flow of new-to-the world technologies over the long term" (FURMAN et al., 2002). Concepts such as regional innovation potential (NAUWELAERS, REID, 1995), innovative potential (RIBA VILANOVA & LEYDESDORFF, 2001) and regional innovation capabilities (DOLOREUX & PARTO, 2005) are also included in this definition. The innovation policies benchmarking related literature uses a wide variety of composite indicators to measure this capacity (DEN HERTOG et al., 1995; LEYDESDORFF & SCHARNHORST, 2001; NISTEP, 2001; FURMAN et al., 2002; HUGGINS et al., 2004; GRUPP & MOGEE, 2004). However, many of them cannot be empirically verified due to lack of statistical data.

The European Competitiveness Index (ECI) (HUGGINS et al., 2004) is based on 49 variables grouped under three categories: Creativity, Economic Performance and Infrastructure and Accessibility. These groups are further sub-divided depending on whether they constitute inputs, outputs or outcomes of technological innovation, or economic development. The ECI also includes a set of variables to account for employment and R&D expenditures, sectoral productivity, and infrastructures such as motorways and rail links.

Although this was seen to be an original approach, it could not be empirically tested based on data for the Spanish regions. The Japanese NISTEP methodology (NISTEP, 2001) has similar shortcomings in that despite the great diversity of variables it employs, these could not be applied to the regional context.

The study that in recent years has been used most widely (in Europe) is the EIS. The EIS responds to EU interests in identifying the factors responsible for the differences among European regions in terms of technological innovation. The EIS methodology uses 17 indicators across four categories: human resources for innovation, creation of new knowledge, transmission and application of knowledge, and innovation finance, outputs and markets.[2]

The EIS 2002–2003 includes seven of the 17 indicators.[3] It also includes regional GDP per capita as one of the main outputs of an IS. Due to lack of statistical data, these indicators identify as the leaders those regions with the biggest investment in high-technology sectors, while regions that may have great potential and require specifically targeted innovation policies are ignored. We consider that this produces a very biased picture of the European reality; the focus is on high-technology sectors, while aspects such as social and organizational innovation, entrepreneurship and the learning to be developed by low-technology sectors are underrated.

Thus, the EIS comprises a methodology based on two composite indicators which rank the most innovative regions. First, the RNSII (Regional National Summary Innovation Index) is a measure of the ranking of regions within their home country, second the REUSII (Regional European Summary Innovation Index) evaluates every region in comparison to the European average. The indices are calculated as follows:

$$RNSII_j = (100/n) \times \sum_i (X_{ijk} / \overline{X}_{ik}), \quad (1)$$

$$REUSII_j = (100/n) \times \sum_i (X_{ijk} / \overline{EU_i}), \quad (2)$$

where X_{ijk} refers to the value of indicator i in region j of country k; $\overline{X}_{ik}$ is the mean value for indicator i in country k; $\overline{EU}$ refers to the average of indicator i for the EU; and n represents the number of X_i regional indicators considered. Hence, a composite index RRSII [Revealed Regional Summary Innovation Index] is obtained from the unweighted average of RNSII and REUSII.

[2] Human resources for innovation (5 indicators): New S&E graduates (% of 20-29 age class), Population with tertiary education (% of 25–64 age class), Participation in life-long learning (% of 25–64 age class), Employment in medium-high and high-tech manufacturing (% of total workforce), Employment in high-tech services (% of total workforce). Creation of knowledge (4 indicators): Public R&D expenditures (% of GDP), Business expenditure on R&D (% of GDP), EPO high-tech patent applications (per million population), USPTO high-tech patent applications (per million population). Transmission and application of knowledge (3 indicators): SMEs innovating in house (% of manufacturing SMEs), Manufacturing SMEs involved in innovation co-operation, Innovation expenditures (% of all turnover in manufacturing). Innovation finance, outputs and markets (6 indicators): High-tech venture capital investment (‰ of GDP), New capital raised on stock markets (‰ of GDP), New to market products (% of sales by manufacturing firms), Home internet access (% of all households), ICT expenditures (% of GDP), % of manufacturing value-added from high-technology.

[3] The seven indicators in the EIS 2002–2003 are: Population with tertiary education, Participation in life-long learning, Employment in medium-high and high-tech manufacturing, Employment in high-tech services, Public R&D expenditures, Business expenditure on R&D, EPO high-tech patent applications.

This study's objective is to compare approaches to measuring innovative capacity in the Spanish regions. The methodology proposed by a Spanish research group (BUESA et al., 2002) was considered to be the most adequate to compare against the EIS. This is the IAIF (Institute of Industrial and Financial Analysis) methodology which is based on 31 variables. It uses factor analysis to obtain four factors (or main components) that explain 85.5% of the IS variance: Regional and Productive Environment for Innovation, Role of Universities, Role of the Civil Service, and Role of Innovating Firms.

The relative weight of each factor in the final index can be obtained from the total variance explained by each factor in the model. Thus, four partial indexes (one for each factor/component) are derived. The weighting of the variables within each partial index (factor/component) is calculated as a percentage of the degree of interrelation between the factor and a particular variable, and the factor and all the variables included in it.

Table 1. IAIF Index for regional innovation (BUESA et al., 2002)

Factors	Variables	Weighting
Factor1: Regional and Productive Environment for Innovation (37%)	Gross Value Added high and medium technology firms	9%
	Gross Value Added low technology firms	11%
	Employment high and medium technology firms	9%
	Employment low technology firms	11%
	Exports High and medium-high technology firms	9%
	Exports Medium-low technology firms	4%
	Exports Low technology firms	12%
	Spanish patents	8%
	National projects funded by the CDTI	9%
	European Patents	8%
	GDP	10%
Factor2: Role of Universities (24%)	Internal University R&D expenditure (% of GDP)	14%
	Internal University personnel (FTE) in R&D	15%
	University researchers (FTE) in R&D	15%
	Students enrolled in tertiary education	7%
	Graduated Students	8%
	Students enrolled in postgraduate courses	13%
	Defended PhD thesis	14%
	Research quality indicator of university	14%
Factor 3: Role of Civil Service (20%)	Government Expenditure on R&D (% of GDP)	24%
	Government personnel (FTE) in R&D	24%
	Government researchers (FTE) in R&D	24%
	Scientific capital stock in R&D	17%
	Venture capital investment	11%
Factor 4: Role of Innovating Firms (19%)	Firms internal R&D expenditure (% of GDP)	16%
	Internal personnel of firms(FTE) in R&D	15%
	R&D researchers (FTE) of firms	16%
	Firm's technological capital stock in R&D	12%
	Regional distribution of technology centres	15%
	Annual income of technology centres	16%
	Innovation Expenditures	10%

Source: Adapted from BUESA et al. (2002)

The most relevant features of an IS are interactions, path dependence, degree of openness of the system, and other qualitative aspects such as the role of institutions (NAUWELAERS, REID, 1995; DOLOREUX, 2002). However, the methodologies referred to above do not take account of these crucial elements. Hence, they can be considered a preliminary approach to the empirical investigations that within the IS framework try to explain regional differences, but not as a quantitative approach to the evaluation of a Regional Innovation System (RIS).

Indicators: strengths and weaknesses

In this section we aim to identify the variables that will feed into the model to be developed in the next section (see Main Results). First, after reviewing the relevant studies, the variables suggested in the literature were compiled and compared (Appendix Table A-1).[4]

Next, we proceeded to the data acquisition phase, using a variety of sources of data on the Spanish Regions for 1996–2000. These sources included the National Statistics Institute (INE), University Statistics (CRUE), Spanish and Iberoamerican Patents (CIBEPAT), the Centre for the Industrial Technological Development (CDTI) and the Spanish Confederation of Innovation and Technology Companies (FEDIT) statistics.

According to the Nomenclature of Territorial Units for Statistics (NUTS) adopted by the EU and EUROSTAT, the administrative divisions in NUTSII correspond to regions. In the Spanish case, these units coincide with the territorial divisions adopted by the 1978 National Constitution (Article 137), and hence will be the ones used in this paper.

Based on the data gathered, a set of 22 variables was compiled. Their values were normalized to enable comparison between regions.

$$\textit{Normalized Value}_{i,j} = \left(\frac{Value_{i,j} - Value\min_i}{Value\max_i - Value\min_i} \right) \quad (3)$$

This involved the value of every indicator *i* for each of the *j* years to be reduced by the lowest value of i over the whole period, and divided by the difference between the maximum and minimum values of i in the 1996–2000 period.

[4] From the variables suggested in the literature we obtained a list of 90 possible ones.

Main results

First we describe the main steps involved in developing a Regional Innovative Capacity Index for the Spanish regions in the 1996–2000 period, based on BUESA et al.'s (2002) methodology. The aim is to verify the similarities in the results obtained, and test robustness. Second, the process was repeated using the EIS methodology. Finally, the results obtained were compared and the differences noted (YGLESIAS, 2003).

With our first approach we aim at replicating the BUESA et al.'s (2002) study to obtain an Innovative Capacity Index (IAIF') to be compared with the original IAIF. A factor analysis of the main components was applied to the 22 variables which explains 89.2% of the total variance of the system (Table 2).

As shown in Table 1, the original IAIF index accounts for 85.5% of the total variance in the system across four factors. The interpretation of these factors in the original IAIF index might seem self-evident. However, the four categories obtained when the analysis was replicated do not make any sense. The first factor includes almost three quarters (15 out of 22) of the variables in the analysis and therefore explains almost all the variance in the system (54.39%). A comparison of the results obtained with the IAIF and IAIF' indices can be found in Appendix Table A-2.

The ranking is led by Catalonia and the Community of Madrid. The next regions in the ranking are the Basque Country, Andalusia and the Valencian Community. The remaining regions are in relatively similar positions.

As can be seen from the Appendix Table A-2, both sets of indices differ in absolute terms. This is due to the fact that the variables in the original IAIF index (31 in total) do not match completely with those in the IAIF' (22). However, in spite of these slight differences, the rankings of the regions are generally similar with the exception of Castilla Leon, Castilla La Mancha, Asturias, Balearic Islands, and Navarre.

Although it might seem that the IAIF methodology depends to a great extent on the number of variables included, it is relatively robust as shown by the fact that the ranks obtained reflect quite precisely the characteristics of the Spanish regions related to innovation (OLAZARÁN & GÓMEZ URANGA, 2001).

Based on RIBA VILANOVA & LEYDESDORFF's (2001) results, Catalonia, and other Spanish regions, cannot be considered to be Regional Innovation Systems because of their limited system interactivity and the fact that the learning processes related to innovation in policy making are in the very early stages. We acknowledge that from a strong conceptual perspective the Spanish regions might not be considered as examples of Regional Innovation Systems. However, the Regional Innovation Systems approach allows us to compare the pros and cons of different quantitative methodologies for determining regional innovative capacity.

Table 2. Rotated factors matrix

	Components			
	1	2	3	4
Employment in high-tech services	**0.968**		0.210	
Graduated students	**0.968**			
Total workforce	**0.951**		0.205	
GDP	**0.949**		0.262	
Gross value added high-tech services	**0.948**		0.198	0.218
R&D expenditures universities	**0.946**		0.168	
Nº universities	**0.937**	0.114	0.110	
Nº of PhD thesis finished	**0.859**	0.130	–0.158	
Employment in manufacturing	**0.815**	0.205	0.411	–0.290
Spanish patent applications	**0.795**	0.250	0.144	–0.155
Gross value added high and medium-high tech manufacturing firms	**0.787**	0.354	0.444	–0.137
Employment in high and medium-high tech manufacturing firms	**0.781**	0.351	0.451	–0.181
Innovation expenditure	**0.758**	0.322	0.432	–0.150
Business R&D expenditure	**0.778**	0.358	0.374	0.245
Public R&D expenditure	0.739	0.165		**0.602**
EPO patent epplications	**0.621**	0.340	0.581	–0.179
Population with tertiary education (%25 34 years age class)		**0.906**	0.121	0.214
% Gross value added by manufacturing firms		**0.858**	0.161	–0.325
% Gross value added by high and medium-high technology manufacturing firms	0.358	**0.812**	–0.105	
GDP per capita	0.121	**0.666**	0.445	0.424
Employment (%) of tertiary educated people			**0.884**	0.100
Nº technology centres	0.293	0.390	**0.588**	–0.350

Main rotated components: Rotation method, Varimax Kaiser Normalization. The bold figures indicate the factors under which the variables are grouped. This we hope makes the results of the factor analysis easier to interpret.

In order to test the robustness of this methodology, a correlation analysis was carried out between the results obtained from the two indices (IAIF vs IAIF’). As can be seen from Figure 1, the correlation for the year 2000 is not only positive, but also shows a significant increase to 84%.[5] Thus, it can be concluded that the methodology based on the IAIF Regional Innovation index is robust.

We followed the same procedure for the EIS methodology. In this case, and to increase the similarities with the RNSII index, we selected the following variables from the 22 primary measures for Spanish regions in the 1996–2000 period: Population with tertiary education (% of 25–34 age class), Employment in medium-high and high-tech manufacturing (% of total workforce), Employment in high-tech services (% of total workforce), Public R&D expenditures (% of GDP), Business expenditure on R&D (% of GDP), Spanish and EPO patent applications (per million population), and GDP per capita. As before, to test the robustness of the EIS methodology, we conducted a factor analysis of the main components in this set of variable (Table 3).

Table 3. Rotated factors matrix

Total explained variance

Components	Autovalues			Sum of the squared saturations		
	Total	% of the variance	% accumulated	Total	% of the variance	% accumulated
1	4.989	62.363	62.363	2.510	31.378	31.378
2	1.643	20.543	82.906	2.070	25.877	57.255
3	0.488	6.100	89.006	1.697	21.215	78.470
4	0.355	4.435	93.441	1.198	14.971	93.441

	Components			
	1	2	3	4
Tertiary education	0.341	**0.863**	0.157	0.283
Employment in high-tech manufacturing	0.531	**0.804**		
Employment in high-tech services	0.160	0.125	**0.728**	0.643
Public R&D			**0.988**	
Business R&D	**0.564**	0.484	0.377	0.376
Spanish Patent applicat	**0.835**	0.414	0.131	0.148
European Patent applicat	**0.868**	0.327		0.250
GDP per capita	0.563	0.390		**0.688**

Main rotated components: Rotation method, Varimax Kaiser Normalization.

[5] Due to the large number of years considered in the analysis we show the results only for the year 2000. However, the Spearman rank correlation indices were positive for all the years with values above 80% in all cases.

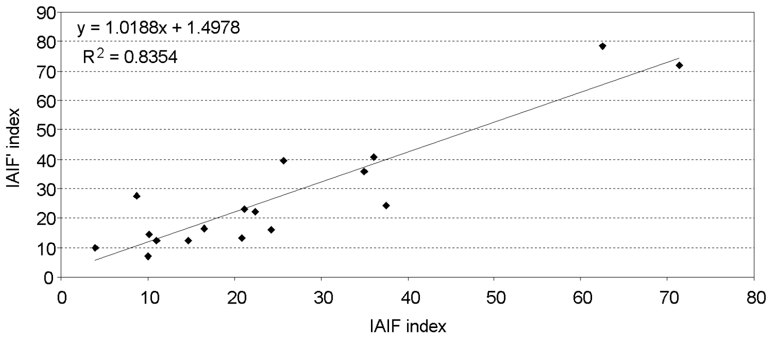

Figure 1. Correlation between the IAIF and IAIF' indices for the year 2000

It is possible to determine 93.4% of the total variance based on four factors. However, their explanation is not as straightforward as the EIS model would suggest, since variables such as Employment in high-tech services and Business R&D expenditure are included in several components and can be considered from various viewpoints.

Applying the EIS methodology to the 8 indicators listed above, an analogous composite indicator (RNSII') was obtained from the original RNSII index. Most Spanish regions show a constant trend over time, with the Community of Madrid ranking 1st since 2002 and 2003, followed by the Basque Country, Navarre and Catalonia (Table 4) with fairly similar scores. These are followed by Aragon which since 1999 has increased considerably, and the Valencian Community which shows a constant trend over time, with Castilla Leon, Murcia and some other regions ranked much lower and displaying lower growth.

As can be observed from the table there is a difference in absolute terms for all the regions except Asturias and Murcia, between 2001 (RNSII') and 2002 (RNSII). The RNSII indices for 2002 and 2003 are obtained directly from the EIS, whilst the RNSII' indices are obtained by applying the EIS methodology to a similar data set. However, the rankings for 2001 to 2002 are virtually the same in relative terms.

If the rankings of the Spanish regions obtained using the two methodologies (IAIF vs EIS) for the 1996-2000 period are compared, some significant differences appear (Table 5).

Table 4. Comparison between the RNSII and RNSII' indices

	RNSII'	RNSII'	RNSII'	RNSII'	RNSII'	RNSII'	**RNSII**	**RNSII**
	1996	1997	1998	1999	2000	2001	**2002**	**2003**
Andalucía	54.43	55.76	56.47	54.23	57.81	56.02	**66.87**	**62.94**
Aragón	100.48	107.94	122.94	127.15	100.85	118.42	**87.21**	**96.47**
Asturias	60.88	58.26	60.91	62.14	70.96	70.72	**70.12**	**64.46**
Baleares	42.53	54.89	45.25	48.36	53.77	54.12	**63.41**	**55.64**
Canarias	51.86	44.71	47.71	44.71	48.02	48.27	**65.38**	**64.80**
Cantabria	66.66	73.26	76.65	77.87	66.91	69.11	**79.88**	**64.08**
Castilla y León	86.48	78.62	75.28	73.30	74.02	74.29	**82.69**	**79.16**
Castilla-La Mancha	44.81	53.58	48.06	43.07	53.46	46.67	**58.45**	**49.78**
Cataluña	153.30	137.55	149.22	134.91	142.33	136.31	**127.37**	**144.06**
C. Valenciana	75.63	83.19	90.33	78.23	90.35	77.16	**85.46**	**91.58**
Extremadura	35.41	37.81	40.42	38.91	40.74	45.20	**55.22**	**55.14**
Galicia	62.56	60.41	63.15	61.21	60.06	64.24	**73.47**	**69.75**
Madrid	144.57	157.79	142.30	137.08	156.46	153.87	**182.04**	**165.80**
Murcia	47.87	57.88	55.17	54.41	65.24	59.45	**62.05**	**74.72**
Navarra	150.32	165.68	160.77	171.00	159.61	159.20	**123.63**	**126.75**
País Vasco	146.07	175.11	154.57	144.69	140.56	155.64	**115.84**	**123.52**
Rioja (La)	73.56	71.19	79.42	73.63	87.89	63.71	**71.17**	**71.19**

Table 5. Innovative capacity ranking of Spanish regions

	1996		1997		1998		1999		2000	
	RNSII'	IAIF'	RNSII'	IAIF'	RNSII'	IAIF'	RNSII'	IAIF'	RNSII'	IAIF'
Andalucía	12	4	13	4	12	4	13	4	13	4
Aragón	5	8	5	8	5	8	5	8	5	9
Asturias	11	14	11	15	11	15	10	12	9	13
Baleares	16	16	14	16	16	16	14	16	14	16
Canarias	13	15	16	14	15	14	15	15	16	14
Cantabria	9	13	8	13	8	12	7	14	10	15
Castilla y León	6	6	7	6	9	6	9	6	8	6
Castilla-La Mancha	15	11	15	10	14	10	16	11	15	11
Cataluña	1	1	4	1	3	1	4	1	3	1
C. Valenciana	7	5	6	5	6	5	6	5	6	5
Extremadura	17	17	17	17	17	17	17	17	17	17
Galicia	10	9	10	9	10	9	11	9	12	8
Madrid	4	2	3	2	4	2	3	2	2	2
Murcia	14	10	12	11	13	11	12	10	11	10
Navarra	2	7	2	7	1	7	1	7	1	7
País Vasco	3	3	1	3	2	3	2	3	4	3
Rioja (La)	8	12	9	12	7	13	8	13	7	12

According to the data in Table 5, the Community of Madrid, Catalonia and the Basque Country are the most innovative regions in Spain over time, for both methodologies. Despite the bigger fluctuations in their rankings, Navarre, Aragon, Castilla Leon and the Valencian Community maintain their relative positions for 1996-2000. Among the remaining regions it should be noted that the relative positions of Extremadura, Andalucia, La Rioja, Cantabria and Murcia are dependent on the methodology.

Figure 2, which is based on the preceding empirical work, shows that the two methodologies applied in the study to determine Regional Innovative Capacity are not closely related. Although their goal is the same, they use different quantitative approaches which encompass some significant methodological differences.

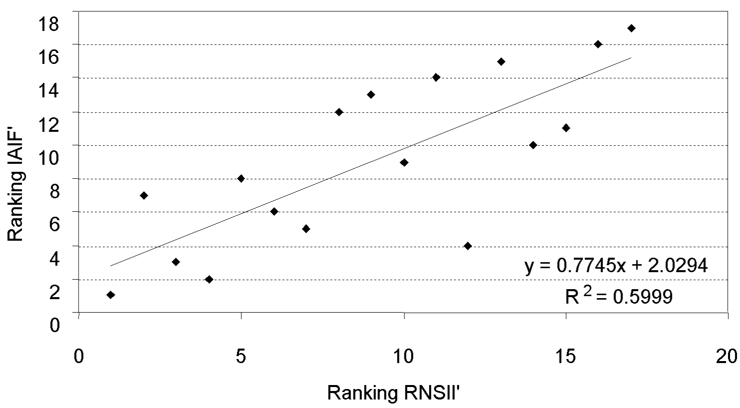

Figure 2. Correlation between the IAIF' and RNSII' indices for the year 1996[6]

Each methodology on its own appears robust, but if the results (ranks) obtained are compared for the two approaches, although there is some correlation, it is not significant.

To sum up, we can say that based on our empirical evidence these two methodologies for measuring Regional Innovative Capacity are not sufficiently robust, since their results are different depending both on the methodology itself and on the indicators applied.

[6] Due to the number of years considered in the analysis we show only the results for 1996. However, the Spearman rank correlation indices were positive for all the years with values above 50% in all cases.

We therefore believe that in light of the wide social, cultural and economic disparities among regions, an index designed to measure innovation would just provide a ranking of the innovation capacity, and would be feasible based on data from “macro” statistics such as those available from Eurostat. Nevertheless, evaluating a Regional Innovation System using a unique index would incur substantial inaccuracies from an economic perspective. In this sense, there is great demand for compatibility among the different approaches and methods used to estimate Regional Innovation Systems, and also for the inclusion in the evaluation of more qualitative aspects (DÍEZ, 2001, 2002).

Conclusions and future discussion

This paper set out to examine the robustness and rigour of some of the methodologies that have been developed for the measurement of innovative capacity (YGLESIAS, 2003), in this case based on an evaluation of the Spanish regions in the 1996–2000 period.

The main conclusion is that the definition of a composite index (SAISANA et al., 2003; GRUPP & MOGEE, 2004) that reflects Regional Innovative Capacity (FURMAN et al., 2002) requires further research and more exhaustive regional data, as well as a clearer theoretical definition of the concept to be measured.

One of the difficulties is the reliability of the data. In most cases the data are based on a representative sample at national level and hence their representativeness at regional level is poor, which is likely to introduce substantial sample errors. In addition, due to changes made by INE in the criteria definition there are differences in the R&D and innovation data depending on the time period, which makes it difficult to obtain comparable time series data. For instance, the data obtained for 1998–2000, are not strictly comparable to the data for 2000–2002.

Among the many weaknesses in the data, a major one is the employment of identical criteria for the measurement of the innovative capacity in very different territories. As a result of wide diversities at both national and European levels, the criteria applied to different territories should reflect their socio-economic structures. Although in the IAIF methodology, the factors grouping several indicators are weighted, which does reflect some of the sociocultural and economic heterogeneity of the territories, the weights are the same for all Spanish regions. In our view, this is a problem that needs to be resolved in future studies.

The weaknesses in the methodologies analysed suggest there should be a major reconsideration of the definition of an Innovative Capacity Index. Since innovation is a relatively new phenomenon, and thus paucity of robust statistical data will be a limitation for some time to come (WAGNER-DÖBLER, 2005), we consider that the individual consideration of a Regional Innovation System will provide a more accurate characterization. In conducting benchmarking studies we would recommend using general statistics, such as those provided by Eurostat or national statistics offices, to identify regions with similar characteristics. This will allow comparison among regions with similar sectoral distributions, social features (FERNÁNDEZ DE LUCIO et al., 2003), historical and/or technologic trajectories, and/or among regions with similar innovation policies (GEORGHIOU et al., 2003). In this sense, the literature concerning the evaluation of innovation policies and systems (DÍEZ, 2001, 2002) advocates for compatibility among quantitative and qualitative approaches in the exercise of an exhaustive evaluation of an IS.

This would allow institutional aspects to be studied taking account of the impact of the legal and institutional frameworks in place and could produce novel and directly applicable results for the definition and implementation of more territorially embedded innovation policies (DÍEZ, 2002), contributing new methodological and conceptual knowledge to the literature in this field.

*

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Appendix

Table A1. Set of variables grouped according to the
European Innovation Scoreboard and FERNÁNDEZ DE LUCIO & CASTRO (1995)

Scientific environment (Input)	
Human resources for innovation	Total R&D personnel (FTE) in the higher education sector
	Total researchers (FTE) in the higher education sector
	Total R&D personnel (FTE) in the government sector
	Total researchers (FTE) in the government sector
	Number of students enrolled in the tertiary education
	Number of students enrolled in PhD studies
Creation of knowledge	Public expenditure in the higher education sector
	Total intramural R&D expenditure in higher education sector
	% of total intramural R&D expenditure performed the higher education sector by source of funds (business enterprise, government, higher education, abroad, private non-profit sectors)
	Total intramural R&D expenditure government sector
	% of total intramural R&D expenditure performed the government sector by source of funds (business enterprise, government, higher education, abroad, private non-profit sectors)
Transmission and application of knowledge	Number of interface structures
	Number of tech transfer offices
Innovation finance, outputs and markets	
Technological environment (Input)	
Human resources for innovation	Employment in R&D services
	Employment in knowledge-intensive high-technology services
Creation of knowledge	
Transmission and application of knowledge	Number of technology centres
Innovation finance, outputs and markets	

Table A1. (cont.)

Productive environment (Input)	
Human resources for innovation	Employment in manufacturing sectors
	Employment in high and medium high technology manufacturing sectors
	Employment in low and medium low technology manufacturing sectors
	Total R&D personnel (FTE) in the business enterprise sector
	Total researchers (FTE) in the business enterprise sector
	Life long learning
Creation of knowledge	% total innovation expenditure in intramural R&D
	Number of firms received public funding from central government, regional or local authorities
	Total intramural R&D expenditure business enterprise sector
	% of total intramural R&D expenditure performed the business sector by source of funds (business enterprise, government, higher education, abroad, private non-profit sectors)
Transmission and application of knowledge	% of enterprises with innovation activities/ number of total enterprises
	High and medium high technology imports
	Low and medium low technology imports
	Number of firms cooperation arrangements on innovation activities
Innovation finance, outputs and markets	Innovation expenditures
	Innovation expenditures in high and medium high technology manufacturing sectors
	Innovation expenditures in low and medium low technology manufacturing sectors
	Creation of private capital/GDP (%)
	Creation of fixed capital/GDP (%)
Financial environment (Input)	
Human resources for innovation	
Creation of knowledge	
Transmission and application of knowledge	
Innovation finance, outputs and markets	

Table A1. (cont.)

Institutional framework (Input)	
Human resources for innovation	Employment rate of university graduates
	Population with tertiary education (% of 25-34 years age class)
Creation of knowledge	
Transmission and application of knowledge	
Innovation finance, outputs and markets	Numnber of new created firms
	Number of new created high and medium high technology firms
	Number of new created low and medium low technology firms
Path dependence (Input)	
Human resources for innovation	Number of universities
	Number of university campus
	Active population
	Occupied population
	Inhabitants
Creation of knowledge	
Transmission and application of knowledge	Investment in ICT
	Number of internet accesses
Innovation finance, outputs and markets	
Scientific environment (Output)	
Human resources for innovation	Tertiary education graduates
	Graduates in humanities
	Graduates in engineering, manufacturing and construction
	Graduates in health and welfare
	Graduates in social sciences
	Graduates in science, mathematics and computing
	PhD theses defended
	Number of publications in ISI journals
Creation of knowledge	
Transmission and application of knowledge	
Innovation finance, outputs and markets	

Table A1. (cont.)

Technological environment (Output)	
Human resources for innovation	
Creation of knowledge	
Transmission and application of knowledge	Degree of penetration of technological advances (ICT) in firms
Innovation finance, outputs and markets	Gross value added knowledge-intensive high-technology services
Productive environment (Output)	
Human resources for innovation	
Creation of knowledge	
Transmission and application of knowledge	
Innovation finance, outputs and markets	Gross value added high and medium high technology manufacturing firms
	Gross value added low and medium low technology manufacturing firms
	High and medium high technology exports
	Low and medium low technology exports
	Gross value added manufacturing sector (%)
	Gross value added high and medium high technology manufacturing firms/gross value added manufacturing sector (%)
	% exports due to new or improved products to the market
	% exports due to new or improved products to the firm
	% turnover of new or significantly improved products to the firm/total turnover
	% turnover of new or significantly improved products new to the market/ total turnover
Financial environment (Output)	
Human resources for innovation	
Creation of knowledge	
Transmission and application of knowledge	
Innovation finance, outputs and markets	Venture capital investments
	Venture capital entities

Table A1. (cont.)

Institutional framework (Output)	
Human resources for innovation	
Creation of knowledge	Patent applications to the OEPM
	High tech patent applications to the OEPM
	Patent applications to the EPO
	High tech patent applications to the EPO
Transmission and application of knowledge	
Innovation finance, outputs and markets	GDP
	GDP per capita
	Commercial balance
	Technology balance high and medium high technology firms
	Technology balance low and medium low technology firms

Appendix

Table A2. Comparison between the IAIF and IAIF' indexes

	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)	IAIF	IAIF'	IAIF-IAIF' (%)
	1996			1997			1998			1999			2000		
Andalucía	27.75	31.27	–12.68	29.41	33.358	–13.42	26.69	36.131	–35.37	26.79	36.801	–37.37	25.61	39.633	–54.76
Aragón	20.57	19.59	4.76	22.89	19.692	13.97	22.13	21.654	2.15	22.03	21.974	0.25	22.37	22.279	0.41
Asturias	15.79	10.263	35.00	17.26	9.955	42.32	15.48	10.223	33.96	15.77	12.057	23.54	20.93	13.094	37.44
Baleares	4.51	6.3	–39.69	3.87	7.13	–84.24	4.14	8.407	–103.07	4.19	9.364	–123.48	4	9.697	–142.43
Canarias	12.85	9.284	27.75	13.11	10.94	16.55	15.23	11.324	25.65	13.47	11.424	15.19	14.65	12.521	14.53
Cantabria	13.29	10.914	17.88	12.95	12.45	3.86	16.35	12.981	20.61	12.58	11.72	6.84	11.01	12.427	–12.87
Castilla y León	7.11	23.298	–227.68	9.51	24.34	–155.94	7.12	25.299	–255.32	7.28	25.921	–256.06	8.73	27.55	–215.58
Castilla–La Mancha	22.46	11.336	49.53	25.96	13.055	49.71	25.65	13.909	45.77	25.79	14.275	44.65	24.27	16.198	33.26
Cataluña	57.73	63.442	–9.89	59.89	64.951	–8.45	60.79	73.889	–21.55	60.66	73.659	–21.43	62.55	78.419	–25.37
C. Valenciana	34.1	26.495	22.30	36.6	29.191	20.24	34.98	31.677	9.44	35.43	32.124	9.33	35.05	35.764	–2.04
Extremadura	5.99	5.35	10.68	9.43	5.542	41.23	8.95	6.586	26.41	7.93	6.502	18.01	10.08	7.065	29.91
Galicia	16.82	18.057	–7.35	21.17	19.378	8.46	19.49	20.901	–7.24	19.87	21.753	–9.48	21.1	23.153	–9.73
Madrid	67.1	58.323	13.08	70.3	62.384	11.26	66.86	64.83	3.04	67.42	68.09	–0.99	71.41	72.039	–0.88
Murcia	14.33	11.627	18.86	16.51	13.039	21.02	15.68	13.316	15.08	16	15.141	5.37	16.47	16.396	0.45
Navarra	36.56	21.424	41.40	37.43	22.692	39.37	36.45	23.352	35.93	37.7	24.996	33.70	37.55	24.374	35.09
País Vasco	37.5	33.478	10.73	39.4	36.719	6.80	40.46	38.707	4.33	38.52	38.641	–0.31	36.12	40.725	–12.75
La Rioja	8	11.265	–40.81	7.79	12.902	–65.62	7.69	12.317	–60.17	9.77	12.056	–23.40	10.18	14.318	–40.65

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EUROPEAN URBAN AND REGIONAL STUDIES

BENCHMARKING INNOVATION IN THE VALENCIAN COMMUNITY

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Abstract

Benchmarking on innovation policies allows less developed territories to adjust their learning processes along with the experiences of others. There are successful territories in Europe where innovation policies have become key to their development, but there are others where this is not the case, as in most Spanish regions. The purpose of this article is to benchmark the Valencian Innovation System, at three levels of analysis: (a) Spanish; (b) Mediterranean; and (c) European regions. Our results highlight its main strengths and weaknesses, which are indicative of the deficiencies in the Valencian industrial structure and the difficulties involved in absorbing newly qualified, highly educated people. The Valencian Community shows relative strengths in those aspects related to public funding while its weaknesses are related to private activities. This structural imbalance drives us to categorize the Valencian Innovation System as weak, unarticulated and unbalanced, which makes us question the real existence of a regional innovation system in the Valencian Community. We consider that support from the regional government should be oriented first towards the definition of some common consensus-based targets in which the main actors are involved. Then second, entrepreneurial activities should be fostered, which may link the existing industrial structure to the public research system in the region. Third, a structural change must be promoted in Valencian universities, with greater emphasis on cooperation with regional firms, and knowledge transfer to SMEs so as to increase their competitiveness.

KEY WORDS ★ benchmarking ★ indicators ★ innovation policy ★ regional innovation system ★ Valencian Community

Introduction

Innovation has become one of the main priorities for most European regions. The agreements adopted in the Lisbon and Barcelona Councils are evidence of this (European Lisbon Council, 2000; European Barcelona Council, 2002). Consequently, innovation-policy benchmarking studies constitute one of the main research focuses in the literature (Hassink, 1993; Dou, 2004).

To provide some support to regions in the development of their innovation policies, the EU launched in 1994 the Regional Innovation Strategies (RIS) initiative to promote the definition of R&D and innovation policies at the regional level. Then, the First Action Plan for Innovation in Europe (European Commission, 1996) provided a structure as well as an analytical method for the definition of innovation policies. Based on this, the 'Trend Chart on Innovation in Europe' was a practical tool for the designers and managers of innovation policies, intended to enable a continuous updating and analysis of available information on innovation policies. The results of the First Action Plan and the Trend Chart should enable less favoured territories to learn from good practice and to institute processes oriented to defining and implementing more territorially 'embedded' innovation policies (Georghiou, 1998). This justifies the increasing attention devoted to benchmarking analyses dealing with R&D and innovation in recent years (Hurmenlinna et al., 2002; Luque-Martínez and

Muñoz-Leiva, 2005) as a process oriented to drive regions to learn from their experiences and from others'.

Within this context should be stressed the key role played by the IRE (Innovating Regions in Europe) Network[1] as a support structure for carrying out benchmarking exercises on innovation policies in European regions. In this sense it has to be added that in December 2006, the Directorate General of Enterprise and Industry launched the PRO INNO[2] platform. This complemented the IRE Network, and aimed to contribute to the development of better innovation policies in Europe, learning from best-practices and transregional cooperation (Perkmann, 2003).

Against this backdrop, the regional dimension has gained in importance, demonstrated by the number of programmes aimed at promoting innovation which have been implemented in less favoured European regions (Henderson, 2000). The great variety of these actions and the innovation policies developed illustrate the structural and cultural diversity as well as the main political priorities of each member state (Fernández de Lucio et al., 2003). The literature has associated these differences with the characteristics of the innovation system (Cooke et al., 1997). In addition, a process of devolution of competences to the regions has been taking place in many European countries. As a consequence, regions have become increasingly important sources of innovation and economic growth.

One of the main focuses of research in these areas has been linked to the indicators used to represent and measure innovation (Oslo Manual, 1992; 2005; Frascati Manual, 1994; 2002; Leydesdorff, 2001). In this sense there is an implicit agreement when recognizing the existence of deficiencies and lacks in the indicators which allow the measurement of R&D and technological innovation (Godin, 2002; 2003). The European Commission has implemented the Community Innovation Surveys and has introduced a European Innovation Scoreboard (EIS) which includes indicators designed to capture innovative capacity (European Innovation Scoreboard, 2002; 2003). This scoreboard enables monitoring of the progress in Europe in relation to the goals defined in the Lisbon and Barcelona Councils.

Within this framework of analysis, this article aims at benchmarking the Valencian Innovation System, making use of the indicators provided by the EIS, Eurostat and national statistics. In relation to the latter, the article by Fernández de Lucio et al. (2001) – who identify the strengths and weaknesses of the Valencian Innovation System according to the main features of its structure, absorptive capacity and articulation – should be mentioned. In our case the analysis will compare the situation of the Valencian Innovation System within Spanish, Mediterranean and European regions. For the Spanish regions, their evolution from 1992–2004 is analysed, while within the different Mediterranean and European regions the analysis is based on the period 1994–2003.

The article is organized as follows. The first section provides the conceptual framework, the methodology adopted, and the data used in the research. The next section presents the main results obtained in this benchmark, and the final section presents the main conclusions achieved as well as some policy recommendations.

Conceptual framework

From a theoretical point of view, Main defines benchmarking as 'the art of finding out, in a perfectly legal and above-board way, how others do something better than you do – so you can imitate – and perhaps improve upon – their techniques' (Main, 1992: 102). Benchmarking thus represents a systematic process which allows improving one's key processes by comparing them with the peak performance of the best-in-class (Hurmenlinna et al., 2002). Similarly, according to Dou, 'Benchmarking could be defined as a system which allows a company and institution or an individual to compare some of their activities with those of the "best in class"' (Dou, 2004: 298).

However, and since we are aiming at benchmarking innovation, innovative capacity could be described as 'the ability to produce and commercialize a flow of new-to-the world technologies over the long term' (Furman et al., 2002: 900). In this sense, the literature offers a broad diversity of composite indicators for measuring this capacity (den Hertog et al., 1995; NISTEP, 2001; European Innovation Scoreboard, 2002; 2003; Grupp and Mogee, 2004; Huggins et al., 2004).

To enhance policy learning and contribute to more appropriate policy recommendations (Benz and Furst, 2002), it is common to use examples of 'best practice' as blueprints for all regions. Use of general statistics and indicators is aimed at highlighting the main strengths and weaknesses of the regions under study (Fernández de Lucio et al., 2001). These general statistics will enable government bodies to identify those aspects where regions and countries are lagging behind. That way, they will also observe the innovation policies being defined, implemented and evaluated by their pairs, which can definitely improve their own policy-making processes. It is to be hoped that this will enable a focus on those institutional aspects which will have the most direct impact on legal and institutional frameworks, allowing more territorially embedded innovation policies to be defined and implemented (Díez, 2002).

As the purpose of this article is to analyse the relative position of the Valencian Innovation System, this regional benchmarking study will be carried out at three levels of analysis: (a) Spanish regions; (b) Mediterranean Regions; and (c) European regions.

First, we have decided to focus on the Valencian Community, because of its structural features. Its regional GDP (€81,781.4m) represents 9.8 percent of the whole Spanish income (€840,106m). This ranks fourth among Spanish regions after Catalonia, Madrid and Andalucia, which have already been studied in the literature (Bacaria et al., 2001; Real Heredia, 2001; Riba Vilanova and Leydesdorff, 2001; Albert and Plaza, 2003). Besides, it has some structural characteristics which cannot be found in any other Spanish region. It's most representative sectors (i.e. wood, tiles, ceramics, toy industry, footwear and textiles) are grouped through industrial districts such as the wood in Benicarlo, tiles in Castellon, toys in Elda, footwear in Elche and textiles in Onteniente. Second, the innovative patterns of firms are not oriented towards R&D activities. On the contrary, firms drive their innovative activities by the acquisition of foreign machinery (INE, 2004). This explains the low–medium technological level of regional firms, which are concentrated on labour intensive subsectors, with an alarming lack of companies in high tech and knowledge-intensive sectors.[3] Third, not only are firms low-technology oriented, but what is more, 66.8 percent of regional firms have fewer than 6 employees, while 96.8 percent have fewer than 50 employees; only 0.02 percent of Valencian firms have more than 1000 employees (INE, 2004). Fourth, universities are the main catalyser of regional research activities, but the existing structural imbalance leads the Valencian Innovation System to be fragmented and disoriented due to the lack of cooperation among firms and the research system (Fernández de Lucio et al., 2001).

The reason why we have decided to divide our benchmark into three stages, and hence include the Mediterranean and European comparisons, is that by doing so we aim to offer a more comprehensive view of the real competitive position of the Valencian Community, not only in Spain, but also in the Mediterranean arch and the whole of Europe. Besides, we consider that the existing high degree of heterogeneity among regions as regards innovation will enrich the contribution of this benchmark.

The Spanish 1978 National Constitution (Article 137) asserts that the territorial divisions in Spain are municipalities, provinces and the autonomous communities. In this sense, the corresponding Territorial Units for Statistics (NUTS) adopted by the EU and Eurostat are the NUTS-II. Hence, we will use the NUTS-II territorial units as the unit of reference for our benchmark.

From a theoretical perspective, we would agree that the Valencian Community, and also most Spanish regions, cannot be considered as 'idyllic' or comprehensive regional innovation systems because of their limited system interactivity and the fact that the learning processes related to innovation in policy making are in the very early stages (Riba Vilanova and Leydesdorff, 2001). So, the regional innovation system's perspective (Cooke et al., 1997) might be considered not to be useful in this context. However, this approach offers a conceptual framework which enables comparison of the relative position of the Valencian Community in innovation: thus we adopt an innovation system's perspective in this article. Besides, the adoption of this common conceptual framework of analysis allows regional authorities to orient their innovation policies according to a systemic view which may cover the identified needs and weaknesses as well as promote those key strengths.

In spite of the multiple approaches found in the literature in the measurement of the innovative capacity, the European Innovation Scoreboard and the indices/indicators it provides are regarded as the main measures of competitiveness in European regions in terms of innovation.[4] Hence we will also adopt this perspective in our study, adapting the indicators to be used as much as possible to the ones provided by the scoreboard. The scoreboard uses 17 indicators across four categories: human resources for innovation, creation of new knowledge, transmission and application of knowledge, and innovation finance, outputs and markets.[5] The 2002–03 scoreboard includes seven of the 17 indicators.[6] Thus, the EIS comprises a methodology based on two composite indicators which rank the most innovative regions. First, the RNSII (Regional National Summary Innovation Index) is a measure of the ranking of regions within their home country; second, the REUSII (Regional European Summary Innovation Index) evaluates every region in comparison to the European average. Hence, a composite RRSII (Revealed Regional Summary Innovation Index) is obtained from the unweighted average of RNSII and REUSII. Based on the RNSII composite indicator, some of the leader regions are above their country average.[7] Hence, it can be concluded that innovative capacity is strongly concentrated in a very few regions in these countries, confirming the existence of 'innovation islands' in Europe (Landabaso, 1997; Clairesse and Muldur, 2001).

Nonetheless, it has to be stressed that despite the great advances made during recent decades in the definition and collection of new R&D and innovation indicators, such as the Oslo and Frascati Manuals, there is still a considerable absence of indicators in this sense (Godin, 2002; 2003).

In both the Spanish and the Mediterranean-European approaches, we want to provide a dynamic perspective which shows how the Valencian Innovation System has evolved in time. In the Spanish benchmark we will use a battery of nine indicators coming from national statistics which draw near the ones employed by the EIS. The next indicators are those employed in the Spanish case for the 1992–2004 period: population with tertiary education (% of 25–34 age class); participation in lifelong learning (% of 25–64 age class); activity rate of the population with tertiary education (% of active population); employment in high and medium–high technology manufacturing sectors (% of employed population); employment in high technology services (% of employed population); business R&D expenditures (% of GDP); public R&D expenditures (% of GDP); innovation expenditures (% of GDP); and patent applications to the EPO (per million inhabitants).

In turn, the Mediterranean-European analysis covers the 1994–2003 period by means of the next 10 indicators obtained by Eurostat: population with tertiary education (% of 25–64 age class); participation in lifelong learning (% of 25–64 age class); employment in high and medium–high technology manufacturing sector (% of total employment); employment in low and medium–low technology manufacturing sector (% of total employment); employment in knowledge-intensive high technology services (% of total employment); business enterprise sector R&D expenditure (% of GDP); government sector R&D expenditure (% of GDP); higher education sector R&D expenditure (% of GDP); patent applications to the EPO (per million of labour force); and high tech patent applications to the EPO (per million of labour force).[8]

Results

The Valencian Community is one of the peripheral Spanish regions, located on the Mediterranean coast, with a total area of about 23,000 square kilometres (4.6% of the country). Its population is around 4.5m inhabitants, (10.5% of the total Spanish population). In 2004 its regional GDP per capita was approximately €17,000, similar to the Spanish average. Its productive structure is mainly constituted by family-owned small firms or small and medium-sized enterprises (SMEs) in traditional manufacturing sectors (i.e. shoes, ceramics, furniture, textile, tiles, toys, etc.), none of which is a knowledge-intensive sector. Hence, the innovation intensity of the region is low. For 2004, the activity rate relates to about 59 percent of the population, and the unemployment rate 11 percent of the active population. In 2004, R&D expenditure in the region was 0.95 percent of regional GDP, of which only 35 percent was attributable to the business sector (INE, 2004), which indicates the small role of firms in relation to public government institutions.

Table 1 Benchmarking the Valencian Community in Spain (1992–2004)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Population with tertiary education													
VC/Spain (%)	80.6	79.0	81.0	83.9	81.0	84.6	88.1	87.2	89.9	82.9	–	–	–
VC/Leader Region (%)	51.7	48.7	73.3	73.6	75.6	72.1	69.9	71.0	81.2	77.4	–	–	–
Position of the VC	11/17	12/17	8/17	8/17	7/17	7/17	8/17	8/17	6/17	6/17	–	–	–
Participation in lifelong learning													
VC/Spain (%)	–	–	–	–	–	–	–	157.24	155.9	152.99	143.37	140.30	140.95
VC/Leader Region (%)	–	–	–	–	–	–	–	85.64	100.0	100.0	98.05	100.0	100.0
Position of the VC	–	–	–	–	–	–	–	2/17	1/17	1/17	2/17	1/17	1/17
Activity rate of the population with tertiary education													
VC/Spain (%)	105.43	101.03	99.87	100.51	96.82	98.86	98.75	99.37	99.63	98.16	98.11	99.25	99.75
VC/Leader Region (%)	99.15	96.32	96.31	97.65	93.27	94.33	93.14	94.75	94.81	93.46	93.30	94.16	94.49
Position of the VC	3/17	3/17	8/17	7/17	15/17	11/17	10/17	9/17	10/17	11/17	9/17	9/17	6/17
Employment in high and medium–high technology manufacturing sectors													
VC/Spain (%)	–	–	–	75.71	75.35	74.97	73.01	72.45	70.94	63.33	65.52	69.20	72.44
VC/Leader Region (%)	–	–	–	31.56	33.74	32.86	32.05	29.85	29.33	29.35	31.44	31.80	33.36
Position of the VC	–	–	–	9/17	9/17	10/17	10/17	10/17	10/17	10/17	10/17	10/17	10/17
Employment in high technology services													
VC/Spain (%)	–	–	–	–	–	–	–	–	70.60	69.67	63.07	61.23	67.49
VC/Leader Region (%)	–	–	–	–	–	–	–	–	27.08	24.70	26.07	27.10	29.57
Position of the VC	–	–	–	–	–	–	–	–	6/17	6/17	10/17	14/17	11/17
Business R&D expenditures													
VC/Spain (%)	33.25	36.34	36.45	38.01	38.01	38.44	26.99	44.38	60.90	38.28	46.05	50.72	53.56
VC/Leader Region (%)	12.31	14.10	14.36	16.76	16.61	17.05	12.71	22.81	33.55	18.41	23.88	27.84	26.55
Position of the VC	10/17	9/17	10/17	11/17	10/17	11/17	14/17	11/17	10/17	11/17	9/17	11/17	8/17
Public R&D expenditures													
VC/Spain (%)	88.19	80.36	89.52	84.27	95.50	97.05	87.47	95.63	96.45	111.89	116.59	113.13	121.23
VC/Leader Region (%)	39.79	38.99	42.16	40.81	48.67	54.42	49.77	53.27	55.04	65.24	69.05	73.53	80.75
Position of the VC	6/17	10/17	4/17	9/17	6/17	4/17	6/17	3/17	4/17	4/17	2/17	2/17	3/17

(Continued)

Table 1 (Continued)

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Innovation expenditures													
VC/Spain (%)	-	-	66.22	-	70.78	-	71.61	-	81.64	-	-	78.24	66.39
VC/Leader Region (%)	-	-	23.24	-	32.30	-	35.49	-	53.10	-	-	49.50	40.53
Position of the VC	-	-	11/17	-	13/17	-	12/17	-	10/17	-	-	8/17	9/17
Patent applications to the EPO													
VC/Spain (%)	81.33	104.73	128.37	105.40	103.25	101.26	105.77	115.74	113.43	104.78	113.23	98.84	-
VC/Leader Region (%)	28.69	43.23	50.95	29.95	45.46	42.68	47.20	48.16	46.42	43.12	44.95	40.37	-
Position of the VC	8/17	5/17	4/17	5/17	6/17	6/17	6/17	5/17	6/17	5/17	6/17	7/17	-

Source: Author's elaboration from National Statistics Institute [INE] and Eurostat.

The Valencian Community in Spain

In this section, we describe the position of the Valencian Innovation System relative to Spanish regions for the 1992–2004 period. As stated above, nine indicators are used in this national benchmarking process. To sum up all the information obtained in the period under study, a comparison between the values for the Valencian Community, the Spanish average, and the leader region(s) is performed for each indicator.

In terms of population with tertiary education, the results show that the Basque Country has the highest percentage of highly educated people, with values above 50 percent in 2001. Navarra, Madrid and Aragon follow with very similar values (about 48%). Extremadura, the Balearic Islands and the Canary Islands are the lowest ranked regions, with 25 percent of their populations having tertiary education. In terms of degree of convergence with the Spanish average, the values are around 80 percent, while with respect to the leader region, the values are around 75 percent.

As regards the participation in lifelong learning, Navarra and the Valencian Community are the best performers with very similar values among them (around 6.5%) and showing substantial differences with the other regions. On the other side of the coin are La Rioja, Catalonia and Cantabria with values close to 2 percent.

Catalonia shows the best results (86.8% in 2004) for the activity rate of highly educated people, with Aragon, the Balearic Islands, Galicia and the Basque Country close to this level. The Valencian Community is in an intermediate position (82% in 2004), close to the national average (99.75% in 2004) and the leader region (94.5%); Asturias is the lowest ranked (76% employment rate). The Valencian Community is shown to have experienced negative growth over the 12 years from 1992–2003, showing some increase in 2004; its position in the ranking has gone down since 1992 when it was third to eleventh in 2001 and finally sixth in 2004.

With respect to employment in high and medium–high technology manufacturing sectors, Navarra, with 12 percent of employment in 2001 and 10.5 percent in 2004, ranks highest, followed by Aragon, Catalonia and the Basque Country with values around 9–10 percent. However, in absolute values, Catalonia alone contributes about 30 percent of the total employment in Spain in these sectors. In the Valencian Community, which ranks tenth, average growth has been negative, decreasing from 4.1 percent in 1995 to 3.5 percent in 2004.

For employment rates in high technology services, the Valencian Community (1.7% in 2004) is lagging behind and close to the more shoddily performing regions such as the Balearic Islands, Castilla La Mancha, Castilla León and La Rioja. However, the Community of Madrid – with 5.8 percent employment in high technology services in 2004 – ranks highest, contributing 40 percent of total employment in high technology services in Spain. Although the period does not allow us to conclude there has been any improvement or worsening, it can be seen that the employment rate in Valencia is only around 27 percent of the leader region and 67 percent of the national average.

In order to alleviate the weaknesses in the high tech manufacturing and services sectors, the Valencian economy should focus on emerging sectors that could generate new technologically advanced and knowledge-intensive jobs. In addition to the attempts being made by most Valencian universities in the form of entrepreneurial programmes and science parks, other efforts designed to promote entrepreneurial activities will be needed. In this respect, the Valencian Business Innovation Centres might play a leading role.

Next we move to analyse the expenditures performed by the business sector in R&D (BERD). The foremost regions are the Community of Madrid and the Basque Country, which both display increasing values above 1 percent. Catalonia and Navarra, with very similar values, are ranked next. Despite the efforts being made by Valencian firms and the fact that a positive trend can be observed (0.15% in 1992, 0.33% in 2004), these are growing at a slow pace such that it is not realistic to talk of any degree of convergence. This low growth can be explained by the sectoral distribution of Valencian firms. As already stated, most of them are SMEs mainly oriented to traditional sectors (Fernández de Lucio et al., 2001; Molina-Morales et al., 2002) where competitive advantage is mainly based on price, and there is little involvement in R&D activities which are mainly developed by universities and public research centres.

Thus, regional authorities must be realistic in acknowledging that the increase in Valencian BERD is still at a very low level, and that there is an urgent need to modify the regional business structure to include more technologically advanced sectors. However, in terms of public R&D expenditure, although the Community of Madrid maintains its lead (0.76% in 2004) – mainly due to the 'capital effect' – the relative position of the Valencian Community (0.4% in 1992 and 0.62 percent in 2004) is significantly improved (ranked sixth in 1992 and third in 2004). That way, the Valencian region, which represented 40 percent of the leader region in 1992 (88% with the national average), had in 2004 a convergence rate above 80 percent (121% with Spain).

These two last indicators show that those regions with higher rates of public R&D expenditure at the beginning of the period – such as the Community of Madrid, Navarra and Aragon – have changed their focus to BERD. This raises the question of to what extent it is necessary to increase public R&D spending in a region and the real effectiveness which public R&D may have on its own territory (Cohen and Levinthal, 1990; Todt et al, 2007). Is it really worth increasing public investment in R&D activities, orienting them towards high technology sectors, if the existing business sector (industrial structure) cannot absorb the advances made by them?

Innovation expenditures are illustrative of the efforts made to introduce successful products in the market. The period analysed is 1994–2000, but it should be kept in mind that the data are not homogeneous. Between 1994 and 1996 there were no changes in the number of sectors included in the innovation survey in Spain. However, from 1998 on, new sectors – such as 'Telecommunication Services' – began to be incorporated (and were included in 2000). Thus, these results should be interpreted with a degree of caution, as growth reflects not only increasing commitment in the Spanish economy to innovative activities, but also the inclusion of new sectors. Aragon is far above all the regions and the national average. The Valencian Community, in spite of the efforts made (average growth rate over the last ten years is 4%), cannot be said to be converging with the leader region and the national average. As already stated, in 2000 most regions show a noticeable increase in their innovation expenses.

Table 2 Benchmarking the Valencian Community in the Mediterranean arch and Europe (1994–2003)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Population with tertiary education										
VC/Mediterranean Leader Region (%)	–	–	–	–	–	53.78	54.12	52.95	51.17	52.89
Position of the VC in the Mediterranean arch	–	–	–	–	–	5/37	5/37	6/37	5/37	5/37
VC/European Leader Region (%)	–	–	–	–	–	20.19	21.41	22.25	22.23	25.12
Position of the VC in Europe	–	–	–	–	–	29/174	29/174	28/174	27/174	24/174
Participation in lifelong learning										
VC/Mediterranean Leader Region (%)	–	–	–	–	–	86.62	75.67	67.94	67.11	72.47
Position of the VC in the Mediterranean arch	–	–	–	–	–	2/37	3/37	3/37	3/37	3/37
VC/European Leader Region (%)	–	–	–	–	–	15.21	15.56	16.06	15.46	16.65
Position of the VC in Europe	–	–	–	–	–	27/174	28/174	25/174	26/174	28/174
Employment in high and medium–high technology manufacturing sector										
VC/Mediterranean Leader Region (%)	25.42	27.56	27.95	27.17	30.27	27.95	26.5	25.39	25.59	27.94
Position of the VC in the Mediterranean arch	14/37	14/37	13/37	15/37	13/37	14/37	13/37	15/37	17/37	14/37
VC/European Leader Region (%)	22.63	21	20.37	17.33	20.65	19.17	17.6	16.71	15.86	17.14
Position of the VC in Europe	67/174	116/174	119/174	126/174	137/174	121/174	128/174	131/174	133/174	131/174
Employment in low and medium–low technology manufacturing sector										
VC/Mediterranean Leader Region (%)	100	100	89.08	84.55	83.55	78.23	81.05	85.89	90.14	80.51
Position of the VC in the Mediterranean arch	1/37	1/37	3/37	4/37	4/37	4/37	4/37	4/37	3/37	4/37
VC/European Leader Region (%)	84.12	77.5	74.36	79.78	73.69	69.29	70.35	73.84	75.12	69.42
Position of the VC in Europe	2/174	6/174	8/174	9/174	9/174	9/174	11/174	10/174	9/174	10/174
Employment in knowledge-intensive high technology services										
VC/Mediterranean Leader Region (%)	29.67	30.51	27.88	30.18	20.85	33.45	28.39	34.76	28.57	24.69
Position of the VC in the Mediterranean arch	20/37	20/37	19/37	19/37	25/37	17/37	19/37	20/37	20/37	21/37
VC/European Leader Region (%)	22.8	22.98	19.54	21.58	15.49	26.26	18.91	23.21	18.47	17.35
Position of the VC in Europe	76/174	120/174	118/174	115/174	133/174	115/174	129/174	120/174	132/174	144/174
Business enterprise sector R&D expenditure										
VC/Mediterranean Leader Region (%)	–	8.93	8.52	9.09	14.37	11.9	16.85	9.78	11.36	12.08
Position of the VC in the Mediterranean arch	–	15/37	15/37	15/37	11/37	17/37	12/37	15/37	15/37	16/37
VC/European Leader Region (%)	–	3.85	4.67	3.68	7.59	4.52	9.03	3.49	8.39	4.29
Position of the VC in Europe	–	92/174	70/174	110/174	73/174	119/174	69/174	116/174	74/174	121/174

(Continued)

Table 2 (Continued)

	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Government sector R&D expenditure										
VC/Mediterranean Leader Region (%)	–	7.21	6.72	5.69	3.31	4.08	6.25	7.86	11.49	10.41
Position of the VC in the Mediterranean arch	–	24/37	17/37	23/37	21/37	25/37	19/37	12/37	7/37	13/37
VC/European Leader Region (%)	–	7.21	3.46	3.28	2.49	3.21	2.59	5.15	6.45	6.66
Position of the VC in Europe	–	79/174	72/174	85/174	95/174	94/174	99/174	83/174	69/174	78/174
Higher education sector R&D expenditure										
VC/Mediterranean Leader Region (%)	–	67.5	64.58	52.46	46.15	41.25	52.31	56.16	66.66	64.71
Position of the VC in the Mediterranean arch	–	13/37	9/37	17/37	13/37	18/37	11/37	5/37	3/37	10/37
VC/European Leader Region (%)	–	28.12	33.33	26.89	23.44	23.57	28.33	32.8	37.5	26.66
Position of the VC in Europe	–	55/174	32/174	59/174	64/174	66/174	65/174	46/174	51/174	55/174
Patent applications to the EPO										
VC/Mediterranean Leader Region (%)	–	–	–	–	–	17.47	15.86	15.79	17.61	13.32
Position of the VC in the Mediterranean arch	–	–	–	–	–	15/37	15/37	15/37	15/37	15/37
VC/European Leader Region (%)	–	–	–	–	–	4.39	3.97	2.95	4.42	4.04
Position of the VC in Europe	–	–	–	–	–	128/174	129/174	129/174	128/174	130/174
High tech patent applications to the EPO										
VC/Mediterranean Leader Region (%)	–	–	–	–	–	4.29	7.36	7.07	6.7	8.99
Position of the VC in the Mediterranean arch	–	–	–	–	–	18/37	17/37	14/37	19/37	13/37
VC/European Leader Region (%)	–	–	–	–	–	0.81	1.26	0.77	0.98	2.67
Position of the VC in Europe	–	–	–	–	–	126/174	120/174	118/174	125/174	97/174

Source: Author's elaboration from Eurostat.

Therefore, it would be interesting to look at the evolution of this indicator in order to clarify whether the observed growth continues at the same rates, or is a consequence of the increased number of sectors.

Finally, according to the results obtained as regards the patent applications to the European Patent Office (EPO), it can be concluded that the Spanish tradition in patenting is very poor, with many regions showing nil growth (the Canary Islands, Cantabria, Extremadura, Castilla La Mancha). Trends in the Valencian Community with respect to the Spanish average and the leader regions (Catalonia and Navarra) are quite uniform (about 100% with Spain and 45% with the leader regions respectively). However, there is a large gap between the leader regions and the rest. In this sense, the Valencian Community ranks seventh after regions such as Navarra, the Basque Country, Community of Madrid and Aragon. The case of La Rioja should be highlighted, in which region from 2000 onwards a noticeable increase has been observed with more than 23 patents (per million inhabitants).

As seen, Valencian competitiveness should be improved through promotion of employment in high technology manufacturing industries and services. This will require universities to play a major role, not only by developing R&D and teaching activities in technologically advanced sectors, but by integrating the knowledge developed in the region and reducing the brain drain effect of highly trained graduates from Valencian universities migrating to other regions such as Catalonia and the Community of Madrid. Increased employment in these high technology sectors, which would contribute to a more knowledge-dependent economic structure, would also entail higher levels of business R&D expenditure and innovation capacity in the region.

The Valencian Community in Europe and the Mediterranean Arch

In this section we study the relative position of the Valencian region in the European and Mediterranean areas.[9] The analysis will focus on comparing the relative position of the Valencian Community and its degree of convergence with regard to the leader region(s) in the ten indicators used.

For population with tertiary education, the Valencian Community ranks 29th in 1999 and 24th in 2004 among European regions. These values are in line with the EU average (close to 90%), despite the fact that in comparison with the leader region for this indicator (Île de France in France) the Valencian Community represents just 25 percent in 2004. Thus, the region is in an advanced position within Europe, with 83 percent of European regions in a worse position, and 16 percent ranking higher. In the Mediterranean area the Valencian Community ranks quite high (fifth position), with 53 percent of the value of the leader region (Catalonia in Spain). Therefore, although the percentage of the population with tertiary education is quite high when compared to elsewhere in the Mediterranean area, within a European perspective this is not the case.

For lifelong learning the Valencian Community stands 27th among European regions for the analysed years. The region represents 15 percent of the leader regions (South East [of England] and London). Its relative position is similar to the one observed in the previous indicator, with 15 percent of the regions ranking higher and 85 percent lower. This trend is also reflected in the Mediterranean benchmark, where the values for the Valencian region correspond to about 70 percent of the level of Lombardia (Italy), leader region for this indicator. In this sense, the region ranks third among the regions constituting the Mediterranean arch (second in 1999 with Andalucia as leader region), with 92 percent of them positioned behind Valencia. These results confirm the predictions already made in the national context.

Employment in high and medium–high technology manufacturing sectors in the Valencian Community represents just 4 percent of the whole employed population, making the region rank very low in Europe, with 17 percent of the values observed for the leader regions (Franche-Comté in France and Stuttgart in Germany). Of the regions in Europe, 75 percent perform better than Valencia and only 25 percent lag behind. In the Mediterranean area the Valencian Community is well below the leader region (Piemonte in Italy), which has 14 percent of its employed population involved in these sectors. The region is in 15th position among Mediterranean regions, 40 percent of them being above this level.

Unlike the results attained for the previous indicator, the Valencian economy ranks really high concerning the employment in low and medium–low technology manufacturing sectors, which confirms the conclusions determined for the Spanish benchmark. About 20 percent of the employed population is involved in these sectors. Within European regions the Valencian Community was second in 1999 and tenth in 2003, representing about 84 percent of the leader region (La Rioja in Spain) in 1999 and 69 percent of Norte (Portugal), the leader region in 2003. Consequently, 95 percent of European regions show lower levels of employment in these low technology oriented sectors. The trend is similar for the Mediterranean arch, where Veneto (Italy) is the leader region with 25 percent of its employed population participating in these low added value activities.

The orientation towards low technology sectors of the region under analysis is once more reinforced by the results observed for employment in knowledge-intensive high technology services. Stockholm (Sweden) acts as the most competitive region in Europe in this sense (more than 8% of the employed population), Lazio (Italy) being the leader region in the Mediterranean arch (5% of the employed population). In both cases the Valencian Community ranks dramatically low with just 17 percent of European regions in a lower position in 2003.

These previous indicators regarding the employment in high and low technology sectors highlight the most remarkable weaknesses of the Valencian Innovation System, and consequently those where the public administration should make the strongest efforts. This endorses the need to promote the creation of new technology-based industries and employment in high technology sectors.

The business expenditure in R&D activities in the Valencian Community illustrates the already observed deficiencies in the structure of the private sector. In 2003 this indicator was 0.29 percent, which represents about 4 percent of the value observed in the European leader region (Braunschweig in Germany). In the Mediterranean arch, Midi-Pyrénées (France) is the leader region with values of over 2 percent. This demonstrates the low levels of business investment in R&D activities in the Mediterranean area in relation to Europe.

Regarding government R&D expenditure, the Valencian Community (0.1% in 2003) is in 78th position among European regions, with 6 percent of that of the leader region (Flevoland in the Netherlands – 1.5% in 2003). The trend is similar in the Mediterranean arch, where the studied region ranked 13th in 2003, representing 10 percent of the values for the leader region (Lazio in Italy). The latter is complemented by the R&D expenditures executed by the higher education sector. In this sense the Valencian Community ranks in some advanced positions both in Europe and the Mediterranean arch. In 2004 the region performed 55th in Europe (10th in the Mediterranean arch), representing 26 percent of the leader region (Övre Norrland in Sweden) and 64 percent of the leader in the Mediterranean arch (Dytiki Ellada in Greece).

In terms of patent applications to the EPO, in 2003 the Valencian Community ranked 130th in Europe and 15th in the Mediterranean arch. These measures represent just 4 percent of the leader region in Europe (Stuttgart in Germany) and 13 percent of the Mediterranean leader region (Emilia-Romagna in Italy). Thus, just 25 percent of European regions (60% of Mediterranean regions) perform lower than the Valencian Community. This indicator shows the severe weakness in the Mediterranean arch in relation to patent applications compared to Europe. These values are in line with those observed for the high tech patent applications to the EPO where Noord-Brabant (Netherlands) and Provence-Alpes-Côte d'Azur (PACA, France) lead respectively. The Valencian Community represents just 2 percent of the value observed in 2004 for Noord-Brabant and 9 percent of the one for PACA. In this sense, a noticeable increase is observed in the performance of the Valencian region from 2002–03, jumping from 125th position in Europe in 2002 to 97th in 2003 (19th in the Mediterranean in 2002 and 13th in 2003). Hence, these patent-related measures have to be analysed with some caution since strong differences are observed from year to year.[10]

Conclusions and recommendations

Great cultural, social and economic diversities can be found in Europe. One of the core aspects of economic growth is technological progress, which is triggered by innovation. There are successful territories in Europe where innovation is becoming the key to development, but there are others where this is not the case, as in most Spanish regions.

Within this framework, benchmarking studies on innovation policies constitute a major focus in the literature. Benchmarking allows one to improve key processes by comparing them with the peak performance of the best-in-class. The results of these studies are allowing the less developed territories to adjust their learning processes to draw on the experiences of other territories, and to establish processes oriented to defining and implementing more efficient and regionally 'embedded' innovation policies. The Regional Innovation Strategies (RIS) initiative developed in many European regions is a clear example of this orientation.

In this context, the concept of innovative capacity has emerged in the literature in relation to benchmarking exercises, including a very diverse set of methodologies and composite indices. However, the literature agrees in the recognition of the existence of deficiencies and lacks in the indicators which allow the measurement of R&D and technological innovation.

As the purpose of this article is to analyse the relative position of the Valencian Innovation System, the regional benchmarking study has been carried out at three levels of analysis: (a) Spanish regions; (b) Mediterranean Regions; and (c) European regions. These three stages aim at offering a more comprehensive view of the real competitive position of the Valencian Community, not only in Spain, but in the whole of Europe.

In general terms, the results of our benchmarking highlight the main strengths and weaknesses of the Valencian Innovation System, from which some policy recommendations can be derived. The Valencian Community shows relative strengths in those aspects related to public funding (i.e. tertiary education, lifelong learning, public R&D expenditures) while its weaknesses are indicated by those measures related to private activities (i.e. employment in medium–high and high technology manufacturing and services sectors, private R&D expenditures, patent applications). The low employment rates in those high technology sectors are indicative on the one hand of the deficiencies in the Valencian industrial structure, based on traditional hand-made sectors such as ceramics, shoes, furniture, toy industry, tiles, etc.; and on the other hand, the difficulties involved in absorbing newly qualified, highly educated people.

These aspects are strongly related to the role of universities. Universities and public research organizations are without doubt the major actors in R&D activities in the region. However, does it really make sense to have an inclusive public research system if the existing industrial structure cannot absorb its advances, graduates, researchers and applications?

This structural imbalance shown by the Valencian Innovation System can be characterized by the next three adjectives: weak, unarticulated and unbalanced. On the one hand, it is weak due to its low technology orientation. It is unarticulated due to the lack of cooperation among the diverse actors which constitute an innovation system. Finally, it is unbalanced due to the fact that the advances made by (in this case) the public research system cannot be exploited by the business sector. These conclusions drive us to wonder in a critical way about the real existence of a regional innovation system in the Valencian Community.

Why should there be such a structural imbalance? In fact, universities and firms in Valencia constitute two sides of a coin. Most European regions are in agreement that the research and business spheres must become more integrated and collaborative. This applies particularly to the Valencian Community. However, due to the traditional character of SMEs (microfirms) it is almost impossible to get them to recognize the advantages of cooperating with the research environment. This lack of interaction constitutes one of the main weaknesses, compromising the future development of the Valencian Innovation System.

We consider, first, that support from the Valencian regional government and the local institutions should be towards the definition of some common regional targets by consensus-based processes in which the main regional actors are involved. Without this common view of the regional economy the innovation system cannot be oriented. Second, entrepreneurial activities should be fostered, which may link the existing industrial structure to the public research system in the region. This orientation may involve an increase in employment and investments in R&D activities made by high technology oriented sectors. As a consequence, a complete renovation in the strategic orientation of sectors such as furniture, ceramics, tiles, toys and shoes could be achieved. Third, a similar structural change must be promoted in Valencian universities, accompanied by greater emphasis on cooperation with regional firms, and knowledge transfer to SMEs so as to increase their competitiveness. It is imperative that the Valencian Community achieves these objectives if it is to continue the growth already achieved and not lose ground in relation to other European regions.

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Notes

1 [http://www.innovating-regions.org/]
2 [http://www.proinno-europe.eu]
3 The high tech firms only represent 8% of regional industrial gross added value, while the low tech firms represent 65% of regional industrial gross added value (INE, 2004).
4 The European Innovation Scoreboard (2002: 12) states that '40 per cent of the variation in per capita regional income can be explained by differences in innovative performance' (RRSII).
5 Human resources for innovation (5 indicators): New S&E graduates (% of 20–29 age class); population with tertiary education (% of 25–64 age class); participation in lifelong learning (% of 25–64 age class), employment in medium–high and high tech manufacturing (% of total workforce); employment in high tech services (% of total workforce). Creation of knowledge (4 indicators): public R&D expenditures (% of GDP); business expenditure on R&D (% of GDP); EPO high tech patent applications (per million population); USPTO high tech patent applications (per million of population). Transmission and application of knowledge (3 indicators): SMEs innovating in house (% of manufacturing SMEs); manufacturing SMEs involved in innovation cooperation; innovation expenditures (% of total manufacturing turnover). Innovation finance, outputs and markets (6 indicators): high tech venture capital investment (% of GDP), new capital raised on stock markets (% of GDP); new to market products (% of sales by manufacturing firms); home internet access (% of all households); ICT expenditures (% of GDP); % of manufacturing value-added from high technology.
6 The seven indicators which constitute the EIS indices for 2002 and 2003 are: population with tertiary education; participation in lifelong learning; employment in medium–high and high tech manufacturing; employment in high tech services; public R&D expenditures; business expenditure on R&D; EPO high tech patent applications.
7 As far as the RNSII composite indicator is concerned, the leader regions in each European Country are: Wien (Austria); Bruxelles (Belgium); Bayern (Germany); Attiki (Greece); Comunidad de Madrid (Spain); Île de France (France); Uusimaa (Finland); Southern & Eastern (Ireland); Lombardia (Italy); Noord Bravant (Netherlands); Lisboa E Vale Do Tejo (Portugal); Stockholm (Sweden); Eastern (UK). In all cases, the same regions have the leadership in both 2002 and 2003.
8 The leader regions for each (Mediterranean/European) indicator are: population with tertiary education (Catalonia/Île de France); participation in lifelong learning (Andalucia-Lombardia/South East-London); employment in high and medium–high technology manufacturing sector (Piemonte/Franche-Comté-Stuttgart); employment in low and medium–low technology manufacturing sector (Valencian Community-Veneto/La Rioja-Marche-Norte); employment in knowledge-intensive high technology services (Lazio- Midi-Pyrénées/Île de France-Stockholm); business enterprise sector R&D expenditure (Midi-Pyrénées/Stuttgart-Eastern-Braunschweig- Västsverige); government sector R&D expenditure (Midi-Pyrénées-Lazio-Languedoc-Roussillon/Midi-Pyrénées-Flevoland); higher education sector R&D expenditure (Ipeiros-Umbria- Languedoc-Roussillon-Dytiki Ellada/Gießen-Groningen-Alentejo-Wien-Övre Norrland); patent applications to the EPO (Emilia-Romagna/ Oberbayern-Noord Brabant-Stuttgart); high tech patent applications to the EPO (Provence-Alpes-Côte d'Azur/Noord-Brabant).
9 The regions that comprise the Mediterranean area are: 5 from Spain (Catalonia, Valencian Community, Murcia, Andalucía and the Balearic Islands); 4 from France (Provence-Alpes-Côte d'Azur, Languedoc-Rousillon, Midi-Pyrenees and Corsica); 15 from Italy (Piemonte, Valle D'aosta, Liguria, Lombardia, Trentino-Alto Adige, Veneto, Emilia Romagna, Toscana, Umbria, Lazio, Campania, Basilicata, Calabria, Sicilia and Sardegna); and 13 from Greece (Anatoliki Macedonia-

Thraki, Kentriki Macedonia, Dytiki Macedonia, Thessalia, Ipeiros, Ionia Nisia, Dytiki Ellada, Sterea Ellada, Peloponnisos, Attiki, Voreio Aigaio, Notio Aigaio, and Kriti).

10 The indicators concerning ICT and Biotechnology patent applications to the EPO (per million labour force) were initially included in the benchmark analysis, but, due to the low degree of homogeneity observed, they were not finally integrated.

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Regional Innovation Systems: How to Assess Performance

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INGENIO (CSIC-UPV), Institute of Innovation and Knowledge Management, Civdad Politécnica de la Innovación, Camino de Vera s/n, E-46022 Valencia, Spain. Emails: jonzait@ingenio.upv.es, pvoigt@ingenio.upv.es, agutierr@ingenio.upv.es and fjimenez@ingenio.upv.es

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ZABALA-ITURRIAGAGOITIA J. M., VOIGT P., GUTIÉRREZ-GRACIA A. and JIMÉNEZ-SÁEZ F. (2007) Regional innovation systems: how to assess performance, *Regional Studies* **41**, 1–12. This paper applies a Data Envelopment Analysis (DEA) methodology to the evaluation of regional innovation system performance based on information provided by the European Innovation Scoreboard (EIS) for 2002 and 2003. Those European regions ranked in the EIS as showing better performance in high-technology areas are ranked somewhat differently according to DEA. The results of the present study show that the higher the technological level of a region, the greater is the need for system coordination. Where this is lacking there is a loss of performance efficiency compared with other similar regions. Policy-making in relation to Regional Innovation Systems (RIS) has in the past depended on systemic analysis. Here, a methodology is proposed that combines quantitative and qualitative analyses to enrich the knowledge base for future policy decision-making.

Regional Innovation Systems (RIS) Efficiency Data Envelopment Analysis (DEA)

ZABALA-ITURRIAGAGOITIA J. M., VOIGT P., GUTIÉRREZ-GRACIA A. et JIMÉNEZ-SÁEZ F. (2007) Les systèmes d'innovation régionaux: comment évaluer la performance, *Regional Studies* **41**, 1–12. A partir des données pour 2002 et 2003 fournies par le European Innovation Scoreboard (EIS), cet article applique la méthodologie de la Data Envelopment Analysis (DEA) à l'évaluation de la performance des systèmes d'innovation régionaux. Il en résulte que le classement des régions d'Europe dont le rang selon l'EIS laisse voir une meilleure performance dans les secteurs à la pointe de la technologie, s'avère différente selon la DEA. Les résultats de cette étude montrent que plus une région est à la pointe de la technologie, plus les systèmes devraient être coordonnés. A défaut de cette coordination, la performance manque d'efficacité par rapport à d'autres régions similaires. Dans le passé, la mise au point de la politique pour ce qui est des Regional Innovation Systems (RIS – des systèmes d'innovation régionaux) dépendait de l'analyse du système. On propose ici une méthodologie qui associe des analyses à la fois quantitatives et qualitatives afin d'enrichir la base de connaissance quant à la future prise de décision.

Systèmes d'innovation régionaux (RIS) Efficacité Data Envelopment Analysis (DEA)

ZABALA-ITURRAGAGOITIA J. M., VOIGT P., GUTIÉRREZ-GRACIA A. und JIMÉNEZ-SÁEZ F. (2007) Regionale Innovationssysteme: Methoden zur Bewertung der Leistung, *Regional Studies* **41**, 1–12. In diesem Beitrag wird die Methodologie der Data Envelopment Analysis (DEA) anhand der Informationen des Europäischen Innovationsanzeigers (EIS) für 2002 und 2003 zur Bewertung der Leistung von regionalen Innovationssystemen eingesetzt. Wir fanden heraus, dass die europäischen Regionen, die im EIS für Bereiche der Hochtechnologie als leistungsfähiger eingestuft wurden, in der DEA etwas anders abschneiden. Aus den Ergebnissen unserer Studie geht hervor, dass bei einem höheren technologischen Niveau einer Region auch der Bedarf an Systemkoordination wächst. Wenn diese Koordination fehlt, geht im Vergleich zu anderen, ähnlichen Regionen Leistungseffizienz verloren. Politische Entscheidungen im Zusammenhang mit regionalen Innovationssystemen hingen bisher von Systemanalysen ab. Hier schlagen wir eine Methodologie vor, in der quantitative mit qualitativen Analysen kombiniert werden, um den Wissensschatz für künftige politische Entscheidungen zu bereichern.

Regionale Innovationssysteme Effizienz Data Envelopment Analysis (DEA)

ZABALA-ITURRAGAGOITIA J. M., VOIGT P., GUTIÉRREZ-GRACIA A. y JIMÉNEZ-SÁEZ F. (2007) Sistemas regionales de innovación: Cómo evaluar el desempeño, *Regional Studies* **41**, 1–12. En este ensayo aplicamos la metodología del análisis envolvente de datos (AED) para evaluar el desempeño de los sistemas regional de innovación basándonos en información proporcionada por los indicadores de la innovación europea, conocido como European Innovation Scoreboard (EIS) para el 2002 y el 2003. Observamos que las regiones europeas que según el EIS muestran un mejor desempeño en áreas de alta tecnología, se clasifican de modo diferente en el AED. Los resultados de nuestro estudio indican que cuanto mayor es el nivel tecnológico de una región, más

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necesario es coordinar los sistemas. Cuando esta coordinación no existe ocurre una pérdida de la eficiencia en el rendimiento comparado con otras regiones similares. Antes la elaboración de políticas con relación a los Sistemas Regional de Innovación (RIS) dependía de análisis sistemáticos. Aquí proponemos una metodología que combina análisis cuantitativos y cualitativos para enriquecer la base de conocimiento que sirva para tomar decisiones políticas en el futuro.

Sistemas Regional de Innovación (RIS) Eficiencia Análisis envolvente de datos (AED)

JEL classifications: O11, O18, O32, O47

INTRODUCTION

Within the context of increasing globalization, regional differences are becoming more apparent. The goal of marginal regions is to close the gap with more developed regions, i.e. to enable economically under performing regions to catch up with more prosperous ones. One of the core aspects of economic growth is technological progress, which it is assumed is triggered by innovation. Since to induce and/or manage innovations is a multidimensional, social, interactive and complex task, analytical studies of these issues must be wide-ranging, and encompass the whole system of innovation (LUNDVALL, 1992; EDQUIST, 1997; BRACZYK *et al.*, 1998). Most of the existing approaches in this area focus on the in-depth examination of a particular region to explore its Regional Innovation Systems (RIS) (BRACZYK *et al.*, 1998); to investigate its internal relations among the actors involved (KOSCHATZKY *et al.*, 2001); and to assess the importance of institutions (TÖDTLING and TRIPPL, 2004). In short, the focus is on the operation of a successful RIS (DÍEZ, 2002). An RIS can be defined as combining a variety of regional settings in order to provide an environment that is conducive to innovation (FERNÁNDEZ DE LUCIO *et al.*, 2003).

It is important to measure system performance as a whole rather than quantifying particular measures or key indicators (LEYDESDORFF, 2001). This should involve an empirical as well as a qualitative[1] assessment (i.e. both numeric and based on a normative 'better–worse' scale). The OSLO MANUAL (1992, 2005) can be seen as an example. Some work has also been done on analysing what is referred to as National Innovative Capacity (FURMAN *et al.*, 2002). In this regard, the European Commission's European Innovation Scoreboard (EIS) and the 'Community Innovation Surveys' (CIS) are invaluable in providing indicators that are increasingly being acknowledged as measures of the performance of European countries and regions. However, when the data are examined in detail, several problems arise, and particularly in relation to cross-country benchmarking analyses, due to the heterogeneity of European regions, the multidimensionality of innovation systems (IS), and differences in the criteria applied by regional (and national) statistics offices.

Based on the indicators provided by the most available data, (R)IS are generally seen as pure technical input–output systems, with an emphasis on the amount of resources employed. However, this simple focus on the empirical assessment of (R)IS performance (based on one or a number of fairly isolated indicators) may provide a biased picture. There is agreement in the literature about the lack of suitable measures (INZELT, 2004) with regard not only to benchmarking system performance, but also to the in-depth evaluation of the particular features of the system (KUHLMANN, 2003). Thus, there is an urgent need to achieve some balance between the data provided by empirical assessment and qualitative analyses in providing an evaluation.

What type of analytical approach should be adopted when studying an IS? And/or which indicators need to be incorporated (and how) does one capture the true performance of a (R)IS? These complex questions require some judgement calls. However, it is nevertheless important to establish how the performance of a complex system such as an (R)IS should be evaluated in a broad sense and to define the appropriate approach and the most suitable indicators.

This paper measures RIS performance by comparing the multi-input–multi-output relationships (later referred to as 'technical efficiency') involved. The literature has called for the consideration of efficiency analyses in the evaluation of public-sector activities such as science and technology (S&T) (GEORGHIOU, 1998; NIOSI, 2002).[2] However, very few studies on the efficiency or RIS have been carried out (SUSILUOTO, 2003), although they have been applied to other areas (KARADAG *et al.*, 2005). The present authors hope that the work described herein will encourage new research directions in relation to the IS and policy evaluation literature, which will provide new evidence and contribute to the literature in these areas. The evaluation of RIS performance in Europe in terms of (technical) efficiency (TE) thus constitutes the main goal of this research. In accordance with EIS and research and development (R&D) and innovation statistics, the amount of resources available within an IS is a crucial aspect. That is, the more resources invested, the more competitive the system will be. Thus, the authors believe that although the identification of these resources is important, the consideration of how efficiently they are exploited, is even more important. It is not evident that those regions with the highest incomes (highest value added, gross domestic product (GDP), etc.) are also the most efficient ones (SUSILUOTO, 2003). The efficiency of use of a system's resources is indicated by the degree to which these inputs generate soaring returns, or whether output results fail to reflect the amount of investment.

ANALYTICAL APPROACH

As indicated above, the aim is to discuss the application of frontier approaches commonly used to estimate efficiency in the context of regional innovation. The aim is to measure technical, cost and allocative efficiency (FARRELL, 1957). Since S&T indicators are being dealt with in order to illustrate regional performance in innovation, it is assumed that an RIS can be characterized by the efficiency of the input–output relation based on a consideration of all relevant inputs and outputs.

This approach challenges the measurement of IS by single-factor indicators (GRUPP and MOGEE, 2004), and it should shed some light on the true performance of particular (R)IS.

Any estimated efficiency score refers to the spatial performance of the related RIS and, thus, can be used to evaluate the entire system by establishing a fictitious optimum for the relationship between input and output and relating observations to that level. From this point of view, RIS are depicted as a technically more or less efficient transformer of inputs into outputs.

It should be remembered that institutional aspects have a role to play within this framework (TÖDTLING and TRIPPL, 2004), and may influence the performance of RIS, and explain some of the variations in individual observations. Therefore, a second dimension should be included in the efficiency analysis. Taking efficiency scores as benchmarks, one needs to examine why one observation shows a lag or an increase compared with another. What are the key variables (institutions, norms, laws, etc.) that affect these differences in RIS performance? How can they be measured? What is their role in overall system performance? As the ultimate aim is to demonstrate the possibilities provided by an efficiency analysis of the RIS in Europe, regional governments and their S&T related policies, norms, laws, funds, etc. require in-depth investigation. This should be seen as an important area for future research.[3]

But what is the point of comparing RIS performance? What does it mean if estimates differ? In spite of the embeddedness of innovation policies (DÍEZ, 2002), it is common in the laying down and evaluation of policy measures and institutional settings to use examples of *best practice* as a blueprint for all regions (KOSCHATZKY *et al.*, 2001). The EUROPEAN COMMISSION (2002, p. 5) stated that:

> The benchmarking of research and innovation policies consists of a mutual learning tool for policy-making, scoreboard and indicators.

Therefore, defining what 'best practice' is becomes a crucial aspect. Since any successful RIS is in reality a very complex framework, it is not easy to identify 'true' and generalizable examples of best practice.

The Lisbon Strategy established the European Trend Chart on Innovation initiative, which was designed to analyse and benchmark innovation policies at European level, and yield information and statistics on innovation policies, performance, and trends in the EU (EUROPEAN INNOVATION SCOREBOARD, 2002). One of the core tools in this initiative is the EIS, which tracks the EU's progress in innovation activities based on 17 indicators divided across four groups. These groups are: human resources for innovation; the creation of new knowledge; the transmission and application of knowledge; and innovation finance, outputs and markets.[4]

The EIS 2002–03 applies seven out of the total 17 indicators,[5] and also includes regional GDP as one of the main outputs of an RIS. These indicators are used to identify those regions with the highest investments in high-tech R&D and innovation-related activities as being the leaders, but take little account of regions with future potential, and those that require specific innovation policies. In the present authors' view this offers a partial picture of the European landscape, focusing only on high-tech activities and underestimating aspects such as organizational and social innovation, entrepreneurship, and the contribution of low-tech small and medium-sized enterprises (SMEs).

According to the data available from the EIS, based on these seven regionalized indicators, two composite indicators can be derived: (1) the Regional National Summary Innovation Index (RNSII), which explains the position of every region within its home country, and (2) the Regional European Summary Innovation Index (REUSII), which refers to the positioning of every region compared with the European average. The indices are calculated as follows:

$$RNSII_j = (100/n) * \sum_i \left(X_{ijk} / \overline{X}_{ik} \right) \quad (1)$$

$$REUSII_j = (100/n) * \sum_i \left(X_{ijk} / \overline{EU}_i \right) \quad (2)$$

where X_{ijk} is to the value of indicator i in region j of country k; $\overline{X}_{ik}$ is the mean value for indicator i in country k; $\overline{EU}$ is to the average of indicator i for the European Union; and n is the number of X_i regional indicators considered.

A composite Revealed Regional Summary Innovation Index (RRSII) can be obtained as the unweighted average of RNSII and REUSII. This index is designed to pinpoint 'local leaders', taking account of the region's relative innovative performance both within the EU and within the country of origin. Thus, the RRSII seems to be the most appropriate measure to compare RIS efficiency scores with the corresponding Scoreboard indicators.

Since the Scoreboard indicators are resource-based indices, a region that invests more resources and thus obtains a higher RRSII will be ranked higher than regions whose investments are lower. However, this does not mean that the competitiveness of the former group will be higher (i.e. their RIS is better) than that of other regions. The efficiency measurement approach aims at providing information about the use (misuse) of these resources. Due to the different perspectives of these two approaches, it is possible that different 'best-practice examples' will be identified and could, rightly or wrongly, become the blueprints for well-meaning but perhaps mistaken policy adjustments.

METHODS

The accurate empirical evaluation and explanation of any unit's performance is a very complex task, regardless of the analytical context. Generally, the notion of efficiency relates a vector of inputs to a vector of outputs. Unfortunately, in public sector analyses all three definitional elements of efficiency (inputs, outputs, and the functional relation of the two) are affected by severe conceptual and measurement problems (LOVELL, 2002). Hence, in analysing RIS, one is dealing with a multi-input, multi-output relation, in which inputs as well as outputs might be heterogeneous and sometimes not even comparable. Time, history and stochastic influence may affect the system, and output generally is lagged (EDQUIST, 1997). All these factors have to be considered in establishing a database and an appropriate model for an efficiency analysis of public sector activities in general, and they are even more important with respect to RIS since it comprises a mix of private and public activities.

There are two general approaches to measuring efficiency: (1) parametric models, such as Stochastic Frontier Analysis (SFA; e.g. KUMBHAKAR and LOVELL, 2000), and (2) non-parametric models, such as Data Envelopment Analysis (DEA; COOPER *et al.*, 1999) and Free Disposal Hull (FDH; DEPRINS *et al.*, 1984). Both approaches have been developed straightforwardly with considerable model-specific enhancements of the basic frontier concept and, depending on their individual strengths and limitations, are frequently applied to empirical analyses (CHERCHYE *et al.*, 2001; MARTIN *et al.*, 2004).

It has frequently been claimed that the DEA has certain advantages in the analysis of public sector activities (CHARNES *et al.*, 1994; MARTÍNEZ CABRERA, 2003) and semi-public activities such as RIS. Thus, DEA represents a new approach to learning from outliers and inducing new theories of best practice (CHARNES *et al.*, 1994). Therefore, DEA was chosen for this analysis.

According to the DEA methodology every convex combination of feasible production plans is also feasible (FARRELL, 1957; CHARNES *et al.*, 1994). In fact, the assumption of convexity, even if widely used in economics, could be important in terms of methodological strengths and limitations (CHERCHYE *et al.*, 1999). It could be argued that in this context the production technology (in this case, regional innovation) might allow increasing returns-to-scale (i.e. outputs increase faster than inputs). For the very highly aggregated context being analysed here, this seems to be of minor interest,[6] but for not so aggregated studies in which particular technologies are analysed (MARTIN *et al.*, 2004) it could be crucial.[7]

Database

The database was compiled from information from the EIS covering 161 European regions for 2002 and 187 regions for 2003 (country aggregates as benchmarks included).[8] Although these indicators are supposed to characterize adequately the performance of an IS,[9] the question with regard to the frontier analysis concerns what one considers to be an input and/or output. Since increased competitiveness and better social conditions are among the common goals of political measures, and are a main objective of RIS, GDP per capita can be considered to be an output (system performance) indicator. However, what about patents, for instance? Are they inputs or outputs? Or even both? In order to answer these questions, one has to reflect on the causal relationship: (1) are patents, in the sense of a property right, more of an input for high- and/or medium-tech industries operating within a certain region than (2) a countable output of successful R&D in the sense of a satisfactory working environment, such as productive higher education institutions (HEI), industry interactions, functional networks, etc., in other words, a successful RIS?

The literature suggests that patents can be considered to be one of the main outputs of an RIS (BROUWER and KLEINKNECHT, 1999; Ernst, 2001), but when this was tested for in the present authors efficiency analysis, the empirical results were very similar.[10] In other words, considering patents only as innovation outputs (which they are) and not also as inputs (benefits) for industry in general should perhaps be reconsidered (GRILICHES, 1990).

Due to the lack of any other regional indicator for output in the present study, patents were used but at the same time – following AZAGRA CARO *et al.* (2003), who argue that the acquisition of patents could increase the innovative competitiveness of industries – patents are also considered to be an input. Therefore, in the context of the measurement of RIS performance, patents might constitute more of an input than an output[11] in regional GDP.

The indicators employed in the efficiency model are those provided by the EIS. Thus, the indicators considered as inputs for the frontier model are: higher education (the percentage of the population between

25 and 64 years of age with a higher education), lifelong learning (the percentage of the population between 25 and 64 years of age participating in lifelong learning activities), medium/high-tech employment in manufacturing (the percentage of the total workforce), high-tech employment in services (the percentage of the total workforce), public R&D expenditure (the percentage of GDP), business R&D expenditure (the percentage of GDP), and high-tech patent applications to the European Patent Office (EPO) (per million population); and the measure of RIS output is regional GDP per capita.

EMPIRICAL RESULTS

Fig. 1 illustrates the distribution of RIS efficiency scores obtained from the frontier estimations (2002 on the left, 2003 on the right).[12] The overall mean of the calculated RIS efficiency scores rose from 0.60 in 2002 to 0.64 in 2003. Even if this trend is seen as promising, it indicates that there is a huge potential for improved RIS performance. In other words, according to the empirical results, RIS potentials are widely under-exploited in Europe (by more than one-third on average). This is on the basis of already existing best-practice examples and not of a hypothetical 'optimal RIS', which could shift the frontier significantly.

It was found that a number of regions had highly efficient RIS (see the bars on the right-hand side of each histogram). Since the methodology is designed to look for best-practice examples and take them as a benchmark (with respect to each of the seven input dimensions), one can expect a relatively high number of observations to be 100% efficient since all those regions with the lowest values for any indicator will be considered as being technically efficient. In fact, this is the case for most Greek, Portuguese and Spanish regions where low technology sectors are widespread and the regional institutions have few innovation policies.[13] Theoretically, most observations could be expected to be close to the frontier and to behave as efficient units, but the histogram shows there is wide variance in RIS performance in Europe.

With regard to the position of each region in relation to the frontier (level, near, far away) and its related TE score, all observations can be ordered by their achieved RIS efficiency. This ranking was compared with that provided by the RRSII, which according to the EIS measures innovation competitiveness of European regions. In Fig. 2(a, b) the two rankings are related: the *y*-axes refer to the RRSII index (a region's position in 2002 (3a) and 2003 (3b), respectively), and the *x*-axes refer to the efficiency-based RIS values (TE).

If the two performance indicators coincided, one would expect the majority of points to be along a 45° line. But this is not the case. Indeed, the trend line has a negative slope, which indicates a negative relationship. Rank correlation coefficients for the two indices were calculated in order to check this evidence empirically. The Spearman rank correlation coefficients for 2002 and 2003 rankings are −0.645 and −0.453, respectively. In addition, the rank correlations for the subsequent years in each index were considered in order to see whether the variation in the scores and/or rankings was random. This yielded positive scores: 0.74 for the TE ranking and 0.91 for the RRSII. Thus, both indices are consistent from an empirical point of view as the measures obtained are robust, and therefore it can be said that there is a difference in the 'best-practice examples' identified. To some extent the rankings are reversed, therefore, as argued above,

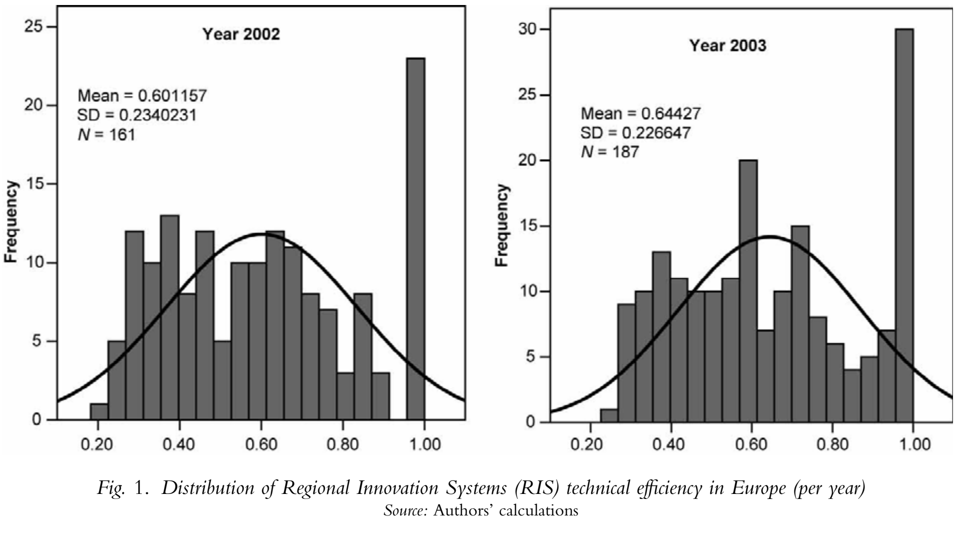

Fig. 1. Distribution of Regional Innovation Systems (RIS) technical efficiency in Europe (per year)
Source: Authors' calculations

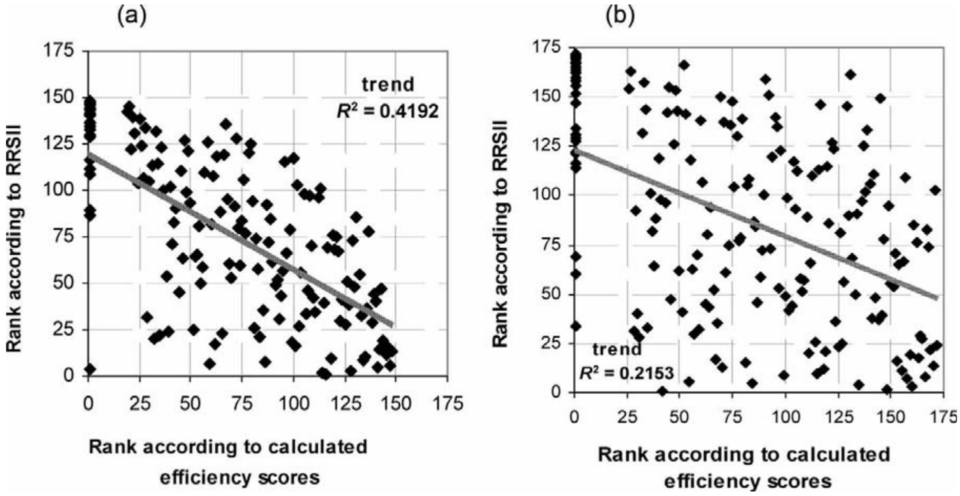

Fig. 2. Ranking of Regional Innovation Systems (RIS) performance according to Revealed Regional Summary Innovation Index (RRSII) and technical efficiency (TE): (a) 2002 and (b) 2003
Source: Author's calculations

radically changing the 'blueprint' on which policy recommendations are based. The negative relation of these indices must result from their different conceptual settings, since the measures employed in both cases are the same. While the RRSII is created as a measure mainly oriented to the inputs in the system in the sense of 'the more the better', the efficiency measure refers to the how these resources are used relative to a particular output. The RRSII, on the other hand, takes account of the relative position of a region in relation to the national average and to the EU average, whilst the efficiency index allows a comparison between the difference levels of regional performance since it compares among regions.

Thus, although a region that is at the top of the TE ranking but which employs very few RIS resources might be efficient in terms of resource use (top in terms of TE), in terms of enhancing regional development, closing the gap in growth rates, social welfare, etc., this same region might be contributing very little and be classed as lagging. On the other hand, a region that invests huge amounts of resources to improve its innovation system (i.e. is top in terms of RRSII), but whose use of resources is identified as inefficient compared with the peer group of best-practice regions, cannot be seen as an example of best practice. Hence, in order to assess the performance and institutional quality of an RIS both aspects must be considered. The policy evaluation-related literature agrees about the need to combine different approaches, methodologies and indicators to avoid a biased picture of system performance (KUHLMANN, 2003).

Taking this into account, the present authors checked the estimates for those regions with a relatively high ranking in both indices, i.e. comprehensive RIS and highly efficient use of available resources. Some regions were found that might be considered to be examples of best practice and these were used as blueprints for policy recommendations, including London/UK and Ile de France/France, which were consistently among the top ranked regions with respect to both RRSII and TE scores. On the other hand, some regions such as Itae-Suomi/Finland, Chemnitz/Germany and Andalusia/Spain had a low ranking in both indices. A significant number of regions were either ranked high in terms of RRSII but low for TE (e.g. Noord-Brabant/the Netherlands, Uusimaa/Finland, Sydsverige/Sweden, Eastern/UK), or vice versa (e.g. Aaland/Finland, Friesland/the Netherlands, Balearic Islands/Spain, Kriti/Greece, and Algarve/Portugal).

Taking into account the spatial distribution of the empirical TE scores, some common clusters can be distinguished (Fig. 3): Northern France (Champagne-Ardenne, Picardie, Haute-Normandie, Bourgogne, Ile de France and Alsace), Luxembourg, Northern Italy (Piemonte, Liguria, Lombardia, Trentino-Alto Adige, Veneto, Emilia Romagna), and Southern/Western Germany (e.g. Baden-Württemberg, Ober- and Nieder-bayern) all score fairly high for TE. However, there are many examples of relatively high as well as relatively low TE rankings across all European countries, which justifies the approach of relating all regions to a common frontier (a peer group of regions identified as examples of best practice).[14]

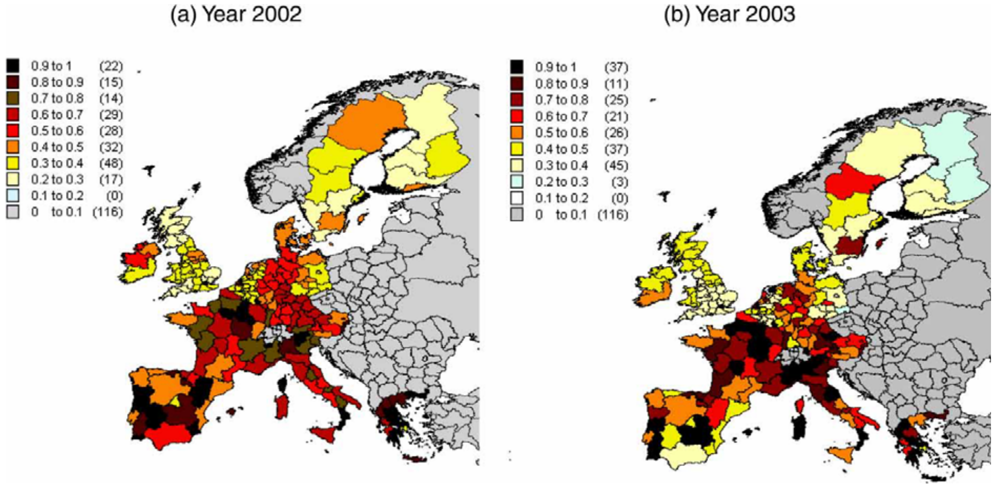

Fig. 3. Spatial distribution of calculated technical efficiency (TE) scores: Regional Innovation Systems (RIS) in Europe: (a) 2002 and (b) 2003

Source: Author's calculations

The need to harmonize the RRSII and TE indices is demonstrated by the results for the Spanish RIS (Table 1). According to the published statistics (EUROSTAT, INE) Madrid is seen as the leading Spanish region in terms of RIS-related efforts. Thus, it is not surprising to find Madrid among the top ranked regions across Europe (RRSII positions: 10th in 2002 and 23rd in 2003). However, in terms of Madrid's resource allocation and use, its ranking is low (estimated TE rankings of 118th and 125th for 2002 and 2003, respectively, across all European regions). The results for Catalonia are similar.[15] In contrast, regions such as Navarre and the Basque Country[16] – both with well-performing RIS (OLAZARÁN and GÓMEZ URANGA, 2001) – are more efficient and competitive in terms of RRSII. Some Spanish regions (e.g. Valencia) are medium/low in terms of both allocation and the efficient use of resources. Some regions, such as the Balearic Islands and Castilla la Mancha, invest comparatively small amounts of resources to RIS, but use them highly efficiently.[17]

Having identified both the best and the least efficient regions, there remains the question of how to close the gap? Or, in other words, to identify what hampers or restricts the efficiency of an RIS. The solution is direct action in terms of regional development and regional policies.

The results obtained might perhaps be explained by the complexity of innovation and thus the need to coordinate the activities promoted by innovation policies (FRENKEN, 2000). Those countries with higher R&D expenditure levels, which have a tradition of good science and are therefore oriented towards high-tech industries, tend to risk more in terms of their innovation policy proposals (CARAYANNIS *et al.*, 2005). As a result, the systems in these countries receive more inputs and make more effort to be better coordinated, and consequently are likely to be ranked as less efficient, since management activities absorb a great deal of attention (GEORGHIOU, 2001). Similarly, those territories with lower absorptive capacity and fewer resources adopt the embodied knowledge and the innovations of others, which involves lower levels of development, but at the same time are efficient since risk is avoided, and the 'new' knowledge is rapidly adopted (FERNÁNDEZ DE LUCIO *et al.*, 2003).

When one focuses on the national level in relation to Spain, the results follow the above patterns. Those regions, such as Madrid and Catalonia, that devote greater amounts of resources to R&D and innovation activities are considered, based on the RRSII scale, to have the most comprehensive RIS. Their innovation policies are oriented to a great variety of emerging sectors, requiring a great deal of coordination among institutions and agents. These initiatives render the systems very dynamic, but the high levels of coordination required reduce their levels of efficiency. Those regions with fewer resources to invest have to pay much more attention to how they are used. They cannot afford to squander the scarce resources dedicated to innovation activities. Their more cautious behaviour produces unexpected and unforeseen efficiencies.

The importance of innovation policies being embedded in their territory must not be overlooked (DÍEZ, 2002). Therefore, it can be said that innovation policies as well as territories, agents and institutions are path-dependent, and thus policies based on best-practice

Table 1. Revealed Regional Summary Innovation Index (RRSII) and technical efficiency (TE) scores and rankings of Spanish Regional Innovation Systems (RIS), 2002 and 2003

	RRSII score		Rank according to the RRSII		TE score		Rank the according to the TE score	
Region	2002	2003	2002	2003	2002	2003	2002	2003
Galicia	60.26	59.35	115	135	0.471	0.599	96	96
Asturias	58.48	53.63	117	145	0.461	0.467	100	129
Cantabria	68.45	55.61	100	142	0.811	0.855	37	44
Basque Country	96.51	98.69	50	47	0.676	0.825	55	46
Navarre	102.91	100.09	36	45	0.554	0.724	85	62
La Rioja	61.22	57.42	114	138	0.834	0.729	34	60
Aragon	75.10	77.97	87	87	1.000	0.636	1	85
Madrid	140.06	127.51	10	23	0.367	0.487	118	125
Castilla Leon	68.88	65.22	98	117	0.444	0.576	105	104
Castilla la Mancha	48.78	42.01	138	163	0.894	0.981	25	27
Extremadura	47.67	43.91	139	161	0.981	0.459	22	131
Catalonia	100.24	107.58	42	36	0.425	0.488	110	124
C. Valencian	69.10	70.71	97	106	0.430	0.422	108	140
Balearic Islands	51.81	45.24	134	158	0.866	1.000	28	1
Andalusia	55.91	51.33	125	149	0.573	0.395	79	145
Murcia	52.45	59.61	133	133	1.000	0.422	1	139
Canary Islands	54.90	52.76	130	148	1.000	0.686	1	75

Source: Author's calculations.

examples will only be successful under certain conditions (GEORGHIOU, 1998; DÍEZ, 2002). Thus, it is crucial that regions learn from evaluations (SHAPIRA and KUHLMANN, 2003) in order to reorient their policies to their particular circumstances.

In Europe there are several efforts that are encompassed by the 'new governance' (SCOTT and TRUBEK, 2002). The open method of coordination (BORRÁS and JACOBSSON, 2004) is one such and is a new model for coordination, learning and policy integration. These new governance methods see efficiency as the key issue in the analysis and evaluation of policies.[18] The evaluation of the efficiency of public (S&T) policies constitutes one approach to analysing a region's ability to use its basic productive resources to improve the welfare of the region (SUSILUOTO, 2003).

In this way, efficiency estimates provide direct answers when considering an inadequate allocation of resources (too much of x_n, not enough of x_{n+1}, etc.). The calculation can be broken down to show efficiency in relation to each (input) dimension.[19] The following could be applied to analyse existing inefficiencies, arising from under or over allocation of a particular input:

$$1 - \mathrm{TE} = |\mathbf{E} - \mathbf{X}|\mathbf{X} \quad (4)$$

where $\mathbf{X}$ is an $i \times j$ matrix of inputs as defined above; and $\mathbf{E}$ is an $i \times j$ matrix of input efficiency levels. Hence, if $\mathbf{E} = \mathbf{X}$, it follows that TE $= 1$. $\mathbf{E} \neq 0$ refers to TE < 0.

Thus, one can measure empirically whether a certain input is allocated and used to the best advantage with respect to the frontier, which may serve as a useful empirical indicator for the formulation of policy recommendations. Since there are data for 161 regions in 2002 and 181 in 2003, and seven inputs for each RIS, for reasons of space this measurement cannot be presented in detail.[20] Institutional restrictions have to be considered, and their role could be analysed by regressing the TE scores for the effects of an ad-hoc selection of explanatory variables reflecting the current status of the institutions in each system. This will be the subject of a future study.[21]

CONCLUSIONS

This study set out to evaluate RIS performance. The approach was based on a well-known methodology comprising efficiency measures used to gauge RIS performance in terms of technical efficiency. Underlying this research is the fact that although the amounts of resources within an RIS are important, it is not evident that those regions with larger amounts of resources are the most efficient ones.

In order to test the proposed methodology (DEA), a European regions efficiency ranking was constructed using data from the 2002 and 2003 EIS. The results were compared with those obtained using the RRSII index, recommended by EIS to measure the EU's progress in innovation activities.

The EIS indicators identify those regions with high investment in high-tech-related activities as 'leading regions', ignoring the regions with potential and those that require specific innovation policies. The EIS demonstrates that the results based on efficiency measures reflect in general terms that RIS are widely under-exploited in Europe and that there are important variances among regions. It has been shown that regions with fewer resources devoted to innovation achieve outstanding levels of efficiency and, contrary to what the EIS predicts, regions with consolidated innovation systems do not show efficiency levels commensurate with their expected competitiveness. A focus on the Spanish national level yielded similar evidence. Those regions (e.g. Madrid and Catalonia) that devote large amounts of resources to R&D and innovation are considered to be the areas with the most comprehensive RIS, according to the RRSII scale, but are not the most efficient ones. On the other hand, those regions (e.g. Balearic Islands, Castilla la Mancha) with fewer resources necessarily have to pay much more attention to the way they exploit them, and hence achieve better results in terms of efficiency.

It has been shown that the higher a region's technological level, the greater is the need for coordination of the system (GEORGHIOU, 2001). Thus, those regions where higher coordination efforts are needed show lower efficiency levels in comparison with other regions with similar investments in terms of RRSII. Territories with lower absorptive capacity and fewer resources adopt the embodied knowledge and the innovations of others, which is less risky and involves lower levels of development; this 'new' knowledge is rapidly adopted by traditional sectors and efficiently.

Both innovation support policies, and territories, are path-dependent and therefore identified best practice cannot be replicated everywhere. Innovation support policies must be customized to support the particularities of each unit of analysis (i.e. sector/region/country). That is, innovation support policies have to be embedded in the territory. This means it is crucial that regions learn from evaluation exercises in order that they can redefine their policies, and assess the performance and the institutional quality of their RIS with greater accuracy (NAUWELAERS and WINTJES, 2002).

The policy evaluation-related literature agrees about the need to combine different approaches, methodologies, and indicators in order to avoid biased assessments of system performance, and to produce a realistic evaluation. The present paper contributes in this respect by incorporating a quantitative approach based on efficiency measures.

From a quantitative perspective, traditional indicators seem to offer a partial view of the actual state of innovation systems. It has been shown that the use of these indicators within different methodological frameworks yields differing, but not necessarily contradictory, results. Thus, they provide a partial picture of the phenomenon being examined; different approaches should be seen as being complementary. Therefore, policy-makers will need to consider the results of different and complementary analyses to obtain a comprehensive picture of RIS. The sum of each partial view will provide a clearer picture than that provided by each in isolation (DÍEZ, 2002).

Current policy is based on a systemic view and the interpretation of the agents involved. Based on the present research, it is recommended that a combination of the methodology presented here, with qualitative analyses and other sources of information provided by empirics, should be used as the basis for the decision-making process to provide better information at the start of a new policy cycle.

These types of evaluations should provide useful information not only for those responsible for defining new innovation support policies, but also for the whole set of agents participating in the RIS. This should ensure an interactive process enabling regions to develop from being passive innovation producers (adopters) to becoming new learning and social systems.

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NOTES

1. In the Policy Evaluation literature it is commonly accepted that the effects of any policy cannot be reducible to a single criterion, so the use of both quantitative and qualitative measures is indispensable (GEORGHIOU, 1998; KUHLMANN, 2003).
2. 'The Systems of Innovation literature takes an ambiguous stand on efficiency' (NIOSI, 2002, p. 293). Thus, 'we would like to propose that the most relevant performance indicators on . . . IS . . . should reflect the efficiency and effectiveness in producing, diffusing and exploiting economically useful knowledge. Such indicators are not well developed today' (LUNDVALL, 1992, p. 6). To conclude, 'aggregate statistics . . . may reveal some types of efficiency or effectiveness . . . it thus may be necessary to desegregate statistics, and to build new ones, to understand some observed yet unexplained *x*-inefficiency of the system as a whole' (NIOSI, 2002, p. 298).
3. Conducting a European-wide comparison at a regional level always involves more or less substantial data problems, e.g. the lack of suitable indicators due to different definitions, short time-series, differences in the criteria applied by different statistics offices, etc. Hence, the present paper differs among three different levels of analysis in this emergent research path. This first step aims to demonstrate the possibilities of this approach in the context of Europe. In a second stage, the study could be replicated for each country to allow institutional aspects to be considered. A third step would involve examining the evolution of efficiency scores, region by region. The time-series needed for these studies will necessarily have to be longer, but the increasing uniformity in each territory as one goes down in the level of analysis will provide much deeper qualitative information for their evaluation.

4. Human resources for innovation (five indicators): New S&E graduates (percentage of 20–29 age class); Population with tertiary education (percentage of 25–64 age class); Participation in life-long learning (percentage of 25–64 age class); Employment in medium-to-high and high-tech manufacturing (percentage of total workforce); and Employment in high-tech services (percentage of total workforce). Creation of knowledge (four indicators): Public R&D expenditures (percentage of GDP); Business expenditure on R&D (percentage of GDP); EPO high-tech patent applications (per million population); and USPTO high-tech patent applications (per million population). Transmission and application of knowledge (three indicators): SMEs innovating in-house (percentage of manufacturing SMEs); Manufacturing SMEs involved in innovation cooperation; and Innovation expenditures (percentage of total manufacturing turnover). Innovation finance, outputs and markets (six indicators): High-tech venture capital investment (percentage of GDP); New capital raised on stock markets (percentage of GDP); New to market products (percentage of sales by manufacturing firms); Home internet access (percentage of all households); ICT expenditures (percentage of GDP); and percentage of manufacturing value-added from high-technology.
5. The seven indicators that constitute the EIS indices for 2002 and 2003 are: Population with tertiary education; Participation in life-long learning; Employment in medium-to-high and high-tech manufacturing; Employment in high-tech services; Public R&D expenditures; Business expenditure on R&D; and EPO high-tech patent applications.
6. The fact that any unit's performance can be obtained as the convex combination of other DMUs – providing virtual units – does not involve any lack of judgement in the analysis. In fact, policy-makers play a direct role in the amount of resources being employed within each subsystem and affect the role of the institutions with the definition and implementation of their regional innovation policies.
7. In the efficiency-related literature concern has been expressed about the convexity restriction and its utility, although there is no consensus to date (CHERCHYE *et al.*, 1999). The Free Disposal Hull (FDH) (DEPRINS *et al.*, 1984) could be another suitable alternative to test the role of convexity in this context. The FDH estimator relies on the free disposal assumption of the production set, but not, as the DEA does, on their convexity. Hence, FDH is a more general estimator than DEA (PARK *et al.*, 2000).
8. According to the Nomenclature of Territorial Units for Statistics (NUTS) adopted by the European Union and EUROSTAT, the administrative division corresponding to NUTS2 are the units considered as regions. Where data were missing the country average was used and/or inter-temporal constant scores were assumed for a certain region.
9. The 49% variation in per capita regional income can be explained by differences in innovative performance – measured by its RRSII – for 2002 and 2003 (EUROPEAN INNOVATION SCOREBOARD, 2002, 2003).
10. Two models were estimated. In the first, both patents and GDP per capita were considered as the desired outputs of any RIS. In the second, patents were considered to be an input rather than an output (all things being equal). The results obtained from both models were, surprisingly, quite similar and significant (the correlation between the models was 65.4% in 2002 and 63.8% in 2003).
11. The patents granted in 't' can be the result (output) of the efforts previously made in time '$t - n$'. In turn, from 't' on, once the patents are already granted, they could be considered as an input for all regions/sectors. However, the time period in the database is not long enough for this assumption to apply. Thus, patents are considered as an input for innovative activities in European regions due to the fact that most patents are generated by a very few regions, but the benefits spill over to all the others (COE and HELPMAN, 1995; GEORGHIOU *et al.*, 2003). Nevertheless, this temporal issue is estimated to be a relevant point that might produce an interesting outcome regarding the appropriability of innovation. This could have implications for policy-making.
12. The procedure was performed using XploRe.
13. A further step in this analysis might be to study regions with a high degree of homogeneity (i.e. the Nordic Countries, the Mediterranean area), whose institutions play similar roles, and where the technological level of firms, the number of universities, etc., are similar.
14. If there was strong evidence of national clusters (e.g. due to major differences in RIS, legal frameworks, institutional settings, technological barriers, administrational restrictions, etc.), the proposed second and third levels of aggregation would be more appropriate.
15. RRSII/TE respective rankings: 42nd/110th for 2002 and 36th/124th for 2003.
16. RRSII/TE respective rankings in Europe: 36th/85th and 45th/62nd (Navarre), and 50th/55th and 47th/46th (Basque Country) for 2002 and 2003, respectively.
17. Balearic Islands: RRSII position: 134th/158th, and TE scores: 0.87 (28th) and 1.0 (10th), respectively. Castilla la Mancha: 138th/163rd (RRSII ranks), and TE scores: 0.89 (25th) and 0.98 (27th) for 2002 and 2003, respectively.
18. For an example of the application of the Open Method of Co-ordination in education policy, see GORNITZKA (2005).
19. According to the methodology, any 'under-use' of inputs will only occur in particular cases where achieving a certain amount of output with less input might be considered as a higher efficient input/output relation and, therefore, would shift the frontier.
20. Since the study aimed at a European-wide comparison and testing the availability of an efficiency approach in this framework, this task cannot be presented in detail. However, in this context, the proposed second and third levels of aggregation would be more appropriate, allowing decision-makers and stakeholders to reorient the resources being used in their RIS.
21. Due to the enormous database that would be needed for a European-wide analysis of these issues, the authors would intend to conduct these future analyses at national level (probably based on Spain) when the second level of the analysis has been accomplished.

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