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CONEIXEMENT i SOCIETAT

THE MERIDIÀ PORTAL OF THE OBSERVATORY FOR RESEARCH (OR-IEC): ANALYSIS, PROMOTION AND COMMUNICATION OF CATALAN SCIENTIFIC KNOWLEDGE

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The highly strategic research, development and innovation (R&D&I) cycle is fundamental to scientific knowledge and economic growth. For the cycle to function adequately, relevant R&D&I information has to be managed effectively. In recent years, the Institute for Catalan Studies (Institut d'Estudis Catalans, or IEC) has played an increasingly important role as a consultant to public bodies, primarily by preparing reports and expert opinions on strategic aspects of Catalan science policy. In 1995, the IEC was commissioned by the Autonomous Government of Catalonia (Generalitat de Catalunya) to produce the Catalan Research Reports (Reports de la recerca a Calunya), describing the state of Catalan research in specific knowledge fields. Two volumes have been published to date, covering the six-year period 1990-1995 (24 reports) and the seven-year period 1996-2002 (27 reports). In 2003, in order to support the work involved in producing the second volume, the IEC founded the Catalan Observatory for Research (Observatori de la Recerca de Catalunya). Since then, the Observatory for Research has gradually compiled data on the R&D&I system from all the Catalan linguistic-cultural regions. In 2008 the web portal MERIDIÀ was launched with the aim of serving as a useful and practical tool for an entire spectrum of users, ranging from researchers to interested members of the general public. Users are offered differing levels of access to the portal and its information, ranging from privileged access—by special agreement—for institutions and public bodies to basic access for the public. Rather than offering comparative analyses of entities or researchers, MERIDIÀ aims essentially to serve as a tool for transforming a large quantity of highly dispersed and heterogeneous information on R&D&I activities in Catalonia into accessible knowledge.

KEY WORDS: R&D&I, Observatory for Research of the Institute for Catalan Studies (OR-IEC), MERIDIÀ portal, scientific documentation, information service

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Contents

1. Introduction

Who is carrying out nanotechnology research projects? How has the number of chemistry and linguistics research staff contracted under the Ramón y Cajal Programme grown? How many patents for wastewater treatment have been applied for since 2000? How many doctoral dissertations have been written on the subject of the Catalan writer, Mercè Rodoreda? These are just some of the questions that the Observatory for Research of the Institute for Catalan Studies (OR-IEC) and the MERIDIÀ portal can answer.

Research and development (R&D) are two scientific and technological activities that lead to the creation of new knowledge, crucial to the advancement of society. Researchers mobilise economic, human and material resources as inputs, with a view to obtaining results, or outputs, in the form of research articles, doctoral dissertations, patents, etc. The

cycle concludes with innovation as a third element in what is referred to as an R&D&I system—with innovation referring to the practical industrial application of results leading to the development of new processes and products.

To enhance efficiency and ensure that the right scientific policy decisions are taken, it is fundamental to describe, measure, analyse and evaluate R&D&I systems.

The highly strategic R&D&I cycle is crucial to the creation of scientific knowledge and to economic growth in the information society. It is therefore fundamental, in a strongly competitive environment, to describe, measure, analyse and evaluate R&D&I systems in order to gauge achievements and

improve functioning, particularly by identifying strong and weak points. This will ultimately enhance the efficiency of the system and ensure that the right scientific policy decisions are taken.

Taking a broad but integrated perspective, the economist Isabel Busom defined the R&D&I system as "the set of agents (those who take decisions on R&D&I, whether companies, research centres or public bodies), values and rules (which condition individual decisions, whether implicit or explicit, public or private) and institutions (the legislative framework, the technology market, the qualified labour market, the financial market and the education system) that directly or indirectly have a bearing on collective R&D&I activities.[1]

The enormous number of producing and funding agents and the great potential fragmentation of information means that description, study and evaluation of the R&D&I systems is a complex task.

R&D&I agents are characterised, among other features, by plurality (in terms of the legal nature of the activity, the sector, the dimensions of the activity, etc) and by dynamic interaction with other activities (through agreements and collaborative networks, the promotion of research teams and knowledge depositories, etc). Any R&D&I system is, in fact, composed of an enormous number of producing and funding agents, which implies a great potential fragmentation of information. The

description, study and evaluation of a system is a complex task[2] given the range of methodologies, classifications and indicators, the variety and differences in sources of information, difficulties in accessing data, fuzzy boundaries between scientific areas, etc. Furthermore, R&D needs to be distinguished clearly from a large number of often similar activities, such as teaching and training, information and data compilation, feasibility studies, testing and the creation of standards, applications for patents and licences, etc. On the other hand, ongoing research to expand human knowledge renders it difficult to set precise aims for analysis, as new study areas, concepts, techniques, interdisciplinary possibilities, etc, are constantly arising.

Compiled information needs to reflect the complete R&D&I cycle and not just specific resources or results. It is often necessary to make both a quantitative and a qualitative analysis of research from a panoramic perspective, taking special care to maintain an equilibrium between all the components in the system. Furthermore, it is important to clearly define the underlying concepts and to use standardised classifications and methodologies. Information has to be comparable at different levels (geographical, institutional, thematic, etc) so as to be able to serve as a suitable reference framework for studies. In this regard, of note is the work undertaken at the international level by bodies such as the Organisation for Economic Cooperation and Development (OECD) and the International Society for Scientometrics and Infometrics (ISSI), which produces periodic publications such as *Scientometrics* and *Research Evaluation*), and at regular scientific conferences including the International Conference on Science

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[1] BUSOM, 2004.
[2] FUENTES & ARGUIMBAU, 2008.

and Technology Indicators and the International Conference on Scientometrics and Infometrics.

As in any other information sphere, the dynamics of data inflows, processing and outflows has to be organised in an efficient, responsive and accurate manner. A key role is played by documentalists in designing and implementing clear classifications and taxonomies and in fostering and communicating information on science and technology initiatives and their outcomes—thereby advancing the frontiers of knowledge. Effective internal management of information produced by R&D&I agents creates a free-flowing results-generating cycle that has the outcome of ensuring greater competitive access to more resources.

2. The Institute for Catalan Studies (IEC)

The IEC is the Catalan national academy of sciences and humanities. It was founded in 1907 with the mission of developing and promoting research policy and disseminating knowledge.[3] Following a long period of clandestine activities (during the dictatorship of General Franco), a Royal Decree passed in November 1976 granted official recognition to the IEC as an academic body charged with carrying out advanced scientific research and whose scope embraces all the Catalan linguistic and cultural regions.[4] The IEC currently fosters research programmes and activities in all knowledge fields through a number of divisions and subsidiary societies. It has also created a Research Committee and Science Secretariat to follow up on these activities.

Some of the aims of the statutes that reflect the core mission of the IEC include the planning, coordination, performance and publication of research in a broad range of science and technology fields. In recent years the role of the IEC as a consulting body for public authorities has come to the fore, through its preparation of preliminary and expert reports on numerous strategic aspects of science policy, including R&D&I.

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In 2004, the IEC made public an institutional position statement on research that was the outcome of reflection as well as a series of talks and debates undertaken by members of the different IEC divisions under the theme *Perspectives del segle XXI: recerca i país* [Perspectives on the 21st century: research and the nation]. The statement concluded with the following recommendation: 'The Institute for Catalan Studies has a key role to play in research itself and in programmes for overseeing and evaluating research, in following up the results of initiatives proposed to foster research, and, most particularly, in socially disseminating and promoting science and research. The results of science must be promoted and disseminated in

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[3] CAMARASA & ROCA ROSELL, 2008.
[4] Royal Decree 3118/76 of 26 November 1976 (Ministry of Education and Science). Spanish Official State Bulletin, BOE (21 January 1977) num. 18, pp. 230-231, in Spanish.

society, both by fostering activities that have as their aim the communication of science and by improving the social status of research and academic staff as key elements for progress. The IEC, along with its five divisions and 26 affiliated societies,[5] and also in view of its geographical coverage and international presence, has a key role to play in this undertaking'.[6]

In 1995, the IEC agreed to launch a project entitled Catalan Research Reports, aimed at publishing studies on the state of research in Catalonia that would apply internationally recognised criteria.

3. Catalan Research Reports (1995-2006)

In late 1983, the IEC was commissioned by the Autonomous Government of Catalonia (Generalitat de Catalunya) to draw up a balance sheet of scientific and technological research in the country was intended to be a first step towards scientific planning. The creation of this report, which was to be a white paper on research in Catalonia, was interrupted due to a lack of resources. The project was relaunched eventually, thanks to assistance from the Interministerial Commission for Research and Technological Innovation (CIRIT). Finally, in 1990 a report on scientific and technological research in

Catalonia (*La recerca científica i tecnològica a Catalunya*[7]) was published that was essentially an inventory of research activity in Catalonia and a description of the situation at the time. The report was published in three volumes; the first volume consisted of individual reviews on the state of research in a number of fields and a sociological study of the research community, the second and third volumes described the research groups already active in Catalonia.

Rounding off these initiatives, in 1995 the Permanent Council of the IEC agreed to launch a project entitled Catalan Research Reports, aimed at publishing studies on the state of research in Catalonia that would apply internationally recognised criteria. Commissioned by the former Generalitat's Commission for Universities and Research and coordinated by the Scientific Secretariat of the IEC, these reports were structured as a regular series of studies of each of the areas into which scientific activity is divided; they were, moreover, drawn up by teams of reputable researchers in each field.

The first edition of the Catalan Research Reports,[8] tahat published with funding from the Interministerial Council for Research and Technological Innovation (CIRIT), was organised into 24 thematic areas covering the period 1990-1995. In 2003—this time with funding from the Generalitat's Ministry of Universities, Research and the Information Society—the Scientific Secretariat continued the task of coordinating the Catalan Research Reports. The second edition,[9] which was

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[5] With the inclusion of the Association of Catalan Sociolinguists and the Catalan Association of Terminology in 2008, the IEC now has a total of 28 subsidiary societies.
[6] Institute for Catalan Studies, 2006a.
[7] Institute for Catalan Studies, 1990.
[8] Institute for Catalan Studies, 1996-2002.
[9] Institute for Catalan Studies, 2006b.

Table 1
Reports de la recerca a Catalunya, 2nd edition (1996-2002)

Reports	Coordination
Other languages and literatures	Hortènsia Curell i Gotor
Architecture and town planning	Manuel Ribas i Piera
Cell and molecular biology and biochemistry	Pere Puigdomènech i Rossell
Organisms and systems biology	Xavier Llimona i Pagès & Jaume Terradas i Serra
Social sciences*	María Teresa Montagut i Antolí
Communication	Josep Maria Casasús i Guri
Law	Encarna Roca i Trias
Economics	Antoni Serra i Ramoneda
Agricultural, forestry and food engineering	Albert Ibarz i Ribas
Civil and construction engineering	Joan Ramon Casas i Rius
Industrial engineering	Joaquim Agulló i Batlle
Catalan language	Joan Martí i Castell
Catalan literature	Eulàlia Duran i Grau
Philosophy	Jordi Sales i Coderch
Physics	David Jou i Mirabent
Geography and demographics	Enric Lluch i Martín & Abel Albet i Mas
Geology	David Serrat i Congost & Salvador Reguant i Serra
History	Albert Balcells i González
History of art and musicology	Francesc Fontbona i de Vallescar & Romà Escalas i Llimona
Linguistics and linguistic sciences	Joan A. Argenter i Giralt
Mathematics	Julià Cuff i Sobregrau
Medicine	Joan Rodés i Teixidor
Pedagogy	Josep González-Agàpito i Granell
Psychology	María Teresa Anguera i Argilaga
Chemistry	Salvador Alegret i Sanromà
Information and communications technologies	Lluís Jofre i Roca
Veterinary	María Teresa Paramio i Nieto

Source: Authors.
(*) The social sciences include sociology, political science and anthropology.

published in early 2006, covered the period 1996-2002 and this time included 27 thematic areas (see Table 1). Both editions are now available from the IEC website.[10] Also available for the second edition reports are summaries in both Catalan and English, and some of the reports have been translated for publication in an IEC English-language publication entitled *Contributions to Science*.[11] As for the future of the Reports, a third edition covering the period 2003-2008 is projected that will include an even broader range of knowledge areas.

Note that the Catalan Research Reports do not aim to conduct a comparison between institutions, groups or individuals; rather, they furnish an overall but nonetheless detailed perspective of the different thematic areas within the Catalan science and technology system.

[10] <http://www.iec.cat/reports>.
[11] <http://www.cat-science.com>.

As to the layout of the Catalan Research Reports, although each has specific characteristics that differentiate it from the others, the analysis of each thematic area is conducted according to a model that covers the following main points:

a) Opportunities. This section defines the entire set of research frameworks, policies and actions developed and implemented by R&D&I agents.
b) Institutional framework. This section consists of an analysis of human and institutional resources—including infrastructure and equipment—and financial data referring to grants awarded, research projects, etc.

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c) Results. In this section, the lines of research underway in different groups are analysed and the research activities themselves are assessed in terms of productivity.
d) Conclusions. Weaknesses and strengths are analysed and recommendations are made

aimed at obtaining improvements in the development of research activities in specific fields.

Besides the groundwork laid in the research plans of different public bodies,[12] other key reports and studies exist, drawn up along lines similar to those of Catalan Research Reports. Regarding Catalonia, in 2006, the Centre for Business Innovation and Development (CIDEM)[13] published a report on the innovation situation in Catalonia (*La situació de la innovació a Catalunya*[14]), analysing and evaluating Catalan public policy and the Catalan innovation system from an European perspective in terms of the public sector, universities and the private sector. An annual R&D&I report for 2008 (*Informe anual de l'R&D i la Innovació 2008*[15]) drawn up by the ACC1Ó[16] [Centre for Business Innovation and Development (CIDEM)/ Consortium for the Commercial Promotion of Catalonia (COPCA)], provides descriptive and up-to-date information on business innovation. The Interministerial Council for Research and Technological Innovation (CIRIT) has commissioned Profesor Jordi Maluquer de Motes to draw up periodic studies on R&D in Catalonia (*La recerca i la innovació a Catalunya*, with editions available for 2001, 2002 and 2003).[17] Unlike the previous studies, which provide a snapshot of data, this last study relies on consolidated information—thus accounting for the time lag between the year of the study and its date of publication (the 2003 edition was published in June 2008).
As for Spain, of particular note are the annual

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[12] Science, technology and innovation plan for the Balearic Islands (2005-2008), 2005; [Catalan] Research and innovation plan (2005-2008), 2005; National [Spanish] science research, development and scientific innovation plan (2008-2011), 2007; Valencian science research, technological development and innovation plan (2001-2006), 2002.
[13] <http://www.cidem.com>.
[14] BUSOM, 2006.
[15] ROMERO, 2008
[16] <http://www.acc10.cat>.
[17] MALAQUER DE MOTES *et al*., 2008.

reports produced by the CyD Foundation (Knowledge and Development)[18] and the COTEC Foundation (for Thechnological Innovation),[19] and also the SISE (Integrated Follow-Up and Evaluation System) report produced by the Spanish Foundation for Science and Technology (FECYT).[20] Also worthy of mention are the initiatives undertaken by the Confederation of Spanish Scientific Associations (COSCE) at the instigation of ACCIÓN CRECE (Committees for Reflecting on and Studying Science in Spain),[21] which has implemented a project that evaluates science from an impartial perspective. Another state-level study analysing publicly funded research (*Radiografía de la investigación pública en España*[22]) retrospectively examines the activities that have been undertaken in the wake of the Spanish law passed in 1986 governing the general promotion and coordination of scientific and technological research.[23]

4. The IEC's Observatory for Research (2003-2008)

In May 2003, to support the tasks involved in preparing the second edition of the Catalan Research Reports, the Scientific Secretariat created an Observatory for Research, to be attached to the IEC (OR-IEC) in response to a detected need for a reference framework for the analysis, planning, coordination and communication of R&D&I activities in the Catalan science and technology system.
From the outset, the OR-IEC has had two strategic

goals:
a) To evaluate developments in different science and technology areas on an ongoing basis using indicative quantitative data (crucial to assisting decision making by politicians, the business community and scientists).
b) To place at the disposal of the scientific community and society in general a system of tools and up-to-date and retrospective information on the state of research in the Catalan linguistic and cultural regions (a goal of a more qualitative nature than the first one).
At present, the OR-IEC, which is hierarchically

From the outset, the OR-IEC has had the strategic goal of evaluating developments in different science and technology areas in the Catalan linguistic and cultural regions on an ongoing basis.

positioned within the IEC's Research Support Department, has a staff of three documentalists and one biologist. It works closely with the Computer Department and is under the academic management of the Scientific Secretariat. Offering specialist R&D&I information on the Catalan science and technology system, the OR-IEC is present on the Internet through the MERIDIÀ web portal. It follows up and disseminates scientific activities

[18] CYD Foundation, 2008. <http://www.fundacioncyd.org>.
[19] COTEC Foundation, 2008. <http://www.cotec.es>.
[20] FECYT, 2007. <http://www.fecyt.es>.
[21] COSCE, 2005. <http://www.cosce.org>.
[22] Sebastián & Muñoz, 2006.
[23] Spanish Law 13/1986, of 14 April, governing the general promotion and coordination of scientific and technological research. Spanish Official State Bulletin (BOE), 18 April 1986, in Spanish.

carried out by the IEC (programmes, academic events, publications, etc), provides support to Catalan scientific journals and ensures the continuity of future editions of the Research *Reports*.

The aim of the OR-IEC is to give both an overview

Information is mainly obtained from agreements for the transfer of information between government bodies, universities and other public and private research organisations and from the systematic harvesting of a broad range of data sources.

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and a detailed perspective on the current state and development of a range of science and technology fields, while avoiding systematic analyses or comparative evaluations of institutions, groups and researchers. It embraces the entire research cycle, from inputs to outputs, and covers the socioeconomic context, research bodies, human, economic and material resources, and results in terms of dissertations, articles and patents. The geographical area of study focuses on all R&D&I activities conducted in Catalan linguistic and cultural regions, with comparisons conducted at the state and international levels.

Before the MERIDIÀ project was launched, as a reference that would ensure optimal functioning of the project, a study was conducted to determine which entities offered similar services, analyse and compare these services and assess best practices. The study covered observatories for specific fields (many of which were not related with the subject matter of the OR-IEC) as well as other services that were not observatories as such but

which offered research-linked information (see Appendix 1). Several conceptual and technological aspects were analysed, website design and content, means of accessing information, etc.

All the information on the resources and results of Catalan research available through the OR-IEC is the fruit of key documentation tasks—including the identification, selection and systematic harvesting of data sources for information for subsequent computer processing—implemented in the five years of existence of the observatory. Information is mainly obtained as follows:

– From agreements for the transfer of information between autonomous government bodies, universities and other public and private research organisations (see Table 2). It should be mentioned that the OR-IEC's mission is to act as a collaborative link that facilitates the integration and sharing of information between agents in the system and to make available detailed data on the scientific and technological environment.
– By systematically harvesting primary data sources (resolutions published in official bulletins, statistics, administrative records, etc) and secondary data sources (national plans, reports, etc). Inevitably there is a publication time lag for original sources; the average is two to three years but it may be far longer for patents. (See Appendix 2 for a full list of these information sources).

Thus, sources are public and/or official, which ensures solid and reliable data in the form of certified and credible information. Once processed and standardised, the information is included in a database for subsequent analysis and dissemination (see Section 5.1). The OR-IEC also has its own intranet where documents and

Table 2
Knowledge transfer agreements 2004-2008

Body	Date signed
Institut de Recerca i Tecnologia Agroalimentària (IRTA) [Institute for Food and Agricultural Research and Technology]	14/09/2004
Universitat de Girona (UdG) [University of Girona]	15/09/2004
Universitat Oberta de Catalunya (UOC) [Open University of Catalonia]15/10/2004	
Universitat Internacional de Catalunya (UIC) [International University of Catalonia]	04/11/2004
Institució Catalana de Recerca i Estudis Avançats (ICREA) [Catalan Research and Advanced Studies Institute]	30/12/2004
Universitat Ramon Llull (URL) [Ramon Llull University]	31/01/2005
Universitat Autònoma de Barcelona (UAB) [Autonomous University of Barcelona]	03/02/2005
Departament d'Universitats, Recerca i Societat de la Informació (DURSI) [Dept of Universities, Research and the Information Society-Generalitat]	03/10/2005
Universitat Politècnica de Catalunya (UPC) [Technical University of Catalonia]	24/02/2006
Centre d'Innovació i Desenvolupament Empresarial (CIDEM) [Centre for Business Innovation and Development]	29/05/2006
Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR) [Agency for the Management of University and Research Grants]	28/06/2008

Source: Authors.

resources relevant to research are uploaded and organised (reports, studies, research body memoranda, decisions regarding calls for applications for funding, websites of interest, etc). This intranet, therefore, functions as a safe and secure warehouse of data that can be consulted by the OR-IEC team.

This information, which is managed and made available through the MERIDIÀ portal, enables the preparation of reports, studies and general and sectoral statistical analyses referring to the Catalan scientific system. The system is flexible enough to respond to very specific requests for information, and the OR-IEC has drawn up a number of made-to-measure reports and studies for bodies such as the Agency for the Management of University and Research Grants (AGAUR), the Centre for Mathematics Research (CRM),[24] the Faculty of Sciences of the Autonomous University of Barcelona (UAB), the Spanish Society for Microbiology (SEM)[25] and the Vice-Chancellor

for Research of the University of Girona (UdG). It has also offered support in the form of documentation and technical advice to several IEC research programmes and contributes to the advisory committee for an AGAUR scientific documentation programme. A number of articles and book chapters have been the outcome of the work of the OR-IEC describing its methods and approaches and providing overall analyses of the R&D&I system (see References).

5. The MERIDIÀ portal (2008)

The ongoing task of the OR-IEC in terms of systematic compilation of the information necessary to support the periodic publication of the Catalan Research Reports has generated, on the one hand, a very high volume of information for use in the third edition and, on the other hand, requires a team expert in handling scientific information. This situation has naturally led to the

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[24] Castellet *et al.*, 2004.
[25] Arguimbau, 2008.

idea of shifting from a static system to a specialised, dynamic environment that would make the OR-IEC's work visible through a portal providing access to basic data in the form of indicators.

Launched to the public in May 2008, MERIDIÀ (Measurement of Research, Development and Innovation)[26] was presented as a tool for specialist users that transforms a large quantity of hihgly dispersed and heterogeneous data into knowledge.

The data cycle commences with the collection of

OR-IEC's task of systematically compiling data was made visible with the creation of MERIDIÀ, a portal that provides access to basic data in the form of indicators.

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data, which is then transformed into information when uploaded to the platform, and which terminates with an individual making use of the information to generate *knowledge*. How this knowledge is used is diverse; for example, it might simply be used to answer concrete questions (similar to those posed in the Introduction) or it might form the basis for strategic reports (institutional position reports, master plans, etc).

The MERIDIÀ project commenced with the drafting of a document that outlined its requirements, defined master lines for the final

product and described specifications for subsequent methodology phases. This document was the work of a mixed team drawn from among OR-IEC documentalists and technical staff in the IEC IT Department. At a subsequent stage the technology consultancy company ID-EST Consultants[27] was brought in to work on developing a tool that would best implement the project. The tool was designed as a platform that would have different modules, as follows:

a) A research database constructed from an underlying conceptual model that would be flexible enough to respond to issues arising from the multiplicity of information sources.
b) An internal data management environment that would support the information management tasks.
c) An analytical environment that would allow information to be harvested for the generation of results in the form of reports.
d) A website environment that would facilitate the dissemination of results.

The design and implementation of each of these four modules posed specific problems, described in turn below.

5.1. The research database

The original depositary of data compiled and stored by the OR-IEC team since its launch and containing information obtained from the systematic harvesting of data sources (as described in Section 4) was composed of around 250 Microsoft Access tables that had not undergone any standardisation or data structuring

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[26] <http://meridia.iec.cat>
[27] <http://www.idest.es>

processes. This combination of a large number of heterogeneous sources and vast quantities of historical information configured a framework for the portal while pointing to the main technological challenge facing the project: the design of a data model capable of both transfering historical information and functioning as a layer of data for the internal data management environment (see Section 5.2).

The kernel of this data model was defined in a study of typical indicators reflecting the entire scientific and technological cycle used for analysing R&D&I systems. The OR-IEC and MERIDIÀ use indicators established by the OECD and described in periodically revised methodological documents such as the *Frascati Manual*,[28] which is an international reference for obtaining reliable and comparable R&D statistics and indicators from surveys. The indicators are classified as follows:

1) Socioeconomic context
2) Research bodies
3) Resources (inputs)
   3.1) Human
   3.2) Financial
   3.3) Material
4) Results (outputs)
   4.1) Publications
   4.2) Patents
   4.3) Dissertations.

The database contains two types of information: basic data and aggregated data. Aggregated data is all information in the form of calculations, statistics and indicators supplied by the different sources to which the OR-IEC has access and which, in a theoretically ideal situation, can be calculated from basic data. However, it is necessary to store both aggregated data and original data, firstly because the same kind of information is not always available from the different information sources and, secondly, because information is not always updated for the same periods of time.

Once the initial transfer was implemented, the

> **A main technological challenge of the MERIDIÀ project was the design of a data model capable of transfering all the available historical information.**

work subsequently carried out by the system administrators resulted in the basic data currently contained in the database, organised as shown in Table 3.

To endow the model with expressiveness, systems

Table 3
MERIDIÀ volumes

Indicator groups	Items
Research bodies	11.208
Financial resources	65.274
Results (publications)[29]	1.022
Results (patents)	5.804
Results (dissertations)	9.755

Source: Authors.

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[28] *Manual de Frascati*, 2003.
[29] Scientific, cultural and humanities journals currently published in Catalan cultural and linguistic regions.

of classification were used that provide a standard frame of reference for analysing and comparing information from several perspectives. These classifications introduce a semantic element into the data and enable it to be prepared for analytical processing and advanced searches. Four basic classification groups are used: scientific and technological disciplines; scientific and technological production; socioeconomic classifications; and geographical classifications. Table 4 shows the full diversity of the current classifications in use.

The values for these classifications serve as thematic labels associated with elements in the database, thereby ensuring that each data item is labelled suitably. This labelling system is referred to as *characterisation*.

To ensure the future coherence of reports while

Table 4
MERIDIÀ classification

Science and Technology Disciplines
Areas covered by the National Science and Technology Council (CONACYT)
Areas covered by the Interministerial Council for Research and Technological Innovation (CIRIT)
Areas covered by the *Reports de la Recerca a Catalunya* (IEC)
Science and technology areas covered by the Advanced Scientific Research Council (CSIC)
Knowledge areas covered by the Spanish Ministry of Science and Innovation (MICINN)
Doctoral study areas covered by the National Statistics Institute (INE)
Thematic areas covered by the National Agency for Scientific and Technological Evaluation and Prospective Analysis (ANEP)
Scientific disciplines covered by the National Statistics Institute (INE)
Subjects covered by the Community Research and Development Information Service (CORDIS)
UNESCO international nomenclature
Science and Technology Production
Areas covered by the social science and humanities journals list (CARHUS)
Categories - Essential Science Indicators (ESI, Thomson)
Categories - *Journal Citation Reports* (JCR, Thomson)
Categories - *National Citation Reports* (NCR, Thomson)
Categories - National Science Indicators (NSI, Thomson)
International Patent Classification (IPC)
Disciplines - *Current Contents Connect* (CCC, Thomson)
Disciplines - Science Bibliometrics and Evaluation (BAC)
Patents in the European Classification System (ECLA)
Socioeconomic Classifications
Catalan Classification of Economic Activities (CCAE)
Catalan Classification of Education (CCED)
Nomenclature for the Analysis and Comparison of Scientific Programmes and Budgets (NABS)
Statistical Classification of Economic Activities in the European Community (NACE)
Activity Branches of the National Statistics Institute (INE)
High and Medium-to-High Technology Sectors (AYMAT) of the National Statistics Institute (INE)
Geographic Classifications
Nomenclature of Territorial Units for Statistics (NUTS)

Source: Authors.

making them independent of any possible taxonomical changes, we apply the concept of *version*, understood as a list of codes for a classification that is valid at a given moment in time. As for linking up the different versions of a classification, this is done by using a concept called *equivalence*, which reflects the relationships between values in the tables of codes for different classifications or between tables of codes for two versions of the same classification. The combined use of versions and equivalences (see Figure 1) equips the model with sufficient flexibility to be able to both incorporate classification changes without needing to alter previously classified reports or to represent different views of the same information. Oracle Database 10g was chosen to implement
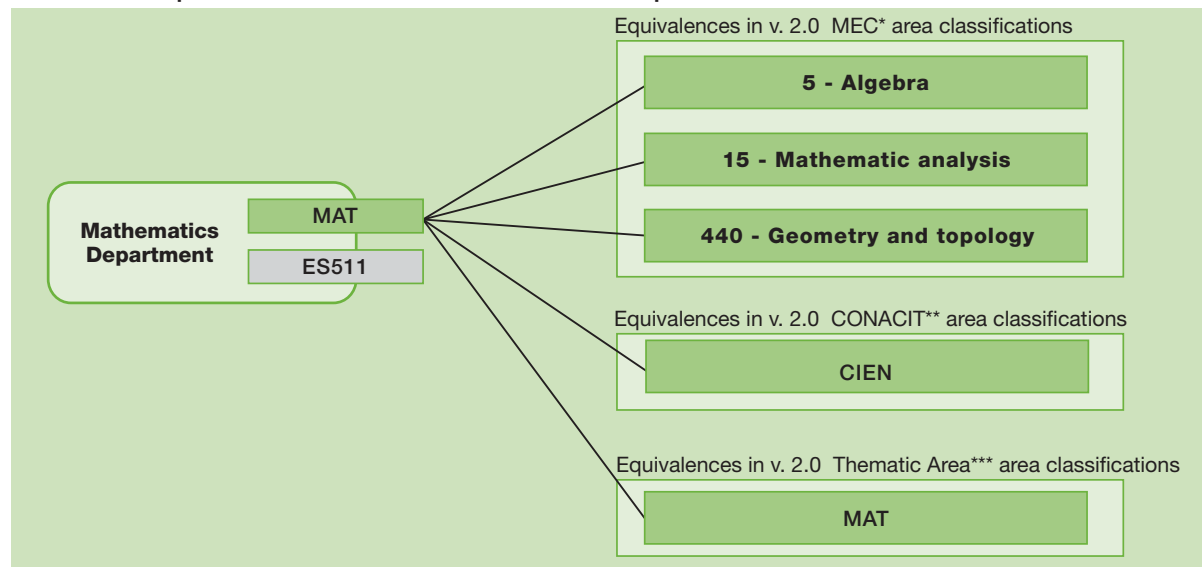
the research database.[30]

5.2. The research data management application

In a project of these characteristics, quality is fundamental to the value of the results that are produced by the platform; consequently, the maintenance and continuous updating of the information that represents the kernel of the platform are crucial.

To facilitate the administration task, a management application was created that allows platform users to incorporate information harvested from original sources in the database. This is the point at which solutions to minimise the considerable manual

Figure 1
Mathematics Department: characterisation and classification equivalences

Source: IEC's IT Department.
(*) Ministry of Education and Science.
(*) National Science and Technology Council.
(*) Thematic areas are those referred to in the Catalan Research Reports.

[30] <http://www.oracle.com>.

effort required for the maintenance of the information were incorporated—mainly a component that allows massive uploading as well as debugging of packages of syntactic and semantic data according to pre-defined rules.

Solutions are included to minimise the considerable manual effort required to mantain of the information—mainly a component that allows massive uploading.

We previously mentioned the challenge implied by the processing of information from multiple sources prior to incorporation of the information in the system. This first-level issue of data integration has traditionally been solved through the definition of data exchange interfaces. Once these *interfaces* acquire weight in a community with common interests, such interfaces become *standards*.

Interfaces and Standards

The first electronic data interchange (EDI) system arose among manufacturers and suppliers (primarily in the automotive and commercial distribution sectors) desiring to save costs and improve supply chain processes. Published standards were adopted by United Nations working parties (EDIFACT)[31] and other sectoral associations (ODETTE[32] and AECOC[33]) that made it necessary to develop tools for translating customer software formats and for developing collaborative outsourcing platforms. The technological advances of the last fifteen years have reduced the high financial cost of using added-value networks that allow electronic interlocutors to be massively incorporated in a communications network through Internet-based technological solutions. Likewise, standards have gradually evolved towards the use of XML[34] as the definition language (as e-business XML).

In the case of MERIDIÀ, internal interfaces for automated uploads by research bodies—whether of research, financial resources, publications, patents or dissertations—were defined in order to make the database independent from the source of the information (see Figure 2).

The generation of these interfaces continues to be one of the points requiring the most manual work in the entire process, for two main reasons:

– A low level of standardisation in the original data. In many cases the data is uncoded such that coding has to be implemented from the description, with all the problems implied by
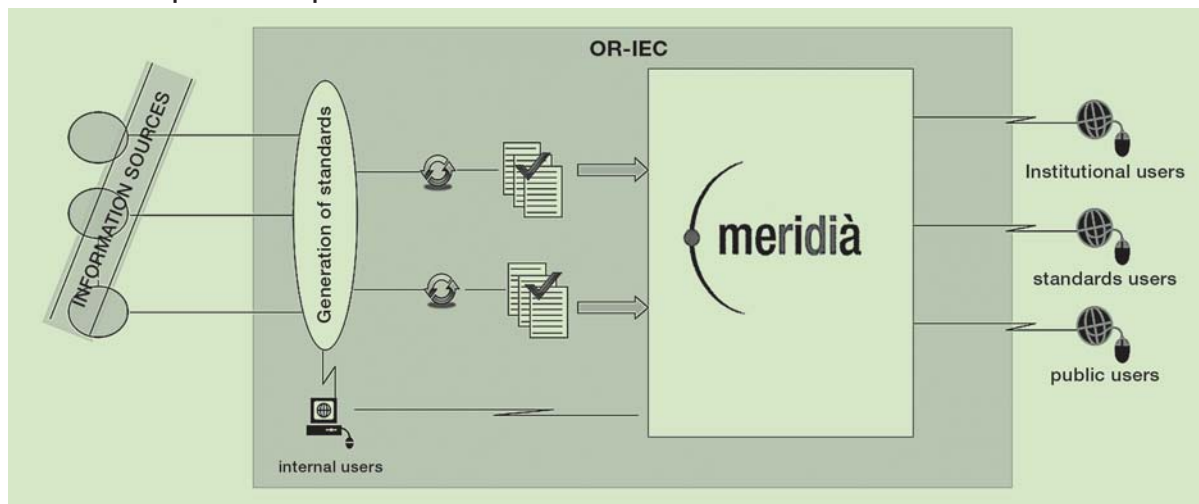
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[31] UN/EDIFACT (United Nations/Electronic Data Interchange For Administration, Commerce, and Transport). < http://www.unece.org/trade/untdid/texts/d100_d.htm>.

[32] Odette International is an organisation formed by and for the automotive industry. <http://www.odette.org/html/home.htm>.

[33] AECOC is a Spanish association created to promote the introduction of barcoding in Spain. It has now evolved as an association that provides a framework for cooperation aimed at enabling the production and distribution sectors provide enhanced vale added for consumers. <http://www.aecoc.es/#this>.

[34] XML (Extensible Markup Language), a simplified adaptation of Standard Generalized Markup Language (SGML), is a metalanguage of labels developed by the World Wide Web Consortium (W3C) that enables the definition of the grammar of specific languages (HyperText Markup Language (HTML) is also derived from SGML). <http://www.w3.org/XML/>.

Figure 2
OR-IEC data acquisition and upload to MERIDIÀ

Source: Authors.

typographical errors, variability in the use of parts of speech like prepositions and conjunctions, translations, and

– A lack of a sufficiently consolidated community for the exchange of this type of data. This means that no standards or translation tools exists as yet that would substantially improve the process.

As commented upon earlier, a substantial amount of work is required to resolve the problem of data integration. Cooperation with other institutions committed to resolving similar problems is likely to lead to improvements that should allow progress from this data integration level to a more powerful level in which applications are integrated through the development of connectors, web services and other technological devices. The

evolution of platforms towards service-oriented architectures (SOAs) is likley to facilitate this step in the coming years.

The research data management application and the web portal have been implemented in Java using the Struts Framework[35] and deployed in an Apache Tomcat 5.5 applications server.[36] The data layer is based on the Oracle database while XML files hold unstructured portal content (news, links, static-information files, etc).

5.3. The analytical environment

The analytical environment is the basic tool from which the most important content —namely, the MERIDIÀ reports— is generated. It was clear

[35] Apache Struts is a free open-source framework for creating Java web applications. <http://struts.apache.org>.
[36] Apache Tomcat, an implementation of the Java Servlet and JavaServer Pages technologies, powers web applications across a diverse range of industries and organizations. <http://tomcat.apache.org>.

from the outset that a high-technology data warehouse[37] would be necessary as it would also ensure a user-friendly, responsive and independent environment for the end user.

Commencing with the database, in which the data are stored, an intermediate environment was created to contain all the reports created by the OR-IEC team.

After exhaustive market research, MicroStrategy 8.0[38] was chosen on the basis of technological criteria (robustness, scaleability and efficient response time) and adaptive capability for the OR-IEC, whether for analysts or expert users.

Commencing with the database in which the data are stored, an intermediate environment —only visible to the system's administrators— was created to house all the reports created by the OR-IEC team. Once the administrators have created the reports, these are published for MERIDIÀ users, by making them available publicly or only to specific users or groups. Reports destined for a potentially unlimited group of users are visualised through a product developed by ID-EST Consultants on the basis of previous experience with similar situations. This product (IEPortal in the version currently in use by MERIDIÀ and JPortal in the new version) allows reports to be constructed, published and mined in a 100% web

environment, while providing administrators with a series of additional configuration, navigation and report access tools.

At this point it is appropriate to comment on the progressive expansion in applications of business intelligence (BI) tools, traditionally conceived as tools aimed at the mining of information generated in corporative applications so as to support decision making and complement customer relationship management[39] systems in banks, insurance companies and services companies (communications, energy, etc). Illustrative examples of these new uses are science information initiatives such as the UNeix[40] university and research portal and the data warehouse environments implemented by a range of institutions—including, the Spanish Foundation for Science and Technology (FECYT) and universities such as the Autonomous University of Barcelona (UAB), Rovira and Virgili University (URV), the Technical University of Valencia (UPV), and the University of Alicante (UA).

As was mentioned earlier, the use of classification-based data labels opens up a number of possibilities when it comes to choosing the analysis dimensions or perspectives be included in reports. Furthermore, the execution of pre-planned daily processes that synchronise information in the research database with that in the warehouse database ensure that the information in the reports is up-to-date.

The analytical environment was developed using MicroStrategy 8.0 and IEPortal for report display.

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[37] A data warehouse is a database specially designed for the analytical mining of data that contains all information on corporative applications (which, for MERIDIÀ, is the research database), restructured and optimised so as to enable mining.
[38] <http://www.microstrategy.com>.
[39] Customer Relationship Management (CRM) automates relationships between organisations and their customers in commercial transaction phases such as supply, sales, post-sales, marketing, etc.
[40] <http://uneix.gencat.cat>.

5.4. The web portal

Once the information has been processed by the research data management application and results in the form of reports have been generated in the analytical environment, the next stage is dissemination through the web portal. The portal was initially viewed as a vehicle for communication and dissemination and operating simply as a depository for the reports. However, this notion evolved in terms of the development of a more generic portal that would function as a tool for communicating OR-IEC activities to society. Thus, the concept of a portal for displaying reports grew into the concept of a portal of contents.

The following consultations can currently be made through the MERIDIÀ portal:

1) Reports. Generated from the analytical environment (see Table 5), each report is structured according to one or more indicators and according to suitable dimensions (for example, modalities, national R&D&I plans, different autonomous communities, etc). Additional information includes the source, scope and date of the last update. The display portal includes a cross-tabulation mechanism that enables users to view reports from different perspectives in rows or columns and to export data to an office environment.
2) Relevant documentation. Additional information includes size, type, publisher and publication year.
3) Search. An additional option offered by the Lucene open-source search engine[41] enables searches in the database and in relevant documentation. Not only does this permit indexing and more complex searches (providing

a more basic level of information than that provided in aggregated form in the reports), it also enables reports to be contextualised.
4) News. Up-to-date news on the OR-IEC is provided to users.
5) Links. Selected website links are offered to users.

Initially viewed as a vehicle for communicating and disseminating reports, the portal was eventually developed as a more generic portal that would function as a tool for communicating OR-IEC activities to society.

The system developed for managing content includes a security layer that restricts access by users and also ensures a capacity to grow on the basis of new types of content that may appear in the future. Additional features of note include the fact that each report provides a detailed explanation of methodology, content, information sources, etc, the possibility of carrying out queries in Catalan, English and Spanish, and the fact that MERIDIÀ users can address a query or comment directly to the system administrator through the "contact" option.[42]

It is necessary to be registered to access most of the information in MERIDIÀ. Two kinds of user are envisaged: institutional users (an access code is provided by the OR-IEC) and other users (who must request access by e-mail). The system is flexible enough to be able to establish specific profiles for each group of potential users, as follows:

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[41] <http://lucene.apache.org>.
[42] <or@iec.cat>.

Table 5
MERIDIÀ: most significant reports

Socioeconomic context
Total internal expenditure on R&D activities as a % of GDP
Autonomous Community expenditure on innovation (in euros and as a % of state expenditure and of GDP)
Employment in R&D activities (full-time equivalents)
Number of researchers (full-time equivalents)
Resources
Academic-researcher staff, by grade and knowledge area
Ramón y Cajal Programme (RyC), by research body, thematic area* and ANEP** area
University Teacher Training (FPU) grants and funding, by research body and thematic area
Research Staff Training (FPI) grants and funding, by research body and thematic area
Catalan Research and Advanced Studies Institute (ICREA) researchers, by research body and thematic area
Centre for Industrial Technological Development (CDTI) projects, by company and CCAE*** code
Health Research Fund (FIS) research projects, by research body
National R&D&I Plan research projects and complementary actions, by research body and programme
European Union Framework Programme (FP) research projects, by company, plan-programme, modality and CCAE code
European Union Framework Programme (FP) research projects, by non-business research body, plan-programme, modality and thematic area
Agency for the Evaluation of Medical Technology and Research (AATRM) research projects, by research body
TV3 Marathon Foundation research projects, by research body and by thematic area
Results
Scientific, cultural and humanities journals, by publisher and thematic area
Scientific production according to Thomson Scientific ISI
Doctoral dissertations, by university, scientific area and study
Patent applications lodged with the Spanish Patent Office (OEPM), by research body, CCAE code and International Patent Classification (IPC) code
Patent applications lodged with the European Patent Office (EPO), by research body, CCAE code and International Patent Classification (IPC) code

Source: Authors.
(*) Thematic areas are those referred to in the Catalan Research Reports.
(**) National Agency for Scientific and Technological Evaluation and Prospective Analysis.
(***) Catalan Classification of Economic Activities.

– Public administration personnel holding political posts.
– Chancellors and vice-chancellors of public and private universities.
– Directors and senior managers in research bodies, research centres and institutions.
– Science and technology policy planners (management and technical staff) in public administrations, universities, research bodies, companies, etc.
– Members, staff and affiliates of IEC subsidiary bodies.
– Research staff specialising in the description and analysis of R&D&I activities (including scientific production, patents, etc).
– General and specialist press.
– The scientific community and society in general.

Already underway is the second phase of the MERIDIÀ project, in which access to content will be enhanced and an integrated search service for all MERIDIÀ content will be implemented.

6. Conclusions and perspectives

Through its MERIDIÀ portal, the OR-IEC makes research data available to users, along with means for consultation and analysis of the data; users can thus locate relevant information rapidly and accurately in response to their queries and searches. Any quantitative approach must, of course, be complemented by the application of qualitative and standardised criteria by experts on general scientific policy or on the R&D&I activities in a specific field.

The purpose of MERIDIÀ is to publicise and foster Catalan science by providing detailed information on research agents, resource investment and results. The portal has a number of strong points:

– It has territorial scope, meaning that it covers all the Catalan cultural and linguistic regions and also allows comparisons at the state and international levels.
– It embraces the complete R&D&I cycle, from the socioeconomic context to industrial application of new scientific and technological knowledge.
– It offers full sectoral (universities, companies, public administrations, non-profit private institutions, etc) and subject matter coverage (hard sciences, life and health sciences, engineering, architecture, social sciences, the arts, etc) coverage.
– It guarantees data reliability and quality by only relying on certified and credible information sources.
– It makes intensive use of information and communications technologies (ICT).

Nonetheless, it is also necessary to be aware of the challenges entailed by a project of this nature, for example:

– Enormous quantities of data and a vast range of information sources have to be handled.
– There is a lack of referents and clear models for conceptual and technological development of the system.
– There is an urgent need to make the portal known and to ensure a natural symbiosis between MERIDIÀ and the R&D&I system, one that guarantees added value.

There is an urgent need to make the portal known and to ensure a natural symbiosis between MERIDIÀ and the R&D&I system one that guarantees added value.

The combined work of the OR-IEC and research managers and scientists meets a demand for qualitative studies on aspects as central to Catalan scientific research as international impact, interdisciplinary cooperation, other networks, etc. Planned for the future is the development of new indicators derived from the consultation of electronic serial publications, patent citations, bibliometric studies applied to the arts and social sciences, etc. Another area that requires further development is the systematic harvesting and organisation of data on all available material R&D&I resources. Finally, technological transfer mechanisms between universities and the private sector need to be studied, as does the role played by the private sector in scientific and technological research.

In conclusion, the MERIDIÀ portal is an ambitious initiative of the IEC that aims to provide an umbrella for all research undertaken in the Catalan

The combined work of the OR-IEC and research managers and scientists meets a demand for qualitative studies on aspects as central to Catalan scientific research as international impact, interdisciplinary cooperation and other networks.

cultural and linguistic regions, one that goes beyond one-to-one exchanges and individual interdisciplinary cooperation undertakings by universities and research centres.[43] It is anticipated that the MERIDIÀ portal will become a reference node for the analysis, promotion and widespread dissemination of all scientific knowledge developed in the Catalan cultural and linguistic regions in the broader context of a networked society.

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[43] CAMARASA & ROCA ROSELL, 2008.

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APPENDIX 1:
Institutions included in the study

General

Fundació Observatori per a la Societat de la Informació de Catalunya <http://www.fobsic.net>.

Observatori Barcelona <http://www.observatoribarcelona.org>.

Observatori de Bioètica i Dret <http://www.ub.es/fildt>.

Observatori de Desenvolupament Estratègic a Catalunya <http://www.odecat.net>.

Observatori de la Comunicació Científica <http://www.upf.edu/occ>.

Observatori de la Mobilitat <http://www10.gencat.cat/ptop/AppJava/cat/arees/mobilitat/observatorimobilitat>.

Observatori de les Desigualtats <http://www.obdesigualtats.cat>.

Observatori del Paisatge <http://www.catpaisatge.net>.

Observatori del Treball <http://www.gencat.cat/treball/departament/activitat/treball>.

Observatori Turístic <http://www.inestur.es/?Idi=2>.

Observatori de Prospectiva Tecnològica Industrial <http://www.opti.org>.

Specific

Balears Innova <http://www.balearsinnova.net>.

Community Research and Development Information Service (CORDIS) <http://cordis.europa.eu>.

Euskadi+Innova <http://www.euskadinnova.net>.

FènixDoc: Producció Científica de la UPC <http://bibliotecnica.upc.es/FenixDoc>.

GREC-UB Research Management Portal <https://webgrec.ub.edu>.

MADR+D: Madrid R&D Portal <http://www.madrimasd.org>.

Observatoire des Sciences et Techniques (OST) <http://www.obs-ost.fr>.

Organisation for Economic Cooperation and Development (OECD) <http://www.oecd.org>.

Red de Indicadores de Ciencia y Tecnología Iberoamericana e Interamericana (RICYT) <http://www.ricyt.edu.ar>.

Sistema Integral de Seguimiento y Evaluación (SISE) <http://sise.fecyt.es>.

UNEIX-Comissionat per a Universitats i Recerca <http://uneix.gencat.cat>.

APPENDIX 2:
Information sources

Socioeconomic context
Institut d'Estadística de Catalunya (IDESCAT) <http://www.idescat.cat>.
Instituto Nacional de Estadística (INE) <http://www.ine.es>.
Organisation for Economic Cooperation and Development (OECD) <http://www.oecd.org>.
Sistema Integral de Seguimiento y Evaluación (SISE) <http://sise.fecyt.es>.
Statistical Office of the European Communities (EUROSTAT) <http://ec.europa.eu/eurostat>.
Bodies
Balears Innova <http://www.balearsinnova.net>.
CAMERDATA (list of Spanish businesses) <http://www.camerdata.es>.
Tecnocerca <http://www6.gencat.net/cidem/tecnocerca/index.asp>.
Catalan research centres <http://www.gencat.cat/diue/ambits/ur/recerca/sistema_cat/centres/index.html>.
Xarxa de Parcs Científics i Tecnològics de Catalunya (XPCAT) <http://www.xpcat.net>.
Resourses
Agència d'Avaluació de Tecnologia i Recerca Mèdiques (AATRM) <http://www.aatrm.net>.
Agència de Gestió d'Ajuts Universitaris i de Recerca (AGAUR) <http://www.gencat.cat/agaur>.
Associación de Parques Científicos y Tecnológicos de España (APTE) <http://www.apte.org>.
Centre d'Innovació i Desenvolupament Empresarial (CIDEM) <http://www.cidem.com>.
Centro para el Desarrollo Tecnológico Industrial (CDTI) <http://www.cdti.es>.
Community Research and Development Information Service (CORDIS) <http://cordis.europa.eu>.
Confederación de Rectores de las Universidades Españolas (CRUE) <http://www.crue.org>.
Confederación de Sociedades Científicas de España (COSCE) <http://www.cosce.org>.
Consejo Superior de Investigaciones Científicas (CSIC) <http://www.csic.es>.
Consell Interdepartamental de Recerca i Innovació Tecnològica (CIRIT) <http://www.gencat.cat/diue/departament/estructura/organismes/comissionat/cirit/index.html >
Consorci de Biblioteques Universitàries de Catalunya (CBUC) <http://www.cbuc.es>.
Fundació Catalana per a la Recerca i la Innovació (FCRI) <http://www.fcri.es>.

Fundació la Marató de TV3 <http://www.fundaciomaratotv3.cat>.

Fundación Banco Bilbao Vizcaya Argentaria (BBVA) <http://www.fbbva.es>.

Fundación COTEC para la Innovación Tecnológica <http://www.cotec.es>.

Fundación Conocimiento y Desarrollo (Fundación CyD) <http://www.fundacioncyd.org>

Fundación Española para la Ciencia y la Tecnología (FECYT) <http://www.fecyt.es>.

Fundación para la Investigación y Prevención de la SIDA en España (FIPSE) <http://www.fipse.es>.

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Institució Catalana de Recerca i Estudis Avançats (ICREA) <http://www.icrea.es>.

Institut de Recerca i Tecnologia Agroalimentàries (IRTA) <http://www.irta.cat>.

Instituto de Salud Carlos III (ISCIII) <http://www.isciii.es>.

Ministeri de Ciència i Innovació (MICINN) <http://www.micinn.es>.

Obra Social Fundació la Caixa <http://www.fundacio.lacaixa.es>.

Red de Bibliotecas Universitarias (REBIUN) <http://rebiun.crue.org>.

Red de Oficinas de Transferencia de Resultados de Investigación (RedOTRI) <http://www.redotriuniversidades.net>.

Sociedad Española de Neumonología y Cirugía Torácica (SEPAR) <http://www.separ.es>.

Xarxa Vives d'Universitats <http://www.vives.org>.

Scientific journals and articles

Base de Dades de Sumaris Electrònics <http://sumaris.cbuc.es>

Bases de Datos Bibliográficos del Consejo Superior de Investigaciones Científicas (CSIC) <http://bddoc.csic.es:8080>.

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Plataforma de Integración de Estudios Métricos y Estadísticos de Información (Π-EmEi) <http://bidoc.ub.es/pub/emei>.

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